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Research Article

A Study of Sustainable Growth Strategies in Global Life Sciences Companies: An Environmental Perspective Based on ESG Principles

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Received date: 10 January 2025
Revised date: 20 March 2026
Accepted date: 15 April 2026
Published date: 10 June 2026

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Abstract: Global life science companies are taking significant steps to become more environmentally friendly by integrating sustainability into their operations and products. For corporate survival, maintaining a sound financial structure is crucial. However, now more than ever, it is essential to also address non-financial risks to ensure sustainable growth, as global protectionism is intensifying and ESG regulations are likely to be used as non-tariff barriers between nations. (1) Background/Purpose: This study focuses on the environmental (E) aspect of ESG, especially for the single-use products issue which is critical in the whole industry, and aims to analyze how leading global life sciences companies manage environmental factors as part of their strategies for sustainable growth. (2) Study Design/Methodology/Approach: This study uses a mixed methods approach combining both qualitative and quantitative research. The qualitative analysis involves case studies and a review of relevant literature, while the quantitative analysis compares sustainability performance data to evaluate results across companies. SASB (Sustainability Accounting Standards Board) indicators are used to provide a consistent and standardized way to measure and evaluate each company's environmental performance. (3) Findings: Global life science companies have introduced innovative ways to reduce greenhouse gas emissions, save resources, and improve the recyclability of single-use products. Despite achievements, managing the waste from single-use products remains a challenge. All three focal companies—Thermo Fisher, Merck, and Danaher—demonstrate significant progress in Scope 1 and Scope 2 carbon emission reductions but still require improvement in Scope 3 emissions reduction. (4) Originality/Value: By leading in sustainability, these companies not only meet environmental regulations but also stand out in the competitive biopharmaceutical market. Future success will depend on expanding efforts, fostering collaboration, and empowering others to adopt greener practices.

Keywords: ESG; environmental sustainability; life sciences; single-use technologies; SASB indicators; circular economy; greenhouse gas emissions

1. Introduction

1.1. Research Background

With the ongoing climate crisis and social issues, ESG—which stands for Environmental, Social, and Governance—has become a big focus for companies since 2020. In January 2020, Larry Fink, the CEO of BlackRock (one of the world's largest asset management firms), encouraged governments, companies, and investors to face the "new climate reality" in his annual letter. He also announced that BlackRock would stop investing in companies that earn more than 25% of their revenue from fossil fuels. This pushed forward the shift

toward a low-carbon economy to fight climate change, making ESG a priority for both investors and businesses. In March 2021, the European Union also began requiring ESG disclosures, increasing global attention on the transparency and consistency of ESG measurement and reporting.

ESG is a way to assess a company's worth not just by financial data but also by looking at non-financial aspects within these three areas. The concept of ESG was introduced in May 2004 by the United Nations Global Compact in a report titled Who Cares Wins: Connecting Financial Markets to a Changing World, which stressed the need to address environmental, social, and governance issues for sustainable growth. This report highlighted that ESG could significantly affect corporate investment choices. In April 2006, UN Secretary-General Kofi Annan launched the Principles for Responsible Investment (PRI) to promote ESG investments among major investors worldwide. Since then, PRI has grown to include governments, civil groups, universities, and over 5,387 organizations.

Many companies have put a lot of effort into establishing and standardizing their ESG practices. Internationally, the EU launched the Corporate Sustainability Reporting Directive (CSRD) in April 2021, and the U.S. Securities and Exchange Commission (SEC) introduced a proposal for mandatory climate-related disclosures in March 2022. Additionally, the International Financial Reporting Standards (IFRS) Foundation set up the International Sustainability Standards Board (ISSB) to create global ESG disclosure standards, and in March 2022, it published draft standards for general sustainability and climate-related disclosures. As a result, ESG considerations are rapidly expanding among companies, financial institutions, and investors, now seen as necessary rather than optional.

Corporate ESG efforts are essential for creating both financial and social value while keeping stakeholders engaged. Stakeholders care about sustainable and responsible business practices, and companies that ignore ESG standards face various risks. Problems related to ESG can harm a company's value, reputation, and customer loyalty. Corporate sustainability performance refers to a company's ability to operate in a way that protects the environment while creating value for its shareholders. This includes effective management of environmental resources, and measuring it requires both qualitative and quantitative indicators.

Although the impact of ESG on sustainability is not always clear-cut, there are several positive examples showing that ESG can enhance corporate sustainability. This is why research on sustainable business models is growing, and why many companies are shifting toward more sustainable practices. There is also strong pressure from investors and financial institutions to consider ESG factors in decision-making.

Investors today are increasingly drawn to companies that take environmental responsibility seriously, as this signals stability and reduces investment risks. Global life science companies focus on the environmental aspect of ESG to meet these expectations. Their efforts to reduce environmental impact make them more attractive to sustainability-conscious investors. Governments worldwide are also imposing stricter environmental regulations, such as reducing carbon emissions and managing waste. Despite the advantages of single-use technologies—like preventing contamination, allowing quick production changes, and speeding up drug development—these products are primarily made of plastic, creating a significant amount of non-biodegradable waste.

While global life science companies are taking steps to address these issues, challenges remain. Recycling single-use plastics is difficult because many products are contaminated or made from complex materials that require special recycling methods. Some life science companies offer take-back programs, while others collaborate with external partners, but scaling these solutions globally is still a hurdle. Additionally, producing and disposing of single-use technologies leads to a high carbon footprint and consumes significant raw materials, energy, and water. Though these companies are reducing emissions, using renewable energy, and creating products that use fewer resources, the reliance on plastics continues to be a concern. As customers and regulators demand more sustainable options, these companies face the ongoing challenge of balancing the need for sterile, convenient products with the push for eco-friendly solutions.

1.2. Research Objective

Global life science companies are placing increasing emphasis on environmental sustainability as part of their ESG strategies. This shift not only aligns with stricter government regulations on carbon emissions, waste management, and resource usage but also appeals to investors seeking environmentally responsible businesses.

Companies that actively work to reduce their environmental impact are often seen as more stable and less risky, enhancing their attractiveness for long-term investment. By incorporating environmental Corporate Social Responsibility (CSR) into their strategies, these companies can meet global and local environmental standards, such as those set by the United Nations, while avoiding legal and financial penalties.

One key area of focus for these companies is the production and use of single-use technologies, which are widely used in healthcare, biotechnology, and pharmaceuticals. Single-use technologies, such as bioprocessing bags, filters, and plastic pipettes, offer significant advantages, including eliminating cross-contamination risks, ensuring sterility, and enabling quick setup and changeover in production processes. These benefits are particularly valuable in industries like vaccine production and biologics manufacturing, where safety and speed are critical. Additionally, single-use technologies provide flexibility, allowing companies to quickly scale production up or down to meet changing demands, such as during public health emergencies.

However, the widespread use of single-use technologies presents major environmental challenges. These products are primarily made from plastic and are disposed of after a single use, generating significant amounts of non-biodegradable waste. Despite efforts by companies to mitigate this issue through recycling and take-back programs, the scale of plastic waste remains a critical concern. Recycling single-use plastics is particularly challenging due to contamination and the complexity of materials used, making it difficult to implement effective recycling solutions on a global scale. These limitations highlight the urgent need for innovative solutions and global cooperation to reduce the environmental footprint of single-use products.

Another pressing issue is the high carbon footprint associated with the production, transportation, and disposal of single-use products. Companies invest in renewable energy and emissions reduction projects as well as adopt lifecycle assessments to pinpoint areas with the highest carbon emissions. Despite these efforts, the environmental impact of single-use technologies remains an area requiring further improvement. Additionally, the production of these items consumes significant raw materials, energy, and water, which adds to their overall resource intensity. While companies have made progress in designing products that use fewer resources, the reliance on plastic remains a key challenge.

Growing customer and regulatory demands for more sustainable options are putting pressure on life science companies to develop eco-friendly solutions. Customers want products that are not only sterile and effective but also environmentally friendly. While these companies are making progress through recycling programs and energy-saving initiatives, they face challenges in balancing these sustainability goals with economic and operational efficiency. Single-use technologies, despite their advantages, still create environmental concerns such as high resource consumption, plastic waste, and carbon emissions. To address these issues, companies need to invest in research and development and collaborate with governments and recycling partners to create sustainable solutions that meet both customer expectations and environmental responsibilities.

1.3. Research Methodology

This study focuses on global life science companies—Danaher ($5.7 billion revenue for biotechnology area in 2023), Merck ($4.1 billion), and Thermo Fisher ($2.4 billion)—for the environmental aspect of ESG because they are leaders in the life sciences industry and have a significant impact on global health and sustainability. These global life science companies set an example for smaller companies in the same industry. When they adopt sustainable practices, it encourages others to do the same. Their leadership in ESG can drive positive changes across the healthcare and life sciences industries.

As life science companies, they produce medicines, vaccines, and scientific equipment, which involve energy use, water consumption, and waste generation. Because of this, their environmental impact is significant, and how they manage it is important to study. The ways they address issues like carbon emissions, waste disposal, and resource conservation can serve as a model for other companies.

All companies in this study are recognized for their strong focus on sustainability and environmental practices. For example, they invest in renewable energy, aim to reduce waste, and work to lower their carbon footprints. Studying companies with strong ESG commitments helps identify best practices that other organizations can learn from.

This study uses a qualitative research approach to explore how companies manage ESG environmental factors. To gather data, ESG and sustainability reports from 2023 of global life sciences companies were reviewed to understand their environmental strategies. Additionally, to understand the rules and guidelines related to ESG, the study examined industry-specific ESG reports and resources from governments and international organizations to compare the environmental strategies of these companies.

Finally, this study used SASB (Sustainability Accounting Standards Board) indicators because these are valuable tools for comparing single-use technology strategies among companies and provide a consistent and standardized way to measure and evaluate each company's environmental performance. These indicators focus on industry-specific sustainability factors, making them especially useful for understanding how companies in the life sciences sector address key environmental challenges, like waste generation, energy usage, and product lifecycle impacts.

2. Environmental Analysis

2.1. ESG Management and Environmental Perspective

Since the 2015 Paris Agreement, life sciences companies have been working toward decarbonization through innovative and resource-efficient practices. Examples include AstraZeneca reducing packaging waste, Boehringer Ingelheim creating reusable inhalers, and Johnson & Johnson using recycled materials in product packaging. However, significant challenges remain, such as improving supply chain sustainability, reducing water usage, transitioning to a circular economy, and meeting stricter environmental regulations. Reporting on sustainability is becoming mandatory in many regions, with new frameworks like the EU's Corporate Sustainability Reporting Directive (CSRD) and the US SEC's climate-related disclosure requirements. Life sciences companies need to stay informed on global legislative changes to meet these new requirements and achieve net-zero goals (Mestroni, 2023).

According to Ottinger (2022), biopharmaceutical production is facing increasing public concern about environmental issues, particularly those associated with large-scale, centralized production. Sustainability has become a key focus in various aspects of life, and both society and industrial decision-makers often view disposable or plastic-based products as contributors to environmental problems. Single-use products in biopharmaceutical production are under scrutiny to demonstrate that they can be a more environmentally friendly alternative compared to conventional stainless-steel systems. However, there remain challenges in comparing different production methods and evaluating how single-use technologies can be effectively integrated with traditional multi-use technologies in various production steps.

A critical area of focus is waste management, particularly addressing the challenges of single-use technologies. These products, such as bioprocessing bags, filters, and pipettes, are widely used in life sciences due to their sterility and convenience, but they generate significant plastic waste. Companies are tackling this problem through innovative recycling programs, partnerships with third-party organizations, and take-back systems to repurpose materials. However, recycling these products is difficult due to contamination and complex material composition, making large-scale solutions challenging to implement. While progress has been made, such as zero-waste certifications and pilot programs, scaling these efforts to meet global demand remains a significant hurdle for the industry.

In addition to waste reduction, life science companies are focusing on sustainable product design to minimize their environmental impact throughout the product lifecycle. This includes developing products that use fewer raw materials, require less energy and water during production, and incorporate environmentally friendly packaging. For instance, companies use lifecycle assessments to evaluate and reduce the environmental impact of their products. These initiatives aim to create a balance between meeting customer needs for sterile, efficient single-use systems and addressing environmental concerns. By embedding sustainability into product design, these companies are positioning themselves as leaders in innovation while meeting the growing demands of eco-conscious customers and regulators.

Life Cycle Assessment (LCA) is a scientific method used by companies to evaluate the environmental impacts of a product throughout its entire life cycle, from raw material extraction to production, use, and disposal or

recycling (Barbaroux, 2020). Known as a "cradle-to-grave" analysis, LCA is especially important for assessing the sustainability of single-use products in industries like biopharmaceutical production. Using LCA, global life science companies can develop strategies to reduce the environmental footprint of their single-use technologies. For instance, these companies analyze material choices, packaging, and recycling options to create more sustainable designs. Programs like take-back systems and partnerships with specialized recycling organizations are informed by LCA data, ensuring that sustainability initiatives are both effective and measurable.

Figure 1. *Lifecycle phases included in a comparative life-cycle assessment (LCA) study. Reference: Reducing the Environmental Impact of Single-Use Systems, Merck 2012.*

2.2. Environmental Sustainability and Single-Use Technologies

Global life science companies place a strong emphasis on the environmental aspect of ESG for single-use technologies due to their significant impact on ecosystems and climate change. Single-use technologies are widely used in the life sciences sector for their efficiency, sterility, and ability to meet the demands of industries like biopharmaceuticals and healthcare. However, these products generate a considerable amount of plastic waste that is challenging to manage. Without proper recycling or disposal systems, this waste often ends up in landfills or incinerators, contributing to pollution and greenhouse gas emissions. Companies are increasingly aware of the need to address these challenges to minimize their environmental footprint and align with global sustainability goals (Keil, 2023; Belkhir, 2019).

Another driving factor is the increasing regulatory pressure from governments and international organizations. Environmental policies are becoming stricter, with a focus on reducing plastic waste, limiting greenhouse gas emissions, and encouraging the adoption of renewable energy. Global life science companies must comply with these regulations to avoid fines, operational disruptions, and reputational damage. At the same time, adhering to these policies positions them as responsible industry leaders who take proactive steps to meet evolving environmental standards.

Customer expectations also play a significant role in shaping environmental strategies for single-use technologies. Healthcare providers, pharmaceutical manufacturers, and research institutions increasingly demand eco-friendly solutions as part of their own sustainability initiatives. These customers seek suppliers that align with their values, offering products with reduced environmental impact. By addressing environmental concerns, companies not only strengthen their relationships with customers but also position themselves as preferred partners in the industry.

Environmental sustainability is not just about compliance and customer satisfaction—it is also critical for long-term business resilience. Single-use technologies rely heavily on non-renewable materials like plastics, which face supply chain vulnerabilities and rising costs due to global resource constraints. By investing in renewable materials, circular economy models, and efficient recycling systems, companies can mitigate risks related to resource scarcity and supply chain disruptions (Riikonen, 2024).

Reputation and brand image are other key motivators for global life science companies to focus on the environment. In today's market, stakeholders, including investors, employees, and customers, increasingly value companies that demonstrate a strong commitment to sustainability. Companies that fail to address environmental concerns risk damaging their reputation and losing trust among their stakeholders. On the other hand, businesses that lead with eco-friendly innovations and transparent reporting of their environmental progress strengthen their credibility and differentiate themselves in the competitive life sciences sector.

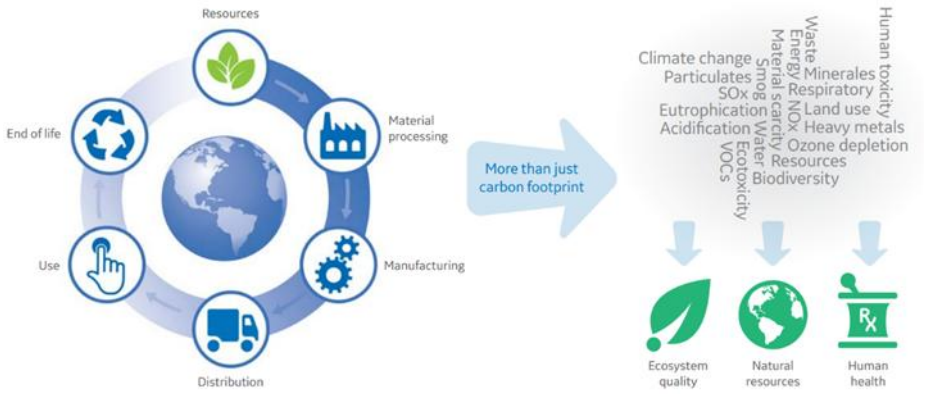
Ultimately, addressing the environmental impact of single-use technologies allows global life science companies to contribute to a healthier planet while aligning their operations with global efforts to combat climate change. By focusing on the environmental aspect of ESG, these companies not only meet regulatory and customer demands but also enhance their business resilience and create a positive brand image. Their efforts to reduce waste, transition to renewable energy, and adopt sustainable materials reflect a forward-thinking approach that positions them as leaders in sustainability and innovation (Achleitner, 2025).

2.3. Impact of Single-Use Technologies on Environment

Single-use technologies made by global life science companies have significant negative impacts on the environment, particularly because they generate large amounts of waste. After being used once, these products are typically discarded, contributing to the growing problem of plastic pollution. On one hand, these products are essential for maintaining high standards of sterility and efficiency in industries like biopharmaceutical manufacturing and clinical research. They reduce the need for cleaning chemicals, water, and energy, which are typically required for reusable systems. Most single-use technologies are made from materials like polypropylene or polyethylene, which are not biodegradable. As a result, they can remain in landfills or the environment for hundreds of years, causing long-term ecological harm and taking up valuable land space.

The production of single-use technologies also has harmful environmental consequences. Manufacturing these items requires the use of fossil fuels, which are not only a finite resource but also contribute to greenhouse gas emissions. The extraction and refining processes for petroleum-based plastics release significant amounts of carbon dioxide and other pollutants, further worsening climate change. Moreover, the energy-intensive manufacturing process places additional pressure on global energy supplies and increases the carbon footprint of these products.

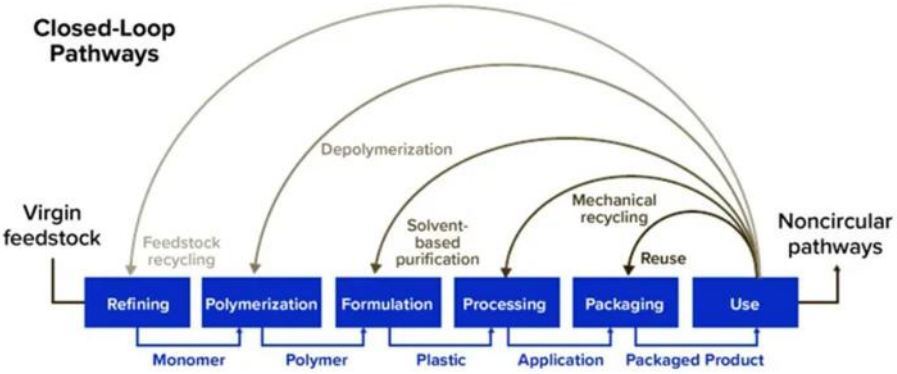
Figure 2. *Product life cycle diagram and impacts evaluated in LCA. Reference: Single-use technology and sustainability, GE Life Sciences, 2017.*



Another issue with single-use technologies is the strain they place on recycling systems. Many of these items are made of mixed materials or contaminated with biological or chemical residues, making them difficult or impossible to recycle. Even when recycling programs exist, the infrastructure may not be sufficient to handle the volume of waste generated by single-use products. This leads to a low recycling rate and leaves most of the waste destined for landfills or incinerators.

Designing single-use technologies and their packaging with sustainability in mind focuses on reducing material usage while still meeting quality and functionality requirements. This involves analyzing the product lifecycle to identify ways to minimize plastic waste, such as rethinking and reengineering product design. Recycling also plays an important role, as products can be made from recyclable materials or include recycled content. Additionally, the new plastic economy encourages the use of renewable feedstocks, like sugarcane, to produce plastics, such as plant-based PET used in some beverage bottles. However, most single-use products today are made from virgin plastics derived from fossil fuels, highlighting the need to explore integrating recycled or renewable materials into their production.

Figure 3. *Overview of different loops for plastics in a circular economy. Reference: The Green Imperative: Part Two — Engineering for Sustainability in Single-Use Technologies, BioProcess International.*



Finally, the widespread use of single-use products perpetuates a throwaway culture, where convenience takes precedence over sustainability. This mindset discourages the adoption of reusable alternatives and slows down efforts to transition to more sustainable systems. While single-use technologies are necessary in some situations, such as medical applications, their environmental impact underscores the urgent need for innovation and better waste management practices to mitigate the harm they cause.

2.4. SWOT Analysis of Life Science Companies to Environmental Aspect

The global generation of plastic waste is estimated at 20 million metric tons annually, with the medical and pharmaceutical industries accounting for only 5.9 million metric tons (Ottinger, 2022). While this represents a relatively small fraction of total plastic usage, it is still a significant amount. The purpose of this SWOT analysis is to evaluate the environmental strategies of leading global life sciences companies. This analysis aims to understand the strengths, weaknesses, opportunities, and threats related to their environmental initiatives and ESG practices. By identifying key areas of excellence and improvement, the analysis seeks to guide these companies in aligning their strategies with sustainability goals and regulatory requirements.

The primary objective is to assess how effectively these companies address environmental challenges such as carbon emissions, waste management, water conservation, and energy efficiency. The analysis focuses on evaluating their current ESG strategies, particularly through the lens of SASB (Sustainability Accounting Standards Board) indicators.

Table. 1. Plastic waste from medical and pharma applications among all waste in different areas. Reference: Ottinger, 2022.

Area	Total Waste [t]	Plastic [t]	Medical & Pharma [t]	Single-use Equipment [t]
World	$20\,000 \cdot 10^6$ (2017) [10]	$353 \cdot 10^6$ (2019) [11]	$5.9 \cdot 10^6$ (2018) [12]	$0.03 \cdot 10^6$ (2019) [14]
			$72 \cdot 10^6$ (2020) [13]	
Europe	$2337 \cdot 10^6$ (2018) [15]	$29.5 \cdot 10^6$ (2020) [16]	$0.1 \cdot 10^6$ (2016)	
Germany	$417 \cdot 10^6$ (2019) [17]	$6.28 \cdot 10^6$ (2019) [18]	$0.4 \cdot 10^6$ (2018) [19]	

Strengths

Global life science companies have demonstrated strong leadership in environmental sustainability by adopting renewable energy programs, implementing recycling initiatives, and conducting Life Cycle Assessments (LCA) to minimize their environmental impact. These efforts help reduce their carbon footprint and align with global climate goals. On the social front, these companies contribute significantly to advancing global health by producing critical tools and therapies that improve the quality of life for millions of people worldwide. Their governance practices are robust, emphasizing corporate transparency, stakeholder engagement, and alignment with international sustainability standards, such as the Paris Agreement. Additionally, their investments in sustainable product design and the use of renewable feedstocks showcase their ability to balance operational

goals with ESG priorities effectively.

Weaknesses

One significant weakness in their environmental management is the challenge posed by single-use technologies, which generate a large amount of plastic waste and undermine sustainability efforts. On the social side, there are technical and economic barriers to scaling recycling programs and implementing global sustainability solutions, which can slow progress. From a governance perspective, inconsistencies in ESG reporting and the difficulty of setting uniform global standards across different regulatory environments present ongoing challenges. Furthermore, transitioning to renewable energy and integrating recycled materials into production requires substantial upfront costs and logistical adjustments, which can strain their ability to achieve ESG targets efficiently.

Opportunities

There are numerous opportunities for these companies to enhance their ESG performance. On the environmental front, they can further innovate by developing biodegradable materials and adopting circular economy strategies, positioning themselves as industry leaders in sustainability. Social opportunities include expanding partnerships with governments, non-governmental organizations (NGOs), and recycling companies to enhance global collaboration and improve community engagement. From a governance perspective, adopting more robust ESG frameworks, such as the Task Force on Climate-related Financial Disclosures (TCFD), can improve accountability and attract ESG-focused investors. Additionally, emerging markets provide an opportunity to integrate sustainable practices into new operations, building resilient and eco-friendly supply chains in regions with growing demand for life science products.

Threats

The companies face several threats related to ESG management. Stricter environmental regulations, such as carbon taxes and waste management laws, could increase operational costs and compliance burdens. Public perception also poses a risk; if these companies fail to address the environmental impact of single-use plastics or other waste issues effectively, it could harm their reputation. Governance threats include competitive pressures from peers that are more aggressively pursuing ESG strategies, potentially impacting market share and investor confidence. Additionally, resource scarcity and price volatility for raw materials, including renewable alternatives, could hinder progress toward achieving long-term ESG goals.

The challenge of plastic waste from single-use technologies can be turned into an opportunity by developing biodegradable or compostable alternatives. By investing in research and development, these companies can design environmentally friendly materials that meet the same functionality while reducing environmental impact. This innovation can position them as leaders in sustainable bioprocessing. Additionally, technical and economic barriers to recycling programs can be addressed by collaborating with governments, NGOs, and recycling companies. These partnerships can help scale recycling infrastructure and create cost-effective solutions.

To overcome threats by leveraging the strengths, stricter environmental regulations, such as carbon taxes, can be managed by further investing in renewable energy programs and continuing the use of Life Cycle Assessments (LCAs). These efforts help companies identify ways to lower emissions and resource use, ensuring compliance with environmental laws while reducing costs in the long run. The threat of reputational harm due to waste issues, like single-use plastics, can be countered by expanding recycling initiatives and introducing more sustainable product designs. By showcasing their leadership in sustainability, these companies can improve public perception, attract environmentally conscious consumers, and build stronger trust with stakeholders.

The risk of losing market share to competitors with stronger ESG strategies can be mitigated by emphasizing corporate transparency and aligning governance practices with international standards, such as the Paris Agreement. Clear reporting and stakeholder engagement can strengthen investor confidence and position the company as a sustainability leader.

2.5. SASB (Sustainability Accounting Standards Board) Indicators

SASB indicators are specific metrics developed by the Sustainability Accounting Standards Board to help companies measure and report on their sustainability performance in areas that are financially material. These

indicators are tailored to 77 industries, focusing on the most relevant environmental, social, and governance (ESG) factors for each sector, such as carbon emissions in energy or drug safety in pharmaceuticals. They include both quantitative data, like greenhouse gas emissions or water usage, and qualitative information, such as policies for worker safety. Designed for global applicability, SASB indicators align with other sustainability frameworks, such as the Global Reporting Initiative (GRI) and the Task Force on Climate-Related Financial Disclosures (TCFD). By emphasizing material ESG factors, SASB helps investors and stakeholders assess how companies manage risks and opportunities that could impact financial performance, enabling transparent and informed decision-making. Table 2 presents the list of environmental SASB indicators especially for the life science/biotechnology industry.

Table. 2. Environmental aspect of the SASB indicators for the biotechnology industry. Reference: The IFRS Foundation, https://sasb.ifrs.org/

Topic	Metric Code	Metric Description
GHG Emissions	HC-BP-110a.1	Scope 1 and Scope 2 greenhouse gas (GHG) emissions
	HC-BP-110a.2	Description of strategies or plans to manage GHG emissions and mitigate climate risks
Energy Management	HC-BP-130a.1	Total energy consumed, percentage from grid electricity, percentage from renewables
Water & Wastewater Management	HC-BP-140a.1	Total water withdrawn, total water consumed, percentage of each in regions with High or Extremely High Baseline Water Stress
	HC-BP-140a.2	Description of water management risks and discussion of strategies and practices to mitigate those risks
Waste Management	HC-BP-150a.1	Amount of hazardous waste generated, percentage recycled
	HC-BP-150a.2	Description of waste management practices

For global life science companies, SASB indicators focus on key ESG factors relevant to the industry, such as product safety, environmental impact, and access to healthcare. These indicators help companies measure and report on areas like greenhouse gas emissions (HC-BP-110a.1), energy and water usage (HC-BP-140a.1), and waste management (HC-BP-150a.2), which are critical due to the resource-intensive nature of pharmaceutical production. They also cover governance issues, including ethical marketing practices, clinical trial transparency, and patient safety. By using these indicators, life science companies can better align their sustainability efforts with investor expectations and regulatory requirements.

3. Case Analysis

3.1. Thermo Fisher Scientific

Thermo Fisher Scientific is a global provider of scientific instruments, laboratory equipment, and innovative solutions for the life sciences and healthcare industries. Headquartered in Waltham, Massachusetts, the company serves a broad customer base, including pharmaceutical and biotechnology companies, hospitals, academic institutions, and government research organizations. The company also provides integrated solutions for drug development, testing, and manufacturing, including bioprocessing and clinical research services, aimed at accelerating innovation in the life sciences industry.

Thermo Fisher Scientific's ESG strategies are focused on creating long-term value for both its stakeholders and the communities it serves. The company is committed to achieving net-zero carbon emissions across its operations by 2050 and has implemented initiatives to reduce its carbon footprint. This includes investing in renewable energy sources, such as wind and solar power, to reduce reliance on non-renewable energy. Thermo Fisher is also focused on enhancing energy efficiency across its facilities by upgrading equipment, optimizing processes, and implementing energy-saving technologies.

Thermo Fisher Scientific developed environmental strategies as part of its ESG framework, focusing on

reducing greenhouse gas (GHG) emissions, optimizing energy and water usage, and enhancing waste management. These efforts are integral to the company's mission to promote sustainability while supporting the global scientific and healthcare community. Thermo Fisher committed to align its environmental strategies with global climate goals and meeting the expectations of its stakeholders, including customers, investors, and regulatory bodies.

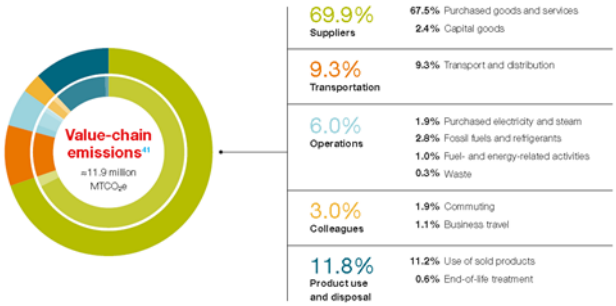


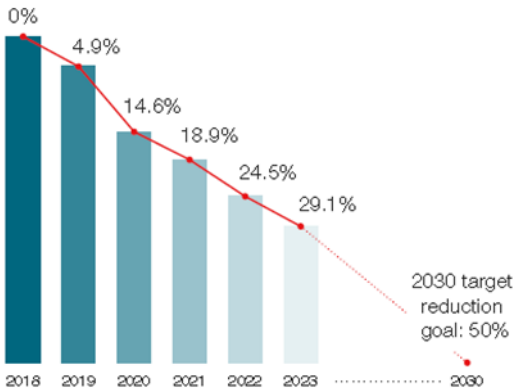
Figure 4. *Value-chain emissions plan. Reference: Corporate Social Responsibility Report 2023, Thermo Fisher Scientific.*

To address greenhouse gas emissions, Thermo Fisher adopted reduction targets, including transitioning to renewable energy sources and enhancing operational efficiency. The company is reducing Scope 1 and Scope 2 emissions by implementing energy-efficient technologies across its facilities, such as LED lighting, advanced HVAC systems, and renewable energy installations. Furthermore, Thermo Fisher collaborates with its supply chain partners to tackle Scope 3 emissions by encouraging low-carbon transportation and sustainable sourcing practices.

In terms of energy and water usage, Thermo Fisher practices efficient resource management to minimize environmental impact. The company invests in energy conservation initiatives, including the use of smart meters and real-time monitoring systems to optimize energy consumption. Similarly, the company integrates water-saving technologies into its manufacturing processes to reduce water usage and waste. By adopting closed-loop water systems and prioritizing water-efficient practices, the company minimizes its reliance on freshwater resources and contributes to the sustainable management of global water supplies.

Waste management is another key focus area for Thermo Fisher. The company committed to reduce waste generation and promoting recycling and reuse across its operations. Thermo Fisher implements sustainable packaging solutions, such as using recyclable materials and reducing packaging volume, to minimize its environmental footprint. Additionally, the company is investing in ways to manage single-use plastics, including partnerships for recycling programs and take-back initiatives for used materials.

Figure 5. *Operational net-zero guidance. Reference: Corporate Social Responsibility Report 2023, Thermo Fisher Scientific.*



3.2. Danaher

Danaher Corporation is a globally diversified conglomerate that designs, manufactures, and markets professional, medical, industrial, and commercial products and services. With a focus on life sciences, diagnostics, environmental solutions, and applied technologies, Danaher operates in fostering innovation across industries.

One of Danaher's prominent subsidiaries is Cytiva, a leading player in the life sciences sector. Cytiva specializes in bioprocessing technologies and services that enable the development and manufacturing of biopharmaceuticals, including monoclonal antibodies, vaccines, and cell and gene therapies. Danaher is committed to advance environmental sustainability as a key pillar of its ESG framework, with strategies focused on reducing greenhouse gas (GHG) emissions, optimizing energy and water usage, and enhancing waste management. As a global provider in science and technology, Danaher integrates sustainable practices into its operations and product innovations, setting measurable goals to meet global climate commitments and industry standards.

To combat greenhouse gas emissions, Danaher has implemented initiatives to transition its operations toward renewable energy sources and enhance energy efficiency. The company invests in advanced technologies that lower emissions, such as energy-efficient manufacturing systems, and seeks to optimize transportation and supply chain operations to reduce carbon footprints.

Danaher also focuses on energy and water conservation, recognizing their critical importance to sustainable operations. The company adopts energy-saving technologies across its facilities and continuously reviews its energy consumption patterns to identify areas for improvement. In water management, Danaher integrates water-efficient systems and practices into its manufacturing processes to reduce water waste and ensure sustainable usage.

In waste management, Danaher developed comprehensive strategies to minimize waste and promote a circular economy. The company emphasizes sustainable product and packaging design, aiming to reduce the use of virgin materials and increase the recyclability of its products. Particularly in its Cytiva division, which serves the biopharmaceutical industry, Danaher manages single-use plastics by exploring innovative recycling solutions and take-back programs.

3.3. Merck

Merck, known as MilliporeSigma in the United States and Canada, is the Life Science business of the global science and technology company Merck KGaA, headquartered in Darmstadt, Germany. With a legacy spanning more than 350 years, Merck operates in pharmaceuticals, life sciences, and performance materials industries. The Life Science division, MilliporeSigma, provides products and services that empower scientific discovery, biopharmaceutical production, and diagnostics, serving customers in academia, biotechnology, pharmaceuticals, and industrial markets. MilliporeSigma focuses on enabling researchers and manufacturers to advance healthcare, address global challenges, and bring innovative therapies to patients. Its portfolio includes more than 300,000 products, ranging from lab materials and tools to biopharmaceutical manufacturing solutions.

Merck's business model in bioprocessing focuses on providing innovative tools, technologies, and services to enable the efficient production of biologics and other biopharmaceutical products. The company serves as a partner to pharmaceutical and biotechnology companies, offering end-to-end solutions that support every stage of the bioprocessing workflow, from research and development to commercial-scale manufacturing.

Merck's bioprocessing solutions emphasize single-use technologies, which streamline manufacturing processes by reducing contamination risks, increasing flexibility, and minimizing the need for cleaning and sterilization. These technologies include bioreactors, filtration systems, and chromatography tools that are tailored for scalable and efficient biologics production. Additionally, Merck provides services in process development and optimization to help customers improve yield, quality, and production speed.

Sustainability is embedded within Merck's bioprocessing business model, with initiatives to reduce environmental impacts through sustainable product design, waste reduction, and recycling programs. Merck developed comprehensive environmental strategies as part of its ESG framework to address greenhouse gas

(GHG) emissions, energy and water usage, and waste management. These initiatives demonstrate Merck's commitment to sustainability and its alignment with global environmental goals, such as the Paris Agreement, while driving innovation and efficiency within its operations.

Figure 6. *Merck waste score. Reference: Sustainability Report 2023, Merck Group.*

To reduce greenhouse gas emissions, the company invested in renewable energy sources, including solar and wind power, and is transitioning to energy-efficient technologies across its manufacturing and operational sites. Merck is optimizing its supply chain logistics to minimize emissions from transportation and distribution. By setting science-based targets to reduce Scope 1, 2, and 3 emissions, Merck is aligned with global standards and transparently reports progress toward these goals.

Merck prioritizes energy and water conservation to enhance operational efficiency and minimize environmental impact. The company integrates energy-efficient systems into its facilities, such as advanced lighting and cooling systems, to reduce energy consumption. Additionally, Merck incorporates water-saving technologies into its manufacturing processes, particularly in regions facing water scarcity. By conducting regular assessments of its water usage, Merck identifies opportunities for improvement and implements initiatives to reduce water waste.

In waste management, Merck focuses on sustainable practices by promoting a circular economy. The company concentrates on reducing, reusing, and recycling materials throughout its operations. The company also aims to minimize the use of plastics and improve the recyclability of product packaging. Additionally, Merck explores recycling solutions for single-use plastics used in biopharmaceutical production, collaborating with industry partners to address waste challenges and develop scalable solutions.

3.4. Company Comparison and SASB Indicators Evaluation

Thermo Fisher set a long-term goal to achieve net-zero carbon emissions by 2050, investing in renewable energy projects such as solar and wind while implementing energy-efficient technologies across its facilities. Merck similarly focuses on renewable energy use, targeting energy-intensive processes in bioprocessing to reduce emissions. Danaher focuses on achieving energy efficiency across its diverse portfolio of operating companies. Danaher demonstrates a similar commitment to reducing Scope 1 (direct), Scope 2 (indirect from purchased energy), and Scope 3 (supply chain) emissions by integrating renewable energy sources into its operations and improving the energy efficiency of its manufacturing processes.

Thermo Fisher promotes recycling programs for its single-use technologies, enabling customers to return used materials for repurposing. Merck excels in this area with its focus on reusable single-use technology systems, reducing plastic waste and optimizing product lifecycles. Danaher embraces circular economy principles, designing products that minimize waste and prioritizing recyclable materials in its packaging and production.

Merck focuses on water conservation, introducing recycling initiatives and optimizing water usage in bioprocessing operations, a key area for environmental impact. Thermo Fisher and Danaher also work to reduce water consumption, though their efforts in this area are not as prominently highlighted as Merck's. Danaher

integrates water sustainability into its product offerings, making it a key player in addressing water management challenges globally.

For SASB indicators, there are both similarities and distinctions in how the three companies' sustainability efforts align with these standards. All three companies focus on critical environmental aspects such as energy management, waste recycling, and product lifecycle management, but their approaches vary based on their unique strategies and priorities.

Table. 3. Comparison of strengths and weaknesses of companies based on ESG environmental aspects.

Company	Strengths	Weaknesses
Thermo Fisher	Focus on renewable energy adoption Comprehensive energy management strategies	Scope 3 emissions across the supply chain and product usage Limited recycling programs for single-use plastics on a large scale
Danaher	Advanced facilities with low energy intensity Effective water management to reduce the environmental impact of manufacturing processes	Dependent on fossil fuel-based processes in some operations Less prominent water-related sustainability goals compared to competitors
Merck	Clear energy efficiency in manufacturing and commitment to carbon neutrality Robust focus on reducing plastic waste in bioprocessing operations	Slow progress in renewable energy adoption across all operations Limited reporting transparency and slower efforts to address comprehensive Scope 3 emissions

All three companies prioritize reducing greenhouse gas (GHG) emissions and transitioning to renewable energy for energy management (HC-BP-110a.1). Thermo Fisher aims to achieve 80% renewable electricity by 2030, Danaher utilizes a Decarbonization Playbook to enhance energy efficiency and adopt alternative fuels, and Merck plans to source 80% of its electricity from renewable sources by 2030 through solar installations and power purchase agreements. For waste and recycling practices (HC-BP-140a.1), all three address waste from single-use technologies with different strategies: Thermo Fisher focuses on zero-waste programs and recycling initiatives for non-hazardous waste, Danaher collaborates with third parties to recycle hard-to-process plastics, and Merck implements take-back programs and repurposes materials like plastic drums into HDPE. In product lifecycle management (HC-BP-150a.2), Danaher and Merck lead with advanced initiatives—Danaher integrates sustainability into product design, reducing materials and optimizing packaging, while Merck uses a Sustainability Scorecard to minimize environmental impact throughout a product's lifecycle. Thermo Fisher also contributes by designing single-use systems that reduce material and energy usage.

The companies share a strong alignment in addressing energy, waste, and product lifecycle issues. However, their approaches differ in scope and innovation. Thermo Fisher's strategies emphasize energy transition and zero-waste certification, Danaher combines energy efficiency with employee-driven innovation and circularity, and Merck leads with comprehensive lifecycle assessments and material innovations. These variations reflect their distinct roles within the life sciences industry and their tailored responses to customer and regulatory demands.

Table. 4. Environmental aspects based on the SASB indicators.

SASB Indicator	Thermo Fisher	Danaher	Merck
Greenhouse Gas Emissions (HC-BP-110a.1)	Reduction of Scope 1 and Scope 2 emissions with renewable energy adoption	Reduction in energy intensity and carbon emissions from operations	Commitment to carbon neutrality in selected areas
Energy Management (HC-BP-110a.1)	Energy-efficient processes and renewable energy sources in key facilities	Energy-saving technologies in facilities	Strong energy efficiency initiatives in manufacturing

SASB Indicator	Thermo Fisher	Danaher	Merck
Waste Management (HC-BP-140a.1)	Circular economy strategies for waste reduction	Limited waste disposal programs	Reduction in plastic waste through reusable technologies
Water Management (HC-BP-140a.1)	Reduction in water usage and addressing water-related impacts from operations	Focus on water efficiency in manufacturing	Reduction in water measurement
Product Lifecycle Management (HC-BP-150a.2)	Comprehensive LCA to assess environmental impact	Integration of recyclable materials into product packaging	Use of renewable feedstocks and circular economy principles

3.5. Summary of Analysis

Thermo Fisher, Merck, and Danaher are exemplary life sciences companies integrating environmental sustainability into their ESG strategies. These companies are actively reducing their environmental footprint by focusing on renewable energy, waste management, and water conservation. Each company has distinct strengths, shaped by its business model and operational focus.

Thermo Fisher focuses on renewable energy and carbon reduction as core pillars of its environmental strategy. The company invests in large-scale renewable energy projects, including wind and solar power, and integrates energy-efficient technologies across its facilities. Its proactive efforts to partner with suppliers and customers for recycling single-use technologies and optimizing packaging design highlight its comprehensive approach to reducing waste.

Danaher approaches environmental sustainability with its decentralized operating structure. The company empowers its subsidiaries to focus on specific environmental challenges. Its portfolio-wide initiatives, including waste reduction and innovative technologies, demonstrate a versatile and scalable approach to ESG. Danaher's focus on fostering sustainable practices across diverse industries amplifies its impact on environmental sustainability.

Merck, on the other hand, addresses water conservation and waste management, particularly in biopharmaceutical manufacturing. Merck has implemented innovative measures like reusable single-use systems, which significantly reduce plastic waste. Its lifecycle assessment methodology ensures that products are designed with minimal environmental impact, focusing on sustainable materials and processes. Furthermore, Merck's supply chain strategies, including eco-friendly product design and emission reduction initiatives, showcase its commitment to circular economy principles.

Overall, these companies exemplify the various ways life sciences organizations can address environmental challenges. Thermo Fisher excels in renewable energy integration and emissions reduction, positioning itself as a leader in climate-focused sustainability. Merck leads in waste reduction and water management, with innovative product designs and circular economy principles driving its efforts. Together, these companies highlight the importance of diverse and strategic approaches in driving meaningful progress toward global environmental goals.

4. Strategic Suggestions Based on Case Analysis

Based on the cases and SASB analyses mentioned, several strategic recommendations can help global life science companies improve their sustainability efforts while staying aligned with industry benchmarks. First, these companies should focus on expanding partnerships with waste management and recycling firms to create standardized and scalable solutions for single-use product disposal. Such partnerships would enable the development of robust take-back programs and new methods for recycling hard-to-process materials like plastics used in biopharmaceutical production. By addressing the challenges of plastic waste in single-use technologies, these companies could not only contribute to a circular economy but also meet growing regulatory and customer demands for environmentally friendly solutions.

All three companies—Thermo Fisher, Merck, and Danaher—should enhance their strategies to reduce greenhouse gas (GHG) emissions across Scope 1, Scope 2, and Scope 3. This involves increasing the adoption of renewable energy, working with suppliers to decarbonize supply chains, and leveraging innovative technologies to reduce emissions during manufacturing. For instance, using energy-efficient systems and transitioning to low-carbon transportation methods would further lower their carbon footprint and align with global climate goals.

Investing in energy-efficient technologies and renewable energy sources are vital for achieving long-term sustainability goals. Companies can establish measurable targets for reducing energy consumption and expand their use of renewable energy, such as solar and wind, across operations. This not only supports sustainability but also helps the companies save on energy costs and become less vulnerable to fluctuations in energy prices over time.

Water management is a critical area for improvement, given the significant role water plays in life science operations. These companies should implement water-efficient systems, increase the recycling of process water, and enhance wastewater treatment practices. For example, expertise in water treatment solutions could be scaled further to set an industry standard for water management practices. This would reduce water use and minimize the environmental impact of wastewater discharge.

Lastly, addressing the waste generated by single-use technologies in biopharmaceutical production requires innovative circular economy solutions. Companies could design products with recyclable or biodegradable materials to reduce environmental impact and increase recycling rates across operations.

Merck's Sustainability Scorecard is a tool providing a structured framework to evaluate and improve the environmental impact of its products across their entire lifecycle. This scorecard goes beyond general approaches by assessing various aspects such as resource usage, energy consumption, waste generation, and recyclability at every stage, from product design to disposal. What sets it apart is its actionable nature, as it helps Merck identify opportunities for reducing environmental impact and guides product design improvements. By aligning with customer demands and regulatory expectations, the scorecard allows Merck to create more sustainable and eco-friendly products.

Compared to Merck, Thermo Fisher focuses on designing single-use systems that reduce material and energy usage. While this is effective, Thermo Fisher's approach does not include a comprehensive assessment framework like Merck's Scorecard. Instead, it targets specific product categories rather than providing an overarching tool for evaluating environmental performance. Similarly, Danaher incorporates sustainability into product design by reducing material use and optimizing packaging. However, Danaher also lacks a dedicated framework like the Scorecard to systematically evaluate and improve environmental impacts across a product's lifecycle.

While Merck's Sustainability Scorecard represents a structured and promising tool, declaring it significantly more innovative than Thermo Fisher's and Danaher's approaches is premature without concrete data. All three companies are making impactful contributions to environmental sustainability through distinct yet valuable strategies. A more balanced perspective would highlight their complementary strengths rather than focusing on one as superior. Moving forward, providing comparative data and showcasing measurable outcomes will be essential for substantiating claims of innovation and leadership in sustainability.

5. Conclusions

This study demonstrates the shared commitment of Thermo Fisher, Danaher, and Merck to advancing sustainability within the life sciences industry, particularly in the environmental aspect of ESG performance. Each company has implemented initiatives targeting renewable energy adoption, waste reduction, and sustainable product design. Thermo Fisher focuses on renewable electricity goals and zero-waste programs, Danaher employs its Decarbonization Playbook and robust recycling collaborations, while Merck works on its Sustainability Scorecard to assess product lifecycle impacts.

A key implication for these companies is the importance of measurable outcomes. Merck's Sustainability Scorecard is an example of how structured tools can guide improvements in product design and align

sustainability efforts with industry benchmarks. However, for it to be considered significantly more innovative, Merck must present concrete results, such as reductions in resource use, waste, or carbon emissions achieved through the Scorecard. Similarly, Thermo Fisher and Danaher could enhance their sustainability strategies by adopting more comprehensive assessment frameworks to better communicate their environmental impact and progress to stakeholders.

Collaboration with waste management and recycling partners presents a significant opportunity for all three companies to address the challenges of single-use plastic waste in biopharmaceutical production. Initiatives such as Thermo Fisher's recycling programs, Danaher's partnerships for processing hard-to-recycle plastics, and Merck's material repurposing efforts could be further expanded into industry-wide collaborations. By working together, these companies can establish standardized and scalable solutions to drive circular economy practices, thereby meeting growing regulatory and consumer demands for sustainability.

Renewable energy and emissions reduction remain critical areas for improvement. While all three companies have set ambitious renewable energy goals, they should also focus on reducing Scope 1, 2, and 3 emissions. Partnering with suppliers to decarbonize supply chains, investing in energy-efficient technologies, and expanding the use of renewable energy across global operations can help achieve these targets. By taking these steps, the companies can not only reduce their carbon footprint but also demonstrate leadership in the global transition toward cleaner energy systems.

Water management is another vital area for life sciences companies to address, given the high water usage in their operations. Danaher's water treatment expertise positions it to lead in this area, but Thermo Fisher and Merck could also strengthen their water conservation strategies by installing water-efficient systems, recycling process water, and treating wastewater. Improved water management practices would not only reduce environmental impact but also mitigate risks associated with water scarcity, particularly in regions with high demand for life science products.

In conclusion, companies are making notable progress toward sustainability, but they must continue to innovate and collaborate to amplify their impact. The adoption of measurable frameworks, such as Merck's Sustainability Scorecard, could enhance transparency and accountability, while shared efforts to tackle single-use waste, emissions, and water usage could set new standards for the industry. Ultimately, the success of these companies will depend on their ability to integrate sustainability into every aspect of their operations, foster cross-company collaboration, and inspire transformative change within the life sciences sector.

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