



RAIN[®]
ALLIANCE

Defining Sustainability for RAIN RFID Importance, Challenges, and Potential

**RAIN RFID Alliance
Whitepaper**

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1 Executive Summary

RAIN RFID technology successfully bridges the physical and digital worlds providing many business-process and financial benefits. Consequently, more RAIN labels are manufactured and consumed than before. This brings an inevitable increase in their environmental impact. Label manufacturers are creating more ecologically friendly labels. Industry players, investors, governments, and end consumers are finding the sustainability benefits from RAIN item-level tracking.

This paper defines sustainability relevant to RAIN and lays out the common frameworks leveraged by industry players to address sustainability within their organizations. It explores the reasons sustainability is important to consider now rather than later, how change management is a pivotal piece of the puzzle when integrating sustainable practices, and how sustainability needs to be considered within the broader ecosystem of an individual organization. Lastly, the positive potential and current challenges of RAIN from an environmental sustainability perspective are covered.

Sustainability as it currently relates to RAIN is relevant whether as a manufacturer, software provider, consultant, consumer, or any other entity leveraging RAIN in any capacity.

Key points are:

- Sustainable Development Goals (SDGs) are relevant for RAIN as illustrated in the World Economic Forum's study where they analyzed 640 IoT projects and mapped them against the 17 SDGs. 84% of the analyzed deployments already support or have the potential to support the SDGs (World Economic Forum 2018).
- Sustainability interest has grown steadily over the past several decades. Now it is a driving force of change as consumers, businesses, investors, and governments make sustainability a priority.
- To be a completely environmentally sustainable technology RAIN has some challenges, including: environmental impact of traditional RAIN tags, adoption challenges for ecologically-friendly RFID tags, and immature waste disposal regulations.
- RAIN helps retail with its largest sustainability concerns. It can increase supply chain transparency and traceability, reduce waste, improve fiber recycling, and provide end-of-life information to consumers.

2 Introduction

Current sustainability potential and challenges described in this document give RAIN stakeholders an understanding of sustainability in context. It shows why sustainability is significant for all involved in RAIN regardless of their primary role.

RAIN is an ultra-high frequency (UHF) RFID wireless technology that connects billions of items to the internet¹. RAIN enables everyday items to be connected to a network and communicate valuable data with a unique identifier, at low cost, long range, without batteries, with an unlimited life and no line-of-sight is required to read the tags.

RAIN has value to companies aiming for sustainability as it allows for tracking the identity, location and authenticity of each item thereby enabling transparency and traceability throughout supply chains.

The impact of environmental sustainability with RAIN is important as it is increasingly adopted worldwide. RAIN Alliance's Sustainability Workgroup strives to identify ways to amplify the positive impacts and mitigate the negative impacts of RAIN. This paper examines current environmental sustainability challenges, positive potential, and overall ecosystem.

Social and financial sustainability implications are certainly of importance when considering RAIN, but remain secondary to environmental sustainability in this paper.

3 Defining Sustainability and Common Frameworks

The definition of sustainability is:

Sustainability is the concept of meeting current needs without limiting the ability of future generations to meet their needs.

It is also important to consider sustainable development or the "process of change in which the exploitation of resources, the direction of investments,

¹ [What RAIN RFID Brings to the Internet of Things](#)

the orientation of technological development; and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations” (World Commission on Environment and Development 1987).

3.1 3Ps and 3Es

Sustainability can be viewed from three angles: environmental, social, and economic. This framework, often called the 3Ps for people, planet, and profit, is also known as the “Triple Bottom Line” and helps define sustainability in a holistic way, while also recognizing sustainability exists where these areas overlap.

Professionals sometimes refer to this as the 3Es of sustainability: ecology, economy, and equity. These three dimensions can also be seen as interdependent with the economy existing within society and society existing within the natural environment (The Association for the Advancement of Sustainability in Higher Education 2021).

Common topics include environmental impact such as natural resource utilization, social impact such as fair labor laws, and financial impact such as the longevity and consistency of profits.

3.2 SDGs Framework

Another common sustainability framework is the United Nation's 17 Sustainable Development Goals or SDGs. They originated after development “involving civil society, government, the private sector and academia, with the support of 193 countries” (World Economic Forum 2018). They were adopted by the United Nation's member states as part of the 2030 Agenda for Sustainable Development in 2015 (United Nations – Department of Economic and Social Affairs Sustainable Development n.d.).

The SDGs address the need for a new type of development “that works for all people” for each of the three metrics of the Triple Bottom Line or “sustainable development: economic growth, social inclusion and environmental protection” (World Economic Forum 2018).



Figure 3: United Nation's 17 Sustainable Development Goals²

SDGs are relevant for RAIN. The World Economic Forum analyzed 640 IoT projects and mapped them against the 17 SDGs. They found 84% of the analyzed deployments already support or have the potential to support SDGs (World Economic Forum 2018). Given their strong commercial relevance, the five significant SDGs for the 640 IoT projects evaluated were:

- SDG 3 – Good health and well-being
- SDG 7 – Affordable and clean energy
- SDG 9 – Industry, innovation, and infrastructure
- SDG 11 – Sustainable cities and communities
- SDG 12 – Responsible production and consumption

4 Why Sustainability Is Important Now

Sustainability's relevance with regards to RAIN will increase as RAIN's adoption grows due to the scale of the environmental impacts naturally reflecting this growth.

The entire RAIN market, estimated to be worth \$2.19 billion in 2019, is projected to grow to \$5.17 billion in 2024 including "tags and readers for RFID labels, cards, fobs and all other form factors". Retail is, by far, the

² [The 17 Goals](#)

industry leading the way with RFID adoption. In retail alone, approximately 13.5 billion RFID labels were needed to meet the needs of the market in 2019. RAIN RFID tags are predicted to increase from approximately 17.65 billion being sold in 2019 to 56 billion being sold in 2024 with a variety of industries making use of this technology to better track their assets including retail and aviation³.

4.1 RAIN RFID is the Bridge Between Physical and Digital Worlds

RAIN will continue to be adopted and RAIN tag sales will grow because it is a critical component of the broader Internet of Things (IoT). Its role in the IoT relates to its ability to act as a bridge between a network connection and physical items:

Virtually all IoT applications require a data connection between the physical and digital worlds, and RFID is the ideal technology to bridge these realms. In fact, as the IoT reaches critical mass, the majority of networked objects will be wirelessly connected via passive, low-cost RFID technology. While other wireless technologies require batteries or another power source, RFID technology makes it possible to network objects where local power is not feasible or even possible⁴.

4.2 Consumers and Investors Are Driving Change

Sustainability is a driving force of change for consumers, businesses, investors, and governments. "We are living in a consumer-driven economy, the increasing push and eco-awareness is connecting competitiveness to sustainability in industries such as the apparel industry" (Denuwara 2019). The Hartman Group's study on how the sustainability mindset has changed over time reveals how, in twelve years, sustainability went from an uncommon word used in the household in 2007 to being a "cultural value and defining concern for today's consumer" in 2019 (Hartman Group 2019).

³ [RAIN RFID Market Research Report](#)

⁴ [What RAIN RFID Brings to the Internet of Things](#)

While this trend was already increasing, COVID 19 and its impact on markets has pushed sustainability even more to the forefront. RAIN is being leveraged to help authenticate PPE and COVID test kits and is increasingly being seen as a technological solution to other humanitarian challenges such as sustainability (Kaplan 2020). In retail, approximately two thirds of consumers believe it is more important now that impacts on climate change be limited with 88% believing the industry needs to give more attention to reducing pollution (Granskog 2020).

Not only due to consumer demand, but also due to pressure from investors, companies are being driven to consider the impact of their operations. An increasing number of people understand how climate risk correlates to investment risk. There has been a "tectonic shift toward sustainability-focused companies...in the wake of the coronavirus pandemic" (Stevens 2021). Black Rock, the largest asset manager in the world, is now requiring companies disclose how "their business model will be compatible with a net-zero economy" (Stevens 2021). This is driving change across all sectors.

The investment community often uses the 3Es framework to measure sustainability when evaluating a company. There may be subtle differences and more emphasis around the "governance" component and more broadly leadership, but they include the following considerations:

- What are the public statements (Vision, Mission, Values) describing the company's reason for existence and actions it takes?
- How does leadership (CEO, CFO, Board of Directors,) commit resources to sustainability?
- Which goals and metrics track its progress?
- What is the quality and impact on its engagement with external stakeholders (Why, Who, What, How, and When to engage)?
- What is the information disclosed to stakeholders (disclosure, reporting, materiality, transparency) (Hedstrom, Sustainability -- A Guide for Boards and C-Suites 2017)?

5 Organizational Considerations When Pursuing Sustainability

Internal and external forces are driving organizations to pursue sustainability. As sustainability is a broad topic that covers many different aspects, companies often turn to consulting firms for help.

Companies want to avoid "greenwashing", a term describing the "practice of making unwarranted or overblown claims of sustainability or environmental

friendliness in an attempt to gain market share" (Dahl 2010). Greenwashing has been broadly recognized for over three decades, but it has become more important in recent years. This importance has led to a sharp increase in the number of products and services making sustainability claims, but many have a questionable basis.

The public is becoming suspicious of sustainability claims, so proof of any company sustainability claims matter. Companies can increase confidence in green claims by following standards established by International Organization for Standardization (ISO). For organizations attempting to manage their environmental impact, ISO has developed a suit of standards called the "ISO 14000 Family"⁵. Some key standards to consider for RAIN RFID are:

- ISO 14001 Environmental Management Standard
- ISO 14064-1 & 14064-2 Measurement and Reporting of GHG Emissions and Removals
- ISO 14064-3 Verification of GHG Statements
- ISO 14021 Carbon Neutrality

To avoid greenwashing and to make organizational changes that foster truly beneficial sustainability practices, industry players must consider best practices for change management as they apply to sustainability as well as the sustainability concerns of the ecosystem in which they operate.

5.1 Strategy and Culture

Equally important to an organization's *strategy* on sustainability is its *culture* in how it operates. This transition takes an intentional strategy and strong leadership support. Companies successful in implementing sustainability strategies have criteria for how they rate on the following questions:

- What is the executive committee's role regarding sustainability?
- How is sustainability factored into executive compensation?
- What is communicated to employees regarding sustainability?
- What is the structure and what are the roles in the organization as they pertain to the necessary changes?

⁵ [ISO 14000 FAMILY ENVIRONMENTAL MANAGEMENT](#)

- Is sustainability included in performance goals and job descriptions?
- Are sustainability-relevant impact measures put in place and can they be clearly measured?
- Are changes in supply chain expectations clearly communicated?
- Is the sustainability strategy clearly communicated to the wider network of stakeholders and is there a clear engagement strategy laid out (Hedstrom, Sustainability: What It Is and How to Measure It 2018)?

Sustainability starts at the top for it to be adopted throughout the organization and value chain. When there is a culture of sustainability, an organization can make their goals around this topic successful. Fostering such a culture requires management attention and accountability. This allows a company to get the desired sustainability-supporting behaviors and outcomes of the structure and people doing the work.

5.2 Industry Ecosystem

Defining and implementing sustainability requires understanding the needs of the ecosystem in which the member belongs. Sustainability may be perceived differently across the RAIN Alliance members, categories, and countries. One framework to consider could be the ISO 26000 standard: "*Guidance on social responsibility*", especially Article 4.5, "An organization should respect, consider and respond to the interests of its stakeholders" (International Organization for Standardization n.d.). A second model is the Organization of Economic Co-operation and Development (OECD) Guidelines⁶.

The model is less relevant than the commitment to identify and to engage their stakeholders to implement their sustainability program. What is material to one member in one part of the industry will likely be seen differently by another member in a different part of the value chain.

⁶ [*ISO 26000 and OECD Guidelines Practical overview of the linkages*](#)

Sustainability may need to be considered from a different angle depending on the needs, interests, and viewpoint of the specific stakeholder. Below are examples of potential stakeholders by group:

- **Customers** – resellers, distributors, end consumers, industry associations
- **Communities** – local and regional
- **Experts** – academia, researchers, legislators, non-governmental organizations, standards development organizations
- **Business partners** – suppliers, manufacturers, contractors, integrators
- **Institutions** - trade associations, certification and testing bodies
- **Financial** – shareholders, investors, analysts
- **Employees** – managers, consultants, contractors

Take the example of a fashion company. They will need to consider sustainability as it relates to many different players in their ecosystem including, but not limited to their customers, employees, suppliers, investors, and technology vendors. As a RAIN company supplying technology solutions to such a retailer, it is imperative to consider what sustainability matters are concerning to the retailer. What matters, or what is material, may be different throughout the ecosystem.

The entire ecosystem around that retailer needs to be considered. Sustainability does not exist in a vacuum. While humane working conditions for garment laborers in a supplier's factories may be of utmost importance to an end consumer, labor concerns may not be on the radar of investors in the retail company who are more focused on carbon emission mitigation strategies deployed by the company.

Depending on the industry, there may also be a list of sustainability-specific ecosystem players to consider. In fashion for example, such organizations as the Sustainable Apparel Coalition⁷, the Ellen MacArthur Foundation⁸, and United Nations Climate Change⁹ have considerable influence. They can

⁷ [*Sustainable Apparel Coalition*](#)

⁸ [*Ellen MacArthur Foundation*](#)

⁹ [*United Nations Climate Change*](#)

provide context around current movements already happening in the industry as well as opportunities for cross collaboration and overall improvement.

Understanding the full ecosystem in which an organization operates, involves having an effective sustainability strategy bringing about real positive impact, as well as effectively communicating that strategy to others. When a company knows how their sustainability strategy fits into the bigger picture, they can also identify where there is overlap with the strategies of their customers and communicate that. This targeted communication creates partnership and synergistic action around sustainability goals.

6 Current Challenges

Although RFID technology has existed for decades with the first U.S. patent for RFID tags being created in the 1970s, there have been many obstacles to its adoption and the industry is just now beginning to consider sustainability as it relates to RFID (Roberti 2005). The RFID industry has overcome such obstacles as proving business cases to justify adoption, unifying protocols and standards, changing business processes and overcoming hardware necessities such as inventing an RFID reader which can read all types of tags across varying frequencies (Sarma 2012).

The RAIN industry is progressing on sustainability metrics as well. The following excerpt describes how it is generally agreed that RFID is more beneficial than harmful to the environment:

"According to the waste hierarchy principle, priority should be given to the prevention in the production of waste itself. The first and most important action to block the issue of waste is not to produce waste. However, it was largely demonstrated how RFID technology enables great advantages and enhancements for the environment and the production. Thus, not producing such devices could generate more disadvantages than benefits. Therefore, from the prevention point of view, it is necessary to operate at the design stage in order to obtain an eco-sustainable product where parts and materials can be easily disassembled" (Condemi, Cucchiella and Schettini 2019).

RAIN RFID must be designed and engineered to limit its environmental impact. While much progress has already been made, several challenges remain to become a completely environmentally sustainable technology. These include environmental impact of traditional RAIN tags, challenges of

adoption for ecologically-friendly RAIN tags, and immature waste disposal regulations.

6.1 Environmental Impact of Traditional RFID Labels

A traditional RFID label can have up to six different layers comprising the label. These layers are made primarily of aluminum, adhesives, PET and paper substrates. These various components vary in their environmental impact including carbon footprint. The footprint of the paper substrates, aluminum and PET vary label to label, but all need to be considered from an environmental standpoint.

Traditional RFID labels can have a negative environmental impact because they are difficult to recycle. This is due the labels being nearly impossible to break down into their individual components. It is easy for metals and extraneous materials to be introduced into the recycling stream. Because of the inherent difficulty in separating components from each other, RFID labels cannot typically be recycled and thus end up going to landfill where biodegradability then becomes an important factor.

The true environmental impact of RFID labels is shown with a life cycle assessment (LCA) illustrating the environmental impact caused at each stage of a product or service's lifecycle. An LCA can be applied to RFID labels to better understand the full scope of their environmental impact.

6.2 Adoption Barriers of Ecologically-Friendly RFID Labels

Various companies have addressed the environmental sustainability concerns associated with traditional RFID labels and multiple variants of ecologically-friendly RFID tags are available on the market. They are made from environmentally friendly materials that make them fully recyclable and biodegradable. Some varieties are also manufactured in facilities that are energy-efficient, therefore lowering the overall carbon footprint of the label. LCAs done for certain eco-friendly RFID tags show up to a 40% decrease in carbon footprint (Barrett 2020).

These types of labels typically do not include a PET substrate or adhesives containing toxic chemicals which impact their biodegradability. Manufacturing technology improvements allow printed instead of etched aluminium antennas. For some labels, the excess aluminium used during manufacturing can now be fully recycled and the paper re-pulped.

Current barriers to adoption include cost, performance, and awareness in the market. Even though the price point of ecologically friendly labels is now on par with traditional labels making them cost-neutral, especially when ordered in bulk, there is the impression in the market they are still significantly more expensive. Despite these various concerns, retailers focused on meeting their sustainability goals are now beginning to take interest in these more ecologically friendly RAIN varieties both for pilots and full deployments.

Additional research is being done on transfer and ink-jet printers as well as nano technologies to produce smaller, lower cost, and more environmentally-friendly RAIN tags, and looking at how RAIN tags can be made using only biodegradable material. Inks are still expensive and performance can be poor when these applications are moved from the lab into production. Further, there are many researchers investigating the use of graphene and similar materials as a metal-free alternative to the use of aluminium in RAIN antennas (Akbari, et al. 2015) (Leng, et al. 2016) (Huang, et al. 2014) (Large, et al. 2020).

6.3 Waste Disposal Regulations

The following excerpt reflects waste regulations as they currently apply to RFID:

Nowadays, the RFID technology represents a valuable solution for many applications to improve the quality and efficiency of the supply chain, as well as for enhanced people or object identification and smart devices. This leads to massive usage of such devices that could represent a threat to the environment, since they are often considered as generic waste and no specific e-waste policy has been identified for RFID (Condemi, Cucchiella and Schettini 2019).

While it is true that there are very limited regulations relating specifically to RFID and this does carry an environmental concern as well as opportunity for improvement, RFID is generally seen as providing far more environmental benefits significantly outweighing the negative environmental impact of the tags themselves regardless of how they are disposed.

7 Positive Potential

While sustainability is important, initiatives that are profitable in addition to being sustainable are more likely to be adopted and integrated at a faster pace. Luckily, RFID adoption in retail for example, can be financially profitable for a business while also being environmentally and socially sustainable. Having a business case for sustainability makes it more feasible. Several examples of such use cases of RAIN, which have both business and sustainability benefits will be explored below.

The potential for RAIN to bring environmental benefits has been most studied in the retail industry due to the high adoption rates of RAIN within this industry. The fashion industry is the "second largest polluter in the world and accountable for 10% of the world's carbon emissions". Consequently, sustainability challenges for retail, and creative ways of solving them are important (Denuwara 2019).

RAIN has promising potential to increase supply chain transparency and traceability, reduce waste, improve fiber recycling, and provide end-of-life information to end consumers.

7.1 Supply chain transparency and traceability

RAIN offers increased supply chain transparency and traceability. Transparency is the ability to access high level information about an item throughout the supply chain, whereas traceability is the ability to access granular, item-level information about a particular item throughout the supply chain. While the two aspects vary, they both enable a greater amount of information on a particular item to be known either to the business or the end consumer or both. Often sought-after information includes where the product was made, by whom it was made, and how it was transported.

59% of sourcing executives from apparel companies expect an increase in level of information on supplier at the points of sale in the retail industry and 65% expect to achieve full traceability from fiber to store by 2025 (Berg and et al 2019). RAIN is seen as a key enabler of these transparency and traceability goals. 13% of retailers already use RAIN for traceability and 58% expect to adopt RAIN to achieve traceability in the next 5 years (Berg and et al 2019).

7.2 Waste reduction

Waste reduction is a key sustainability benefit of RAIN. By allowing for much more accurate and transparent inventory management, RAIN can facilitate more efficient supply chains. The food supply chain in particular is where waste reduction is sought. Some RAIN tags contain sensors which are capable of measuring temperature and humidity. This type of information, when acted upon, helps to ensure quality of perishable food is maintained thereby preventing that food from becoming waste (Nikolicic, et al. 2021).

RAIN can also improve retail inventory accuracy allowing retailers to reduce their safety stock and lower overall stock holding (Denuwara 2019). This in turn means less garments ending up wasted, as well as less emissions caused during production and the transportation of product (Denuwara 2019). Research reveals an indirect negative relationship between RAIN and waste as reducing a retailer's safety stock prevents waste from occurring and entering the retail supply chain (Denuwara 2019).

7.3 Other

Environmental benefits of RAIN technology include improving "efficiency, accuracy, and safety of fiber recycling" by bringing awareness to where an individual item came from and what particular material it is made of (Denuwara 2019). RAIN can also help consumers understand how and where a garment can be recycled at the end of its life cycle by carrying information such as how to care for it to make the product last longer and pointing the consumer towards the closest donation location. Additionally, RAIN can help retail become more sustainable by digitalizing resell platforms.

8 Conclusion

RAIN RFID is on the precipice of becoming an enabler of increased environmental friendliness. RAIN is uniquely situated to become one of the primary technologies that increases sustainability across sectors and industries. With major steps being taken to improve the environmental friendliness of the labels themselves, the future may see outstanding challenges such as eco-friendly label adoption and waste disposal regulation concerns triumphed over as well as positive potential use cases of RAIN met and widely applied. RAIN RFID industry players and consumers can realize this technology's true potential to make our world not only more efficient, but also more sustainable.

9 Resources

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10 Background and Contributors

This white paper was created by the RAIN Alliance Sustainability Workgroup. The main contributors were:

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ABOUT RAIN RFID ALLIANCE

The RAIN RFID Alliance is an organization supporting the universal adoption of RAIN UHF RFID technology. A wireless technology that connects billions of everyday items to the internet, enabling businesses and consumers to identify, locate, authenticate, and engage each item. The technology is based on the EPC Gen2 UHF RFID specification, incorporated into the ISO/IEC 18000-63 standard.

Join the RAIN RFID Alliance to enable connectivity for your business and consumers: identify, locate, authenticate, and engage items in our everyday world. For more information, visit www.RAINRFID.org.



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Visit the RAIN RFID website – RAINRFID.org.

If you are interested in learning more about the RAIN RFID Alliance, contact us at info@rainrfid.org.