Sustainable Receipts

Gaia's Path to a Reduced Carbon Footprint

Gaia: A Solution for the Future

This document reveals why **Gaia** is not just an alternative but the definitive answer to the challenges of the present and the future. Gaia doesn't just solve problems; it redefines how we perceive sustainability, privacy, and technology in a world crying out for radical solutions.

From the beginning, Gaia was born with **a mission: to change everything**. We set out to tackle the significant issues of current receipts, from the devastating environmental impact of paper to the security and privacy gaps that conventional digital options cannot address.

Protect your data, your privacy, and your time while drastically reducing environmental impact. It's the perfect symbiosis between technology and purpose, designed to simplify your life and enable effortless care for the planet.

Innovation can and must serve the common good, each receipt counts, and every individual choice has the power to transform our collective destiny.

Gaia is the future. It is the key to unlocking a cleaner, safer, and more conscious world. It's not just a promise; it's how we will build a tomorrow worth living together.

1. Environmental Impact of Thermal Paper: A Comprehensive Vision

1.1 Paper Consumption and Deforestation

The use of thermal paper poses a significant challenge to the environment. Available data on its consumption is often inconsistent, with multiple sources citing each other without a solid foundation, leading to confusion. In response, the Gaia team conducted an exhaustive investigation to consolidate reliable figures, referencing recent data from the French Ministry of Finance (1) and the ANF certification authority (2). For example, in France**, 30 billion receipts are issued annually**, of which **12 billion are cash register receipts**. These generate approximately **150,000 tons of paper waste**.

Based on the range provided by ANF, which estimates that each ton of paper requires the felling of 28 to 49 trees, it is calculated that around **5.8 million trees are cut down annually in France** to produce cash register receipts alone. This figure doubles when considering all types of receipts.

1.2 Resources Consumed in Paper Production

The impact of thermal paper extends beyond deforestation. Its production consumes significant amounts of other essential resources:

- **CO_2 Emissions**

  Approximately **951 kg of greenhouse gases are emitted** for every metric ton of paper produced (3). Globally, the total emissions of the paper and pulp (P&P) industry surpass those of countries like Denmark, Finland, Norway, and Sweden combined. This sector also generates significant indirect emissions: 12.3 million tons of CO_2 from purchased electricity and 5 million tons from transportation.

- **Water**

  The paper industry uses between **10 and 300 m^3 of water per ton produced**. With global production reaching 400 million tons annually, this equates to a consumption of between 4,000 and 120,000 million m^3 of water (4). Additionally, up to 97% of this water ends up as waste, creating further issues for aquatic ecosystems.

- **Chemical Products**

  Paper production involves intensive chemical processes, especially during bleaching, which generates pollutants harmful to health and the environment. In the case of thermal paper, substances like **bisphenol A** (BPA), a known carcinogen and endocrine disruptor, and **bisphenol S** (BPS), whose impact on human health is not yet fully understood, are used.

1.2 Advances and Regulations

In an effort to mitigate these impacts, countries like France have implemented significant measures, such as the **AGEC Law** (5), which aims to limit the mass use of paper receipts. Eliminating the automatic printing of receipts not only helps reduce deforestation and resource consumption but also prevents exposure to BPA and BPS, benefiting both workers and the environment.

This comprehensive approach highlights the urgent need to advance toward more sustainable practices in paper consumption by adopting digital alternatives and promoting reuse and recycling.

2. The Environmental Impact of Email: Beyond the Obvious

2.1 Is Email a Sustainable Alternative? ... And Secure?

Email is often perceived as an eco-friendlier option compared to paper receipts. However, its sustainability depends on appropriate usage, which involves sending concise messages without unnecessary images or bulky attachments. Even so, this perception is often mistaken.

Inbox overload is a significant issue, with a considerable proportion of messages being unwanted emails. According to recent statistics, **46% of emails are spam** (6), equivalent to more than 10,000 messages annually per account. Additionally, nearly 1% are phishing attempts, meaning at least one digital scam attempt occurs daily. This volume of unwanted emails hampers quick access to important messages, resulting in lost time and increasing the likelihood of essential emails, such as digital receipts, ending up in the spam folder due to imperfect filters. Providing email addresses to more entities can exacerbate these issues, increasing spam and complicating inbox management.

2.2 The Carbon Footprint of Email

Greenhouse gas emissions associated with emails represent a significant global impact. These emissions are estimated to range between **20 and 216 million tons of CO_2 annually**, approximately 0.3% of the global carbon footprint. This calculation accounts for all stages of an email's lifecycle, from creation, sending, and receipt to reading (or even ignoring) the message. Appendix A provides a summary of the calculations made to estimate email's carbon footprint.

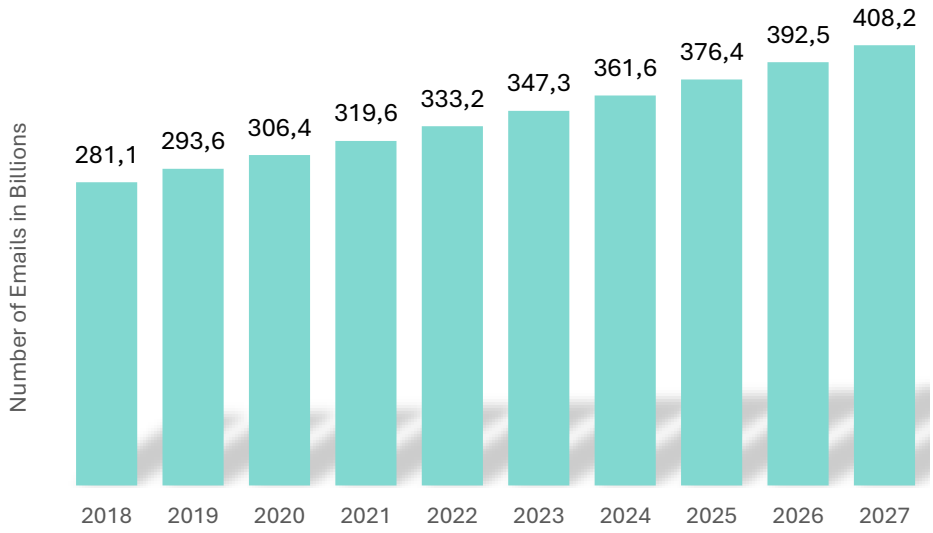

Figure 1: Number of Emails Sent and Received Daily Worldwide, 2018–2027.

A potential strategy to reduce this footprint would involve eliminating spam and unnecessary emails (7). However, the volume of malicious emails has grown exponentially in recent years, making progress in this area challenging. For instance, phishing websites saw a 1,200% increase between 2020 and 2023 (8), a phenomenon that intensifies fraudulent email usage. This is also reflected in the fact that, **in 2023, email-related cyber claims increased by nearly 25%, with financial fraud accounting for 61% of these claims** (9). These statistics illustrate not only the functional and security impacts of email but also the role of malicious practices in this context.

To address these issues, it is crucial to **adopt new tools and technologies** that help mitigate the impact, focusing on reducing irrelevant and unnecessary emails. At the same time, these new alternatives to email should provide a more convenient and efficient experience for users opting for digital receipts as a sustainable alternative to paper.

2.3 The Impact of Database Storage

An often-underestimated aspect is the impact of storing emails on servers. Each saved email consumes resources cumulatively, and it is estimated that **storing an email for one year generates up to 10 g of CO_2** (10). Considering the number of messages stored globally, this contribution becomes significant.

2.4 Security and Privacy

Another critical aspect to consider is the security and privacy associated with digital receipts. It is common for establishments to request **personal data to enroll customers in loyalty programs**, promising exclusive promotions and discounts. However, this practice carries **associated risks**, as users often accept terms and conditions written in fine print that unknowingly authorize the indiscriminate sending of spam messages.

Moreover, **inadequate implementation of security policies** by many companies, particularly small and medium-sized ones, increases the vulnerability of personal data. This not only results in a constant flow of unwanted emails but also exposes users to scam attempts from third parties who have illicitly obtained access to their personal information.

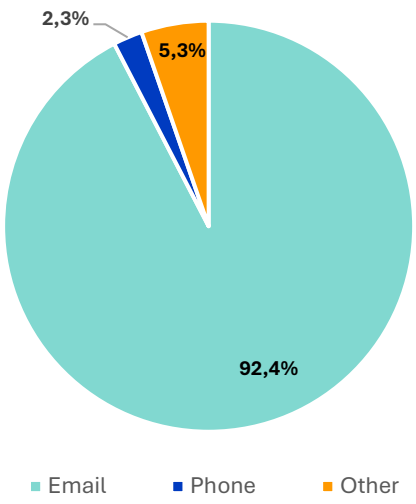

Figure 2: % of Financial Fraud Incidents by Communication Channel

In this context, it is imperative for companies to adopt clear and strict data protection policies to ensure user trust and minimize the risks associated with using email as a commercial communication tool.

2.5 Concluding Thoughts

Although email represents an alternative to paper, **it is not exempt from a significant environmental impact**. The transition to digital solutions must be carefully managed to ensure that the benefits outweigh the drawbacks and that new issues do not arise from its widespread implementation.

Recent legislation in France, which promotes digital receipts as a replacement for traditional paper ones, marks a crucial step toward sustainability. However, implementing this measure without providing adequate tools for management and considering its global impact could lead to **counterproductive results**. Poor planning might result in inbox saturation, increasing user frustration and compromising the functionality of the system, contrary to the initial goals of convenience and efficiency.

If other countries adopt similar regulations, it will be essential to accompany them with technological solutions that enable efficient email management. This includes systems for filtering, classifying, and storing digital receipts to prevent them from becoming an additional burden for users and unnecessarily increasing emissions associated with email.

In conclusion, the adoption of laws promoting sustainability must be accompanied by a comprehensive approach that considers not only environmental impact but also consumer experience. **Only in this way can these initiatives effectively achieve their goals and truly contribute to a more sustainable future**.

3. Gaia: A Sustainable, Secure, and Private Solution

In a world where technology and sustainability play a significant role, **Gaia** emerges as an innovative solution for managing digital receipts. Our mission is not only to reduce environmental impact but also to address growing concerns about **privacy and security** in personal data management. With Gaia, users can bid farewell to spam, scams, and the need to share sensitive information, ensuring a reliable and secure experience.

3.1 Sustainable Infrastructure Based on Blockchain

Gaia is supported by the Algorand blockchain network, globally recognized for its energy efficiency and **commitment to carbon neutrality**. This technology excels in minimizing its environmental footprint while efficiently processing transactions.

On Algorand, operational nodes consume approximately 65 W each, enabling the processing of over 9,000 transactions per second. This consumption is not only minimal but also crucial for ensuring the speed, security, and accessibility of operations. Across the network, **the energy consumption per managed receipt is reduced to 0.00087 gCO_2**, setting a standard that highlights the potential for technological innovation without compromising the environment.

This infrastructure redefines sustainability standards in digital solutions, combining technical efficiency with environmental responsibility. All supporting data and calculations for this estimate, as well as emissions associated with this solution, are detailed extensively in Appendix B.

3.2 Comparative Sustainability

Gaia's solution not only outperforms paper in terms of sustainability but also stands out against email in terms of energy efficiency. **Gaia is between 36 and 400 times more sustainable**, demonstrating that the energy expenditure associated with this platform is significantly lower and justified by the additional benefits it offers. This efficient approach is combined with the inherent advantages of blockchain technology, such as **security, privacy, and the guarantee that digital receipts will never be lost.**

In Gaia, energy consumption is not only reduced but also translates into a solution that does not compromise data protection or system reliability—key elements that will be addressed in the next section. For a more detailed comparison, see Appendix C.

3.3 Security and Privacy

The security of personal data is a critical challenge in today's digital landscape. **In recent years, there has been a significant increase in data breaches and security leaks, with consequences primarily affecting end users**. These vulnerabilities have led to scam attempts via email, text messages, and even phone calls, exposing people to increasing risks.

To address this, it is essential to implement solutions that reduce users' exposure to such activities. **At Gaia, we propose an address-based system that eliminates the need to share personal information with establishments**. This significantly improves user privacy while also reducing the risk of unauthorized access to their data.

Email is used exclusively to facilitate access to the user account and plays no other role within the system. Instead, the Gaia application offers advanced features such as personalized discounts and detailed commercial activity analysis, all within a completely secure environment. Data is encrypted end-to-end, ensuring that only the user, from their device, can access it. **Not even Gaia could view this information, reinforcing our commitment to privacy and security**.

Gaia positions itself as the definitive platform to protect users from illicit activities, provide a more convenient experience, and actively contribute to a more sustainable future.

3.4 Gaia's Commitment

Gaia combines advanced technology, sustainability, and a user-centered focus on privacy. By choosing Gaia, you not only adopt a tool that protects your personal data and enhances your daily experience but also actively contributes to environmental preservation.

Gaia is not simply a solution for today's challenges; it is a platform that looks to the future, demonstrating that technological progress can align with environmental responsibility. With Gaia, we move toward a safer, **more sustainable, and technologically balanced future.**

Appendix

A. Calculations of Email Emissions

To estimate the emissions associated with email usage, key data points must be considered, such as the total number of email users ($n_{\,total\ acc}$) and the number of emails sent and received daily ($n_{\,emails/day}$). These data points were extracted from a reliable statistical source (9).

$$n_{\,total\ acc} = 4.481E^9$$

$$n_{\,emails/day} = 361.6E^9$$

From these values, we calculate the average number of emails received per account daily ($n_{\,emails\ acc/day}$) and its annual equivalent ($n_{\,emails\ acc/year}$).

$$n_{\,emails\ acc/day} = \frac{n_{\,emails/day}}{n_{\,total\ acc}} = \frac{361.6E^9}{4.481E^9} = 80.696 \approx 81$$

$$n_{\,emails\ acc/year} = n_{\,emails\ acc/day} * 365 = 81 * 365 = 29{,}565$$

Given that a significant percentage of these emails are spam ($Spam$), the total annual emails can be divided into two categories: spam emails ($n_{\,spam\ acc/year}$) and other emails ($n_{\,rest\ acc/year}$).

$$Spam\ [\%] = 46\%$$

$$n_{\,spam\ acc/year} = n_{\,emails\ acc/year} * Spam = 29{,}565 * 0.46 = 13{,}600$$

$$n_{\,rest\ acc/year} = n_{\,emails\ acc/year} * (1 - Spam) = 29{,}565 * (1 - 0.46) = 15{,}964$$

This implies that, on average, each account receives 29,565 emails annually, including:

- 13,600 spam emails.
- 15,965 other emails.

For spam email emissions ($Email_{spam}$) the average of the figures provided by Mike Berners-Lee in his book How Bad Are Bananas? (12) is used, where the estimated emissions are 0.03 and 0.05 gCO_2.

$$Email_{spam}\ [gCO_2] = \frac{0.03 + 0.05}{2} = 0.04\ gCO_2$$

For the emissions of other emails ($Email_{rest}$) two scenarios are considered based on the type of email:

1. Scenario 1:

   Short emails, either read or sent from a mobile device or a PC, with emissions of 0.2 and 0.3 gCO_2 respectively. The average of these emissions is:

   $$0.25\ gCO_2$$

2. Scenario 2:

   Longer emails requiring approximately 3 minutes to write and 1 minute to read, with estimated emissions of:

   $$3\ gCO_2$$

The variables $footprint_{spam/day}$ and $footprint_{rest/day}$ represent the daily emissions associated with spam and other received emails, respectively.

$$footprint_{spam/day}\ [gCO_2] = n_{emails/day} * Spam * Email_{spam}$$

$$footprint_{rest/day}\ [gCO_2] = n_{emails/day} * (1 - Spam) * Email_{rest}$$

Using these values, the total annual carbon footprint of emails ($footprint_{yearly}$). can be calculated. These emissions are expressed in tons of CO_2, considering both spam and other emails:

$$footprint_{yearly}\ [t\ CO_2] = \frac{(footprint_{spam/day} + footprint_{rest/day}) * 365}{1000000}$$

To compare the consumption of an email with a transaction in Gaia's infrastructure, the average carbon footprint of an email ($Email_{average}$) is calculated:

$$emailFootprint_{average}\ [gCO_2] = (Spam * Email_{spam} + (1 - Spam) * Email_{rest})$$

This calculation accounts for emissions from all devices involved in sending and receiving emails. However, to focus solely on infrastructure, the emissions related to networks and data centers ($Email_{infra}$), are calculated using data from Mike Berners-Lee, who estimates that 14% of total email emissions come from these elements.

Thus, the emissions associated exclusively with networks and data centers are:

$$Email_{infra}\ [gCO_2] = Email_{average} * 0.14$$

$footprint_{rest}$	$footprint_{yearly}\ [t\ CO_2]$	$footprint_{average}\ [gCO_2]$	$Email_{infra}\ [gCO_2]$
Scenario 1: 0.25 gCO_2	20,246,346	0.1534	0.021
Scenario 2: 3 gCO_2	216,242,586	1.6384	0.229

Table 1: Comparison of the Total Carbon Footprint of Email in Two Possible Scenarios

B. Gaia Emissions Calculations

To estimate the energy consumption of a Gaia receipt, equivalent to a transaction on the Algorand network, it is necessary to calculate the energy consumption of a single transaction on the Algorand network, considering all factors involved in the process.

When a transaction is issued on a network, it must be validated by all nodes composing it. However, estimating the power consumption of an average node is complex, as no empirical data detail the specific hardware used or the operators' preferences. Node operators consider several factors when selecting hardware, with energy efficiency being one of the most relevant to minimize operating costs.

In this context, a binomial distribution was used to model hardware selection, following the approach proposed by the CCRI (13). Based on these distributions, the weighted energy demand of an average node is calculated as the most accurate estimate for a specific network. For the Algorand network, this distribution yields an estimated electricity consumption of:

$$P_{node}\,[W] = 43.51\,W$$

The total network consumption is calculated by multiplying the consumption per node (P_{node}) by the total number of active nodes in the network (n_{nodes}), obtained as an average from the second-quarter 2024 report (14):

$$n_{nodes} = 1508$$
$$n_{tx}\,[TPS] = 9384\,TPS$$

To determine the electricity consumption associated with a single transaction ($electricityConsumption_{tx}$), the total consumption is divided by the number of transactions processed by the blockchain (n_{tx}):

$$electricityConsumption_{tx}\,[W] = \frac{P_{node} * n_{nodes}}{n_{tx} * 3600} = \frac{43.51 * 1508}{9384 * 3600} = 0.0019\,W$$

With the electricity consumption calculated, the carbon footprint of a Gaia receipt ($footprint_{gaia}$) is derived using the European carbon intensity factor ($carbonIntensity$), which is 300 grams per KWh or 0.3 g per Wh.

$$carbonIntensity\ [gCO_2] = 0.3\ gCO_2$$

$$footprint_{gaia}\ [gCO_2] = electricityConsumption_{tx} * carbonIntensity$$

$$\boldsymbol{footprint_{gaia} = 0.0019 * 0.3 = 0.00057\ gCO_2}$$

C. Final Comparison: Email vs. Gaia

To evaluate and compare the emissions of both solutions, the following values are presented:

System	$footprint\ [gCO_2]$	Difference Factor (Email/Gaia)
Email	$0.021 - 0.229$	$36 - 400$
Gaia	0.00057	1

Table 2: Comparison of the Carbon Footprint of Email vs. Gaia

According to these data, Gaia's proposed solution is at least 36 times more sustainable than sending traditional receipts via email and can be up to 400 times more efficient in terms of carbon emissions.

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