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How is Environmental Sustainability a Key to Innovation?

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Abstract

The private sector plays an important role in the global climate goals and the 1.5°C target set during the Paris Agreement. Through investment in green projects and technology and energy efficiency initiatives, their carbon management strategy is paramount to achieve sustainability and good business practices. It is crucial to understand the proposals that the industry has established to reduce its environmental impact by applying supply chain optimization and technological advances or by participating in the carbon market. By identifying key aspects related to climate action within an organization's sustainability reports and linking them to climate change and carbon management literature from global entities and peer review assessments, the present research evaluates how the IT sector is acting towards increasing emissions. More specifically, this case study analyzes Hewlett Packard´s climate action performance, emissions estimates, and reduction methods, as one of the most sustainable technology companies in the world. During 2020, Hewlett Packard claims to have emitted 44,891,000 tons of carbon dioxide equivalent (tCO_2e) which represented an emissions reduction compared to 2019, considering their increasing renewable energy consumption, waste management applications, product optimization, and energy efficiency projects. However, by comparing with what other leaders in the IT sector are doing, improving environmental indicator monitoring and determination, increasing renewable energy and

green projects implementation, developing a resilient life-cycle assessment program, and effectively engaging supplier stakeholders, are urgent tasks to achieve better emissions monitoring and abatement. Thus, by engaging with these set of objectives the company and the IT sector, will be able to effectively cope with climate change and establish mitigation and adaptation strategies that will support global environmental targets.

Keywords
Climate strategies; carbon emissions accounting; carbon disclosure; corporate sustainability; climate resilience; climate finance; climate risk; sustainable investment; supply chain management; IT sector

1. Introduction

The Paris agreement represents an important opportunity for the national governments and corporations, to build and support a resilient society. Every nation needs to get involved within initiatives that mitigate the effects of climate change and reduce the emissions of greenhouse gases (GHG). Therefore, the private sector and the industry play an important role in the national economy and the formulation of indicators and their reporting. Ambition, innovation, and sustainability need to be coordinated within both the public and the private sector, to comply with international environmental agreements and national emissions reduction targets.

In this acknowledgment, carbon management is a clear contribution to the governments' objectives of reducing GHG emissions, mitigating the impacts of climate change, and complying with the specific national contribution (Nationally Determined Contribution-NDC) that was established before international agreements [1]. Furthermore, engaging in these contributions will reflect in the improvement of air quality, water quality, health care systems, reduction of environmental disasters caused by climate change, biodiversity protection, ecosystems conservation, agricultural systems, fisheries, ecotourism, and many other positive outcomes for the economy, society, and the environment [2].

On the other hand, the industry and the private sector could also benefit from their commitment due to their enhancement in carbon management and environmental protection. Initially, the finance and net flow of the organization could have a positive impact because of the savings in operating costs as the company would be shortening its energy consumption and therefore, reducing its carbon footprint and electricity bill. Plus, through the implementation of a carbon strategy (emissions reduction estimations of the organization and/or their products and services) the organization would be able to trade remaining carbon offsets coming from its compensation initiatives [3]. Additionally, through these interventions, the company would be meeting customer demands and improving the organization's image, which in turn supports their revenues. Likewise, investors, as they are concerned about their carbon footprint, would be more satisfied and motivated to continue investing in that specific company [4]. And finally, this would give the possibility to comply with local and national regulations or with sustainable standards such as the Global Report Initiative (GRI), the ESG Reports, and the Task Force on Climate-related Financial Disclosures (TCFD), or the Carbon Disclosure Project (CDP) [5]. Through these schemes, the

organizations may establish a monitoring and reporting process of key indicators, which could support the planning of adaptation/resilience actions and the assessment and disclosure of climate risks.

In this case study, Hewlett Packard (HP) is the objective enterprise. This organization has engaged its supply chain, products and solutions, and operations, with the most aggressive and comprehensive climate action indicators and goals of the technology industry [6]. Their effective use of renewable electricity in their global operations, their performance in the monitoring indicators and targets of carbon dioxide equivalent (CO_2e) emissions, and their reduction in GHG emissions intensity from their products and transportation derived in a 4% reduction of their carbon footprint compared to that registered in 2019 [7]. It is not a surprise that "in 2020, HP was named to the CDP Climate "A" list for the 7th time and is the only company to receive a quadruple "A" score for climate, forest, water, and supplier engagement leader" [6] (p.19), which is a result of their efficiency and commitment with climate change mitigation. As a matter of fact, HP supports many third-party eco-label certification standards that recognize environmentally preferable products such as ENERGY STAR [8], which highlights the company´s efforts for more energy-efficient products available in the market.

Their report focuses on the continual improvement actions and investments in renewable energy and energy efficiency, to accomplish three main objectives approved by Science-based Targets (SBTi): Achieve net-zero GHG emissions across their value chain by 2040, beginning with their Supplies business achieving carbon neutrality by 2030; reduce HP value chain GHG emissions 50% by 2030; and reach carbon neutrality in their operations by 2025 [6]. These include the reuse and recovering of all products to advance in their 75% 2030-goal of circular economy strategy, and the creation of the HP Sustainable Forest Collaborative to support the protection and restoration of global forests. To this 2020 report and to meet investors' and other stakeholders' interests, the company included the TCFD Index which contains key disclosures and information related to Governance, Strategy, Risk management, and Metrics and targets linked to the CDP submissions [9].

The aim of this case study is to analyze HP's climate strategy and carbon management, so the company and other organizations within the sector and perhaps other industries, would correctly assess the appropriate optimization procedures in key production areas such as products/services, operations, and supply chain. The result of this report and consequent industry assessment should be the evaluation and inclusion of sustainable technology and emissions reduction plans, that generate impact through green investment and effective climate action. In addition, a specific company could be able to support its sustainability action through this research, to improve their environmental response towards national and international commitments and legislations.

This evaluation provides an initial overview of the firm, after which a series of targets set by the company's climate action evaluation is detailed. Furthermore, data related to the company´s emission estimates and to how the organization has reduced them is presented, followed by a performance appraisal of their carbon management. Finally, relevant conclusions are discussed and complemented with limitations to this analysis and possible recommendations to the company´s carbon management performance.

2. Materials and Methods

HP is a multinational information technology American company that provides hardware and software goods and services (PCs, printers, and related items and supplies) to businesses, governments, and people. This assessment focuses on the revision of the annual reports related to human resources and sustainability actions, provided online by the organization. Such analysis will highlight HP's climate change mitigation activities and the aspects that the enterprise could fortify to better cope with climate risks.

Currently, around 55 thousand employees work at HP Inc. and most of its revenue comes from selling desktop and notebook computers, followed by printers and printer supplies [10]. It is important to clarify that in 2015, as the PC market changed from hardware assembly to more software and cloud services [10], the Hewlett Packard Company grew and broaden its products and services creating the HP Enterprise Company (HPE). The other area of the company focused on computers and printers was renamed HP Inc., and 270,000 employees were relocated to either one of those two companies [10]. Moreover, for 2020 HP's annual revenue was US $56.6 Billion [11] which represents the total revenue from the company dedicated to enterprise products and services (HPE), and the one specialized in personal computers and printers (HP Inc.).

This growing market and diversification involved HP in an equivalent of 44,891,000 tCO_2e during 2020 [6]. Thus, the company has committed to reducing in half their GHG emissions during the upcoming decade and plans to reach net-zero emissions by 2040, through the implementation of more renewable energy in its processes while being more energy-efficient. Additionally, the company has adhered the initiative to reduce waste and protect forests through renewable materials, the inclusion of recycled and reused sources, responsible forest management, and the investment in forest restoration to reduce deforestation caused by other organizations [6].

3. Results

Through their climate action strategy, HP has committed to become net zero carbon by offering a sustainable portfolio of products and services. As per Table 1, they claim to have the most comprehensive strategy and set of pledges in the industry where they have included forests preservation, circularity, and carbon emissions. They have been working towards reducing their carbon footprint across their value chain by implementing ambitious science-based emissions reduction goals, investing in renewable electricity, reinforcing supply chain collaborations, and scaling in energy efficiency solutions [6].

Table 1 HP Targets[1]. Adapted from: "2020 Sustainable Impact Report", by Hewlett Packard. 2021.

Approach	Pledges/Targets	Reasons	Category
Plastic Use	By 2025, use 30% recycled plastic material across personal systems and print products.	Focus on recycled plastic given issues related to plastic waste and pollution.	Products and Solutions

[1] Targets were extracted from Sustainable Impact Report 2020.

Plastic Use	By 2025, eliminate 75% single-use plastic packaging compared to 2018.	Generate sustainable packaging that "enhances customer experience and drives progress towards circular and net zero carbon economy" [6] (p.92).	
GHG Emissions	By 2025, reduce product use GHG emission intensity by 30% compared to 2015.	This process corresponds to the 35% of the overall carbon footprint. Focus on reducing and offsetting emissions.	
Recycling	Since 2016, recycle 1.2 million tons of hardware and supplies by 2025.	Generate a circular flow that reduces waste and gives materials and products another life.	
Zero Deforestation	By the end of 2020, reach zero deforestation linked to paper and paper-based products.	Improve the sourcing of virgin fiber (recycled sources) and increase the ratio of certified material in products and packaging.	Supply Chain
Supply Chain	By 2025, reduce in 10% the first-tier production supplier and product transportation-related emissions intensity compared to 2015.	Reduce supply chain GHG emissions and improve energy management and efficiency.	
Supply Chain	Help suppliers reduce 2 million tCO_2e emissions between 2010 and 2025.	Reduce supply chain GHG emissions.	
GHG Emissions	By 2025, implement 100% renewable electricity in operations.	Improve energy management and efficiency.	Operations
GHG Emissions	Reduce in 60% Scope 1 and Scope 2 emissions from global operations by 2025, compared to 2015.	Reduce climate impact and emissions, increase renewable energy use, and save money.	
Water Consumption[2]	Focusing on high-risk sites and by 2025, reduce potable water withdrawal in global operations by 35% compared to 2015.	Prioritize reduction in water-stressed sites, decrease water use, recycle water, and reduce potable water usage.	

[2] Related to HP's Water Footprint.

3.1 Emissions Estimates

3.1.1 HP Carbon Footprint in 2020

HP calculates its emissions following the guidelines developed by the World Resources Institute (WRI) GHG Protocol [6], with which they provide their organizational footprint estimates. Thus, as a member of the WWF Climate Savers program, the company developed science-based targets for Scope 1 and Scope 2 GHG emissions and a supply chain GHG emissions intensity reduction goal for Scope 3 emissions [8]. These GHG goals have been approved by the SBTi, as well as the scopes approach and classification required to keep global warming to 1.5°C.

For Scopes 1 and 2 emissions reported in Table 2, HP utilizes the GHG Protocol Corporate Standard and for Scope 3 emissions (Table 2) the GHG Protocol Corporate Value Chain Accounting and Reporting Standard. Within Scope 2, HP presents two methods: the market-based method and the location-based method. In HP's Carbon Manual [12] it is mentioned that for this scope's estimates, the report takes the market-based method using the WRI's hierarchy of emission factor assignment, which consists in evaluating the emission factors provided by the supplier, the residual mixes for markets, and the regional or national grid factors for the balance of the portfolio. Under the Location-Based method, only regional and national grid mixes were used, and the estimates when integrating renewable energy, had no impact on emission figures.

Table 2 Scopes 1, 2, and 3 of HP Emissions for 2020 (tCO_2e)[3]. Adapted from: "2020 Sustainable Impact Report", by Hewlett Packard.

SCOPE 2 (Tons CO_2e)	
Type	***2020***
Purchased Electricity	119,600
Purchased Cooling and Heating	800
TOTAL	**120,400**
SCOPE 1 (Tons CO_2e)	
Type	***2020***
Natural Gas	21,400
Diesel/gas/oil/LPG	300
Transportation Fleet	24,000
Refrigerants (HFCs)	2,100
Perfluorocarbons (PFCs)	2,800
TOTAL	**50,600**
SCOPE 3 (Tons CO_2e)	
Type	***2020***
Material Extraction	26,400,000
Capital Goods	100,000
Upstream Energy Production	100,000
Transport	2,100,000
Waste Generated	*De minimis*

[3] For detailed information related to previous years (2011-2019), please refer to [6] (pp.21-23) and [13] (pp.65-67).

Business Travel	20,000
Employee Commuting	100,000
Upstream Leased Assets	N/A
Processing of Sold Products	*De minimis*
Product Use (Energy and Paper)	15,800,000
Product End of Service	100,000
Buildings Leased to Others	*De minimis*
Franchises	N/A
Investments	*De minimis*
TOTAL	**44,720,000**

De minimis values are less than 0.25% of Scope 3 emissions.

All facilities are in Scope 1 and 2. Leased furniture and equipment are taken as capital goods.

$$\textbf{Scope 1} + \textbf{Scope 2} + \textbf{Scope 3 Emissions } (\mathbf{t}CO_2\mathbf{e}) = \mathbf{44,891,000\ t}CO_2\mathbf{e}$$

In addition, HP organizes within its Carbon Manual [12] the components (gaseous emissions) that are included in each scope (Figure 1):

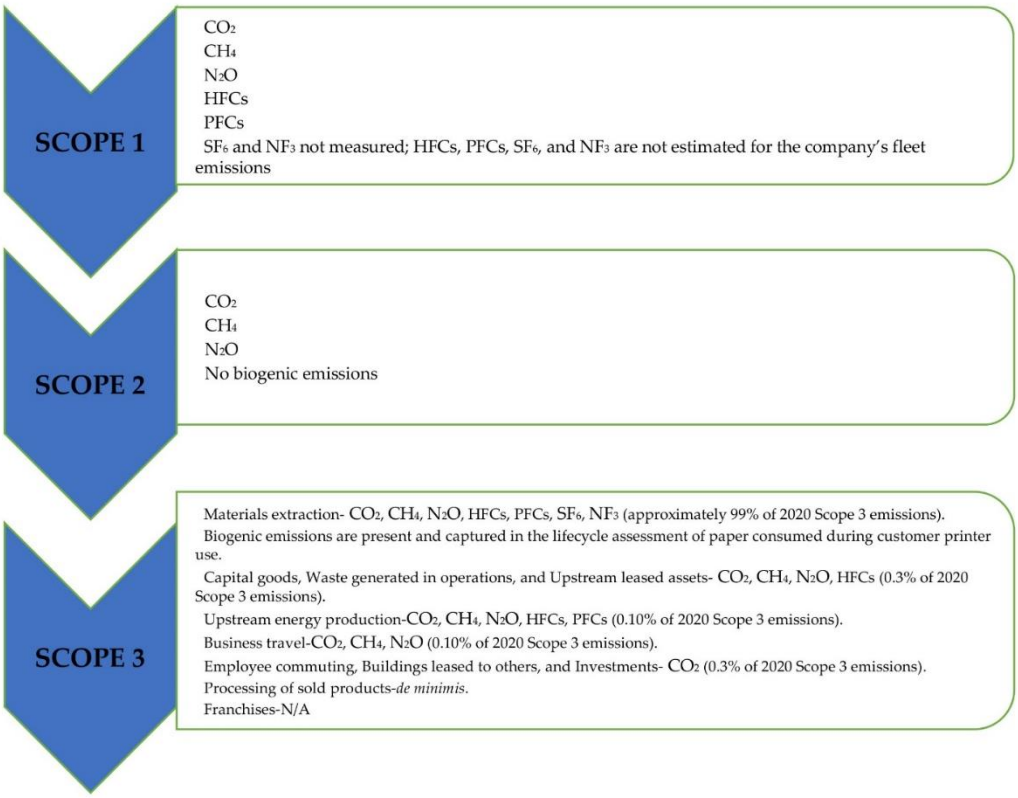

Figure 1 Gaseous emissions in each scope. Adapted from: "HP Policy Position/Climate Action", by Hewlett Packard.

In this sense and as previously shown, HP divides its activities into Products and Solutions, Operations, and Supply Chain. Figure 2 exposes the percentages that each one represents within the company, being Supply Chain accountable for more than 60% of the emissions in 2020.

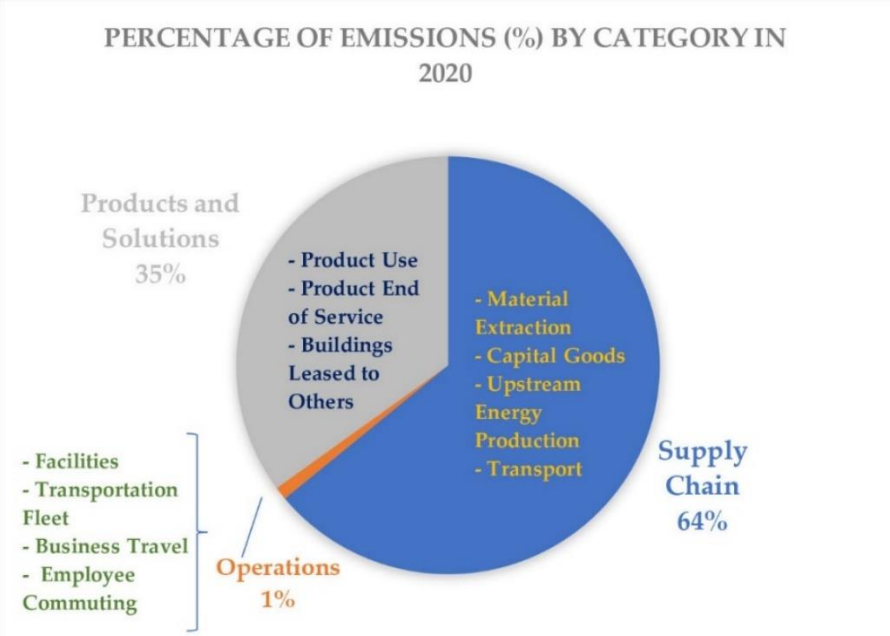

Figure 2 Percentage of total emissions (%) by Category in 2020. Adapted from: "2020 Sustainable Impact Report", by Hewlett Packard.

3.1.2 HP Historic Carbon Footprint (2015-2020)

As per the 2015 and 2020 reports, the company presents a detailed distribution of the emissions for each scope and the total footprint for each year. First, Figure 3 relates to the emissions for each scope and their distribution between 2015 and 2020, from which Scope 3 stands out with the highest values. And on the other hand, Figure 4 summarizes the total emissions over the years (2015-2020) and displays a rather constant level of emissions, with a decline in 2020 compared to 2019.

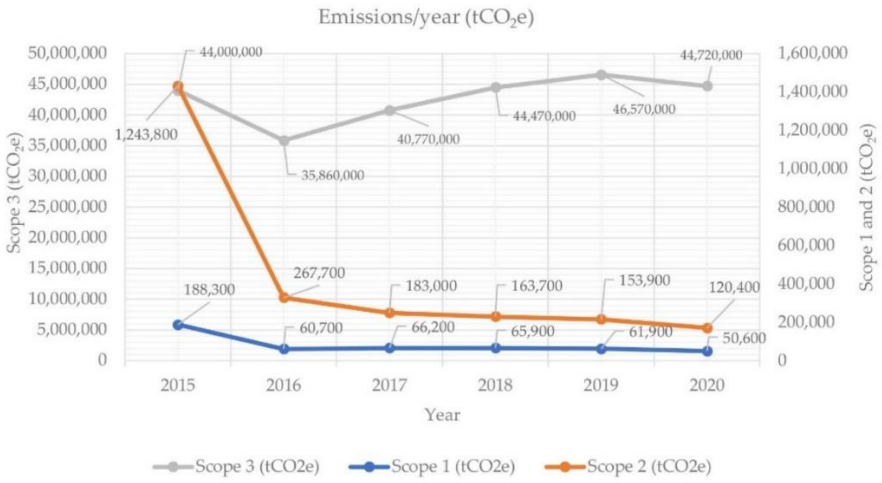

Figure 3 Emissions per year for each Scope (tCO_2e). Adapted from: "2020 Sustainable Impact Report", by Hewlett Packard.

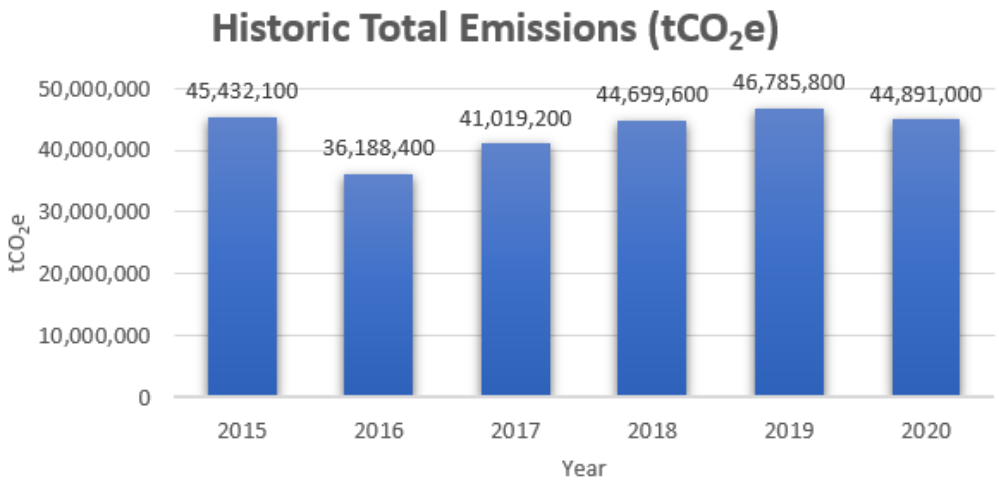

Figure 4 Historic total emissions (tCO_2e). Adapted from: "2020 Sustainable Impact Report", by Hewlett Packard.

3.2 HP in the Sector

Worldwide approximately 50 billion tCO_2e/year are emitted and 73.2% corresponds to Energy. Within this percentage, energy use in industry accounts for 24.2% (12,100,000,000 tCO_2e) of global emissions which is where the IT industry, including HP, is located [14].

This means that, with these estimations, HP will represent:

$$\frac{44{,}891{,}000\ \text{t}CO_2\text{e (HP 2020 emissions)}}{50{,}000{,}000{,}000\ \text{t}CO_2\text{e}} = 0.1\%\ \text{of Global Emissions}$$

$$\frac{44{,}891{,}000\ \text{t}CO_2\text{e (HP 2020 emissions)}}{12{,}100{,}000{,}000\ \text{t}CO_2\text{e}} = 0.4\%\ \text{of Energy in Industry Emissions}$$

Additionally, as exposed by Capgemini Research Institute [15], IT industry represents around 4% of global emissions:

$$50{,}000{,}000{,}000\ \text{t}CO_2\text{e} \times 4\% = 2{,}000{,}000{,}000\ \text{t}CO_2\text{e}$$

Which provides a more approximate value to the specific sector where HP activities are developed. Following this, the company's emissions represent:

$$\frac{44{,}891{,}000\ \text{t}CO_2\text{e (HP 2020 emissions)}}{2{,}000{,}000{,}000\ \text{t}CO_2\text{e}} = 2.2\%\ \text{of IT Industry Emissions}$$

Taking this into account and considering what has been done and proposed by HP, the company becomes one of the 10 most sustainable technology companies just after Apple [16]. HP was the first IT company to publish GHG emissions associated with manufacturing in 2007 and was the first to set a supply chain GHG emissions reduction goal in 2013, after publishing their complete carbon footprint [17].

3.3 Emissions Reductions

As exposed through this report, HP is committed to reducing energy use and GHG emissions across its value chain. Therefore, the company has established important low carbon initiatives, to achieve the targets in Table 1.

Initially, HP's Sustainable Forests Collaborative program is working to ultimately protect 200,000 acres in Brazil (tropical forest) and China by investing US $11 million (in 2019) to support WWF's efforts to restore forests and improve the management of state-owned and private forests [6]. The company has identified "more than 10,000 acres of land in Brazil and China for restoration and transition to responsible management" [6] (p.95). This initiative aims to reduce not only the company´s effects on forest ecosystems but also the actions of other external drivers.

Additionally, since April 2020 and in partnership with Arbor Day Foundation (ADF), HP committed to plant one tree for every printer sold during the month and began planting a tree (Brazil, Ireland, Indonesia, and the United States) for each of HP's 55,000 employees [6]. The company also joined the World Economic Forum 1t.org initiative (conserve, restore, and grow 1 trillion trees by 2030) and announced 1 million trees planted in 2020 [6].

The company predominantly focuses on lowering GHG emissions from operations, supply chain, and products[4] and consolidates a circular assessment for their products and services through which they deliver a better value to customers, with reduced environmental impact and capital costs [6]. Service offerings include regular maintenance which provides their products a longer use and, consequently, reduces waste. This generates a reduction in shipments and customer visits, which reduces GHG emissions [6]. In the end, HP recaptures value from materials by repairing, reusing, and recycling. Various climate indicators are measured under the scope of GHG emissions intensity (tCO_2e/US $ million of HP net revenue), which describes the performance of their portfolio. The methods undertaken to reduce GHG emissions are outlined in Table 3[5].

Table 3 HP Emissions Reduction Methods. Adapted from: "2020 Sustainable Impact Report", by Hewlett Packard. 2021.

Method	Outcome
HP helps its suppliers improve energy management and efficiency, through renewable energy and science-based targets.	Since 2010, suppliers avoided 1.38 million tCO_2e emissions and saved a cumulative 887 million kWh (US $114 million) of electricity, plus 40 million kWh (US $5.1 million) in 2020. Furthermore, through CDP these production suppliers reported savings of 23 million tCO_2e (US $613 million) from reduction initiatives implemented in 2019.
HP optimizes their logistics network by consolidating shipments, identifying new	These projects avoided 3,487 tCO_2e emissions in 2020.

[4] HP displays a US $1.5 billion expense on Research and Development where they include developing technologies; the majority is focused on inventions and development for products.
[5] Taken from 2021 Sustainable Impact Report [6].

routes, shipping directly to customers or local distribution centers, and innovating in packaging assemblage.	
First-tier production supplier and product transportation-related GHG emissions intensity decreased 3% in 2019 (most recent data), compared to 2015. In 2019 the intensity was 78.4 tCO_2e/US $ million of HP net revenue.	Production supplier renewable energy use (% of total energy use) increased to 25% in 2019. Nonproduction supplier Scope 1 and Scope 2 GHG emissions decreased a 9.5% from 2010 to 2019, providing 190,000 tCO_2e attributable to HP in 2019 (most recent data).
Reduce energy consumption through optimization and efficiency projects.	Improvement in design contributed to the reduction in energy consumption. Compared to 2010, energy consumption of HP personal systems products decreased 47%. GHG emissions intensity equaled 3.0 tCO_2e/$ millions of net revenue in 2020, a 19% reduction from 2019. Energy intensity improved a 5%, accounting for 10MWh//$ millions of net revenue. Direct energy use in operations (Scope 1 emissions) decreased 9.6% compared to 2019. Indirect energy use (Scope 2) decreased 8.6% compared to 2019. The company purchased less electricity in 2020. Voluntary purchases of renewable energy increased in 2020 (renewable energy and renewable energy credits). Supplier-specific renewable energy decreased. Purchased district cooling/heating and Ozone depletion potential of estimated emissions decreased.

	They claim they did not make a significant investment in energy efficiency projects during 2020 due to Covid-19, but by adjusting temperature and lighting settings they reduce GHG emissions. Their operations consumed 604,901 MWh of energy in 2020, 9% less than in 2019. Global electricity use decreased by 9% compared to 2019. GHG emissions from product use decreased 13% in 2020 compared to 2019. Increase on-site generation of renewable power. In 2020, they generated 243,661 MWh of renewable electricity globally (95.9% wind, 3.6% solar, and 0.5% hydro). Renewables accounted for 51% of their global electricity consumption, compared to 43% in 2019. HP acquired off-site renewable power, including renewable energy credits (RECs), utility supplier green power options, and power purchase agreements (PPAs). Sources of renewable electricity in 2020 included RECs and IRECs (88.3%), direct purchases (10.1%), and renewable energy generated on-site and on-site PPAs (1.6%). HP provides employees low-impact travel choices through (travel providers, planning tools, and transportation alternatives).
HP increased the postconsumer recycled content in plastic and reduced single-use plastic packaging.	Their 2020 progress highlights 27,490 tons (11% of total plastic used). From an average of 221 grams/unit in 2018 to 180 grams/unit (19% reduction). 41% circular by weight which equals 34,200 tons of recycled content plastic used (4% of total materials use), 100,800 tons of recycled fiber paper and packaging (11% of total

	materials use), 248,300 tons of certified sustainably managed fiber in HP brand paper and packaging (26% of total materials use).
HP engineered lighter printers for home installation which helped reduced paper sales.	Not reported.
Through their carbon neutral Managed Print Service offering (MPS), HP works to reduce emissions along the life cycle of their products and finances carbon offset projects for customers within MPS.	MPS improves resource efficiency by 13%, decreases ecosystem impacts by 12%, reduces paper waste by 25%, and offsets 100% of customer´s emissions related to these HP systems.

4. Discussion

4.1 Scope Analysis

HP's pledges to meet net-zero goals have a holistic approach and could support the objective of keeping global warming to 1.5°C. The procedures followed (GHG Protocol) for footprint estimates are pertinent and show the results for the estimations within each activity included in operations, supply chain, and products and solutions. The organization states what each Scope includes and determines targets and reduction goals for each of them. Nonetheless, it could be useful to standardize science-based targets for the three scopes to normalize the methodology that is being applied and reduce error during monitoring, evaluation, and continual improvement [18].

As per the values that were estimated, the company committed an error when reporting the final value of CO_2 emissions. In their 2020 report, they claim that they emitted 44,890,100 tCO_2e and when calculating the emissions, the real number is 44,891,000 tCO_2e. This difference is an underestimation of the real value, and it could generate inefficient investments when searching for abatement strategies and/or a non-compliance of local policy, which could also impact the carbon market (e.g. voluntary market).

On the other hand, to better understand and evaluate the formulation of the pledges (Table 1), data from the 2015 report was included to visualize the behavior through the years (2015-2020). From this information and the resulting Figure 3, it can be concluded that Scope 2 had the most significant improvement over time. Even though direct emissions from owned/controlled sources (Scope 1)[6] are lower than those estimated for Scopes 2 and 3, the indirect emissions from purchased electricity, heat, and steam have decreased at a higher rate since 2015 due to the reduction in energy use and that of purchased electricity for 2020. Figure 5 presents how total emissions of direct and indirect sources have decreased given this change in energy consumption and the use and purchase of renewable energy (on and off-site) and credits. In addition, within operations and the indirect energy use accountability, HP shows an interesting input regarding Voluntary purchases of no/low-carbon energy. The company does not generate any data related to this initiative perhaps

[6] Fuel consumption from HP's transportation fleet is not included in the Direct energy use in operations figures.

because they already present the purchases of renewable energy, but it could be an additional investment that would help manage their carbon footprint.

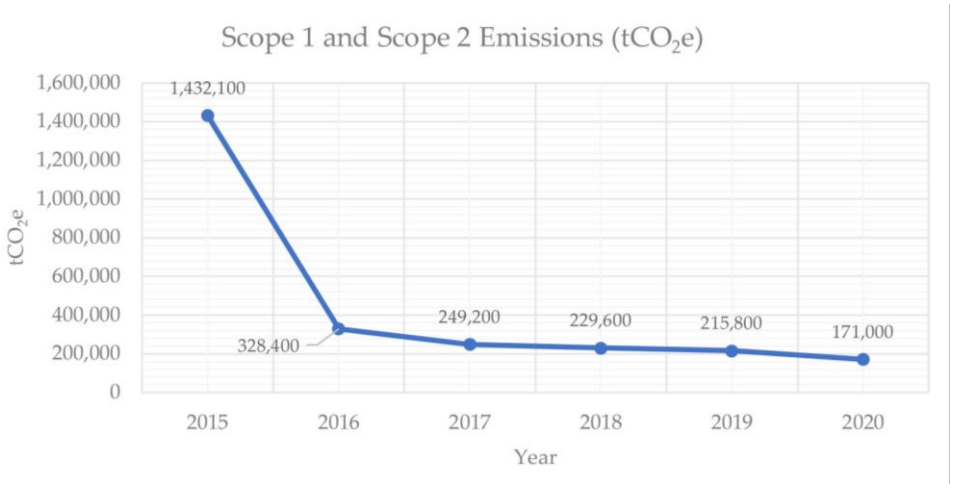

Figure 5 Historic Scope 1 and Scope 2 emissions (tCO_2e). Adapted from: "2020 Sustainable Impact Report", by Hewlett Packard.

For the case of the indirect emissions coming from sources not owned or directly controlled (Scope 3), Figure 3 demonstrates that between 2015 and 2020 the emissions increased and is essential for the company to efficiently integrate supply chain stakeholders around renewable energy use; HP´s audits and third-party audits [19] need to focus on continuous revision and follow-up to include that 20%-10% of suppliers that is missing [6]. Moreover, as shown in Figure 2, supply chain and primarily, material extraction, represent the highest percentage within the total 2020 emissions. To address this issue HP could strengthen its life-cycle assessment and increase recovered and recycled material (e.g. by continuing to improve routes, product design, and consumer engagement with recycling) and, additionally, invest more in renewable energy and energy efficiency [20].

The latter would impact production and nonproduction supplier Scopes 1 and 2 emissions, and product transportation, which are the only emissions presented for 2020 within the supply chain data and showed an increase between 2016 and 2020 (in 2020 they increased possibly due to covid-19 restrictions). If the other supplier emission performance indicators were considered [8] (p.45), and as seen during 2019, the tendency would be for production supplier estimates to increase and nonproduction estimates to decrease.

Regarding this information, HP explains that the data reported for nonproduction and production (first tier) suppliers comes from the extrapolation to 100% of those considered strategic: how are those strategic suppliers chosen? Did they apply a representative sampling technique? These concerns must be addressed to improve transparency because the emissions could be under or overestimated.

4.2 Renewable Energy, Energy Consumption, and Carbon Offsetting

To explicitly show the renewable energy use tendency, and as a complement of the previous analysis, Figure 6 presents the application of renewable energy between 2016 and 2020. As exposed, HP exclusively uses renewable energy in the processes related to Scopes 1 and 2 emissions. Even if

they claim that production supplier renewable energy use has increased to 25% (data from 2019, most recent information) and voluntary purchases of renewable energy increased around 3% from 2019 to 2020, they still need to incorporate more production suppliers to renewable energy use, support them in reporting practices, and reduce Scope 3 emissions.

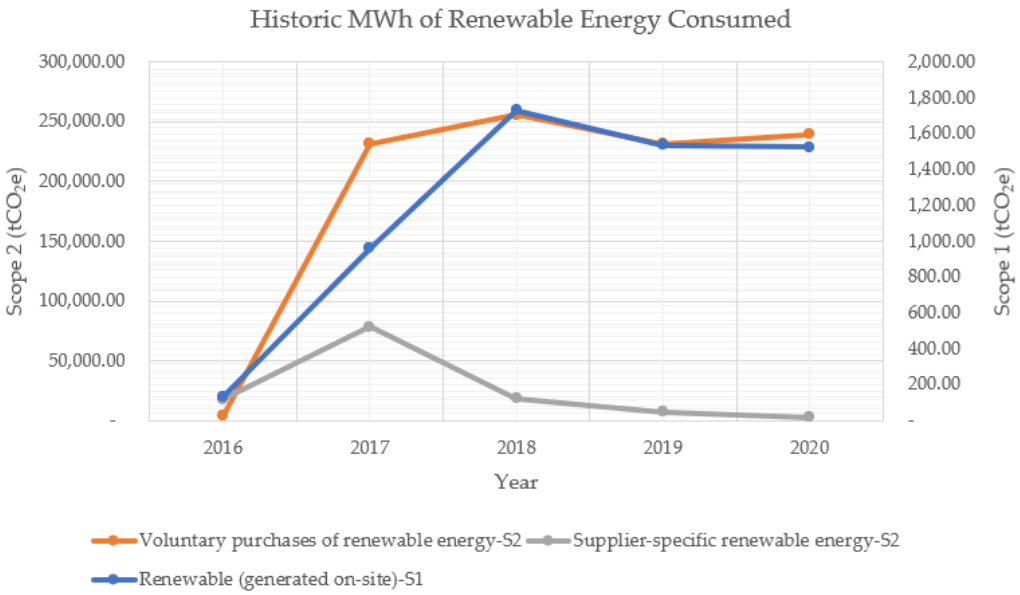

Figure 6 Historic renewable energy consumption (MWh). Adapted from: "2020 Sustainable Impact Report", by Hewlett Packard.

Moreover, the organization highlights that renewable energy accounted for 51% (243,661 MWh) of their global electricity consumption in 2020, which compared to the 43% of 2019 (227,695 MWh), represents an improvement. But, as mentioned before, electricity consumption was reduced during 2020 (due to covid-19 restrictions, energy efficiency initiatives, and decrease in purchased electricity) which means that that percentage of renewable energy increased perhaps due to the reduction in electricity consumption (MWh for Renewable Electricity/MWh for total electricity consumption). Additionally, following the 2020 report renewable energy on-site decreased from 2018 to 2019 and was even lower in 2020 (almost 1% from 2019 to 2020), but increased around 47% in relation to Diesel/gas/oil/LPG use[7]; Natural gas also decreased. This is a big concern to the company's pledges and to the environment because even if they claim to have increased renewable energy use, they have not efficiently tackled the necessity of conventional sources.

It must be highlighted that, as HP increases its operations and product development, and suppliers expand as well, there is more energy demand. Figure 4 presents the historic total emissions from which 2016 are the lowest (period 2015-2020) mainly due to a reduction in Scope 3 emissions (Figure 3). From 2017 to 2019 there was a rise in the emissions year by year, but in 2020 they decline again given the implementation of those methods mentioned before. Therefore, to counteract the rise in energy demand the company could improve renewable energy and greener technology/project investment. Another option, if the demand is not met or costs are too high, is to drive financing towards a mix of energy sources and storage capacity.

[7] Diesel is mostly used at HP for testing generators. In limited cases, diesel is also used for long-term on-site energy generation [6].

Regarding the MPS program and the support through the offsetting process, it is interesting that HP would provide guidance for businesses to invest in projects that help reduce their carbon footprint. In their report, HP does not mention that they offset with other types of projects, but it would be an additional abatement method to incorporate into their investment plans. For instance, they could finance a carbon project in a mangrove or a tropical forest site with a technical developer and claim those carbon offsets. This supports the local community and biodiversity and protects the ecosystems and its resources.

If they were to implement a carbon offset strategy, they could initially focus on the 200,000 acres of forest that the company protects (see Emissions Reduction section) through the Sustainable Forests Collaborative program. As a conservative approximation, it is assumed that HP would be able to acquire carbon offsets from the 10,000 acres that were identified. In addition, these estimations are presented taking 50% of the area as Tropical Forest (Brazil) and 50% as Temperate Forest (China):

$$10{,}000 \text{ acres} = 4{,}046.86 \text{ hectares}$$

$$4{,}046.86 \text{ hectares} \times 50\% = 2{,}023.43 \text{ hectares each}$$

Tropical forests approximately store 160 tC/hectare in the above-ground vegetation, around 40 tC/hectare in the roots, and around 90-200 tC/hectare in the soil [21]. On the other hand, Temperate forests present an overall estimated carbon storage between 150 and 320 tC/hectare [21]. This means that this hypothetical project could sequester (possibly offset):

TROPICAL FOREST

Above-ground biomass

$$160 \ \frac{\text{tC}}{\text{ha}} \times 2{,}023.43 \text{ ha} = 323{,}748.48 \text{ tC} \times 3.67 = 1{,}188{,}156.92 \text{ t}CO_2\text{e}$$

Below-ground biomass

$$40 \ \frac{\text{tC}}{\text{ha}} \times 2{,}023.43 \text{ ha} = 80{,}937.12 \text{ tC} \times 3.67 = 297{,}039.23 \text{ t}CO_2\text{e}$$

Soil carbon

Scenario 1 (90 tC/ha)

$$\frac{\text{tC}}{\text{ha}} \times 2{,}023.43 \text{ ha} = 182{,}108.52 \text{ tC} \times 3.67 = 668{,}338.27 \text{ t}CO_2\text{e}$$

Scenario 2 (200 tC/ha)

$$200 \ \frac{\text{tC}}{\text{ha}} \times 2{,}023.43 \text{ ha} = 404{,}685.60 \text{ tC} \times 3.67 = 1{,}485{,}196.15 \text{ t}CO_2\text{e}$$

Adding the above and below-ground biomass results with the soil carbon results, the total sequestered emissions in a particular year for this forest ecosystem would be between **2,153,534.42 tCO_2e (Soil carbon scenario 1) and 2,970,392.30 tCO_2e (Soil carbon scenario 2).**

TEMPERATE FOREST

Overall carbon storage

Scenario 1

$$(150\ \text{tC/ha})\frac{\text{tC}}{\text{ha}} \times 2{,}023.43\ \text{ha} = 303{,}514.20\ \text{tC}\ \times 3.67 = 1{,}113{,}897.11\ \text{t}CO_2\text{e}$$

Scenario 2 (320 tC/ha)

$$320\frac{\text{tC}}{\text{ha}} \times 2{,}023.43\ \text{ha} = 647{,}496.96\ \text{tC}\ \times 3.67 = 2{,}376{,}313.84\ \text{t}CO_2\text{e}$$

The total sequestered emissions in a particular year for this forest ecosystem would be between **1,113,897.11 tCO_2e (Scenario 1) and 2,376,313.84 tCO_2e (Scenario 2).**

Adding the estimations and identifying the lowest emissions value (sum of scenario 1 for each ecosystem) and the highest possible value (sum of scenario 2 for each ecosystem), the **total sequestered emissions in a particular year for both ecosystems would be between 3,267,431.53 tCO_2e and 5,346,706.15 tCO_2e.** This value represents a 7%-12% of the total 2020 emissions, and its potential as abatement initiative could increase if more hectares are considered as conserved and/or planted.

These estimates are hypothetical, and many environmental and technical factors need to be taken into consideration when coupling this initiative to the carbon management strategy (variations according to the actual hectares that are accounted for sequestration, bushfires, the type and characteristics of the soil, the growth curve of the species involved, species and ecosystems conservation status, rainfall, and other meteorological and external conditions). Perhaps, not all the 10,000 acres would be included and do not account for the total carbon offsets but, once the relevant hectares are identified and stratified, this procedure could be implemented to verify the real offset emissions and the subsequent reduction in the carbon footprint.

4.3 Financial Report

Through this analysis, the author could verify specific financial/investment aspects that impact HP's carbon management and reporting. In their 2020 report, HP displays a US $1.5 billion expense on Research and Development where they include developing technologies (possibly renewable energy), but they do not clarify what percentage or expense could correspond to this initiative and argue that the majority is focused on inventions and development for products (the other part is for HP Labs, new business creation, and developing technologies) [22]. They rather exhibit the performance indicator (GHG emissions intensity) but not how much emissions reduction activities cost. Thus, by including the cost for each initiative the company could precisely evaluate their investment options, based on the potential emissions reduction.

An additional detail that could be evaluated is HP´s expense with diverse suppliers. Within the supply chain data [22] (p.52) they state the millions of dollars that they spent on a list of categories of suppliers (US $596 million in 2020). If we could track the amount of energy from renewable initiatives that energy suppliers provided to the company (or the amount of tCO_2e that suppliers reduced-1.38 billion tons in 2020), it could be argued that part of that expense was for renewable acquisition but first, we do not know the percentage that could have been destined to renewable energy and second, this table of suppliers only presents those from the US; hence, it is still unclear

the expense for reducing emissions. In fact, the company could develop a matrix (and might already have it) for all its suppliers worldwide with the investment on each one of them and the product or commodity that they provide, so HP could see the distribution of expenses and which suppliers to monitor. In this sense, the cost of emissions reduction from suppliers could be accurately evaluated.

Furthermore, within their 2020 financial report [22] they mention that environmental costs and benefits are currently not material to their operations, nor their cash flows or financial position. This is something that needs to be done along with all the private and public sector organizations because in this way, the amount of loss could be estimated and real costs or benefits from a certain activity/process could be truly accounted for [23]. Valuing the environment and the real effects on it could help corporations transform their environmental performance.

4.4 Targets' Analysis

Finally, a specific evaluation of the targets proposed by HP in Table 1 could be useful feedback for the organization to improve the objectives and their progress. The company could evaluate the following analyses to better structure the pledges that were made and efficiently address their climate action strategy.

4.4.1 Plastic Use

Within their pledges related to plastic, the company commits by 2025 to use 30% of recycled material across personal systems and print products. Their 2020 progress highlights 27,490 tons (11% of total plastic used) nevertheless, to reach their 2025 goal they should triple their recycled content. They must implement more pick-up sites for recycled plastic and perhaps, include plastic pellets from other useful types of plastics that could increase the recycled ratio.

Furthermore, the information presented in the postconsumer recycled content plastic table [6] (p.90), is rounded and not exact quantities are given which could lead to error and misinterpretation from other stakeholders. Nonetheless, the total tons for 2020 are higher indicating an improvement in the recycling process.

In addition, by this same year HP has dedicated to eliminating 75% of single-use plastic packaging compared to 2018. As mentioned before, they have had a 19% reduction compared to 2018 and 41% by weight has been included into a circular scheme. Within this circularity objective they have pointed out two different years, 2025 and 2030, and for an efficient communication they should standardize this deadline. Additionally, the data is spread throughout the products and solutions section and could make stakeholder interpretation difficult.

4.4.2 GHG Emissions

In relation to their emissions, HP has committed by 2025 to initially reduce product use GHG emissions intensity by 30%, compared to that of 2015; as for the year 2020, HP had reached a 33% reduction. 35% of the company's overall carbon footprint (15,800,000 tCO_2e) was linked to product use and there was a 13% decrease in absolute emissions from product use compared to 2019 due to a 7% decrease in personal systems and printer electricity consumption of models. Covid-19 also impacted sales in commercial print and print supplies, which also reduced GHG emissions (68% of product use GHG emissions represented energy use and 32% paper used by customers).

The latter drives to the conclusion that there was, indeed, an increase in the percentage reduction and a decrease in GHG emissions from product use along the years, despite the impact of the pandemic. Therefore, the company should continue to reduce, with a higher ambition and percentage goal, these emissions by optimizing energy consumption in their products through innovation. The real reduction should then be given by this innovation and not by external factors, such as commercial or market fluctuations.

Nonetheless, there are some calculation aspects regarding renewable energy use in operations that need to be clarified. HP has established that by 2025, they would implement 100% renewable electricity in operations and reduce in a 60%, compared to 2015, Scope 1 and Scope 2 emissions. First, they claim to have generated 243,661 MWh of renewable electricity, which represent 51% of their global electricity consumption. If only indirect energy use was considered that amount of renewable energy corresponds to a value close to 51% but, as renewable energy is also generated on-site (direct energy use) when estimating the real percentage, that value is lower. These estimations should be clarified for a better understanding and for stakeholder communication purposes.

On the other hand, they claim to have emitted 171,000 tCO_2e (Scope 1 and 2) which represent a 56% reduction compared to 2015. In fact, the number of tons related to Scope 1 and 2 has decreased along the years but, the difference is much higher (1,432,100 tCO_2e in 2015). Again these estimations must be evaluated for an efficient and assertive communication.

4.4.3 Recycling

Within their recycling pledges, HP has committed to recycle 1.2 million tons of hardware and supplies by 2025. As for the year 2020, they had recycled 642,300 tons and the materials use indeed has declined between 2019 and 2020 [6] (p.88) but, as shown on the company's report, they exclude products and packaging for some products. Thus, this missing data could lead to false conclusions. Moreover, the company total recycling of hardware and supplies in tons, has declined as per page 114 on the 2020 report but the units of remarketed, reused, and repaired electronic equipment has increased. This means that the organization should reinforce its circular scheme to increase both indicators and promote a more consistent increase in recycling.

4.4.4 Zero Deforestation

By the end of the year 2020, HP committed to reach zero deforestation linked to paper and paper-based products, from which 99% was accomplished. A remaining 1% was determined to ensure that the reported fiber usage meets the company's Sustainable Paper and Wood Policy. However, despite the company having FSC certification and other relevant certification which support sustainable forest management, the Sustainable Paper and Wood policy cannot be found and even if there is a direct link within the report, this does not work. This must be revised to clearly present that the company meets the requirements for paper and usage fiber, as well as those related to the standards.

4.4.5 Supply Chain

Finally, by 2025 HP has committed to reduce in 10% the first-tier production supplier and product transportation-related emissions intensity, compared to those of 2015. This reduction in their 2020 progress marked a 3% level, but this data is only given until 2019 and presents an increase compared to 2018 (2.55%). In addition, the 2015 estimation is not available [13] but, if the 80% from previous years is maintained, the reduction is close to 3%. However, there is no data for 2020 which highlights the responsibility of the company to present accurate and sufficient information. This must be included for effective monitoring and continuous improvement.

4.4.6 General Observations

It must be clarified that, for those indicators based on intensity (tCO_2e/net revenue), measuring it could not give the appropriate idea because if net revenue increases, even if the emissions are high, the intensity will decrease. Instead, the company could separate the indicator into tCO_2e/MWh and wholesale cost ($/MWh), evaluate investment opportunities on energy efficiency and green technology/projects and present how much of the revenue was destined to sustainability initiatives. This will objectively measure the real impact on the environment.

Additional attention should also be given to the rate of conformance of sites audited. This aspect has increased between 2018 and 2020, and HP has extended its coverage of non-conformities resolution and continual improvement. Finally, something to evaluate is the conformation of the baseline years from which to establish a progress percentage and the targeted year. As a consultant, it would be a task to define those years with data and evidence and in this case, HP is evaluating almost all the climate targets based on the 2015 data with a 2025 goal and as seen in their progress, there are some uncertainties in the estimations between the baseline and the target years. This will derive in false conclusions and carbon management plans.

4.5 Firm Comparison

Lastly, it is relevant to include HP's performance compared to another firm's performance within the sector. In this case, Apple Inc.'s development focuses on low-carbon design, renewable electricity, direct emissions abatement, carbon removal, and energy efficiency. They have compiled their targets into two main competitive goals, that aim to carbon neutrality for the entire carbon footprint and a net-zero carbon production by 2030 [24].

Apple claims to have achieved carbon neutral operations investing, additionally, in high-quality projects that protect and restore forests, wetlands, and grasslands (nature-based solutions) [24]. They have had an increased inclusion of renewable electricity at their facilities and have reduced by around 73% their product energy use, which helped to decrease twice as many tons of CO_2e as HP decreased.

Scope 3 emissions accounted for the highest percentage of the total emissions (manufacturing being the highest and Scope 2 accounting for 0% of the emissions) which represented a total of 22,600,000 tCO_2e, more than 50% less than those emitted by HP [24]. In addition, when analyzing Apple's carbon footprint their total emissions throughout the years have shown a more consistent decline (Figure 7), but their data presentation is not as detailed as HP's. Nonetheless, they present

a carbon footprint for each corporate facility that includes renewable biogas, an energy resource not mentioned in HP's strategy.

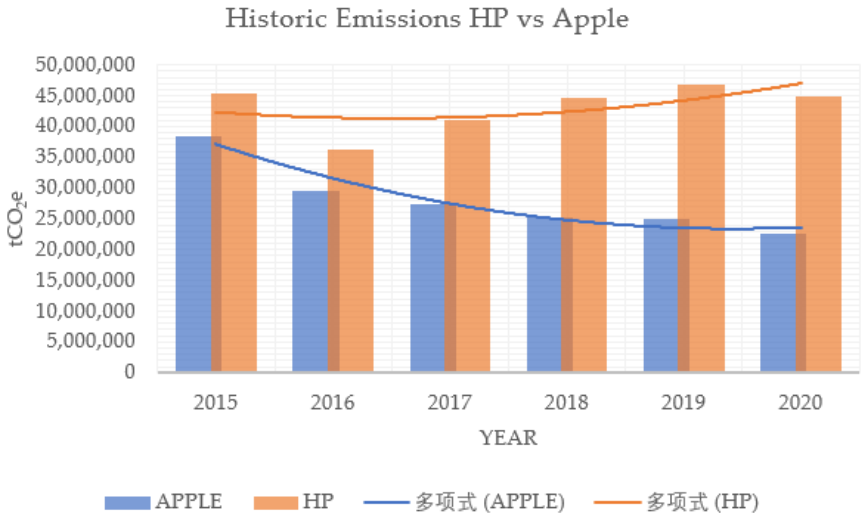

Figure 7 Historic Emissions HP and Apple (tCO_2e).

HP presents a robust report and provides a diverse amount of information for transparency purposes, that could also be misinterpreted or inconclusive. Apple summarizes its climate action for a better understanding (with an assertive and explicit accounting and monitoring) and through its Green Bond Impact Report [25] demonstrates the exact distribution of costs for green investments. They include the number of projects and the expenses within each initiative related to low-carbon design and engineering, energy efficiency, renewable energy, carbon mitigation, and carbon sequestration, which could be useful to HP as a benchmark evaluation for their emissions reduction strategy and net-zero goal.

These two IT leaders could be implementing this set of climate actions to deliver better outcomes that reduce environmental impact, but also to comply with national and international agreements and legislations. These government and multilateral organization policy strategies are necessary to maintain a monitoring control, on the effects of humans upon the natural ecosystems [26]. Thus, the national government could apply a command-and-control approach to prohibit or reduce certain technology use in the industry, implement a carbon pricing mechanism to encourage a reduction of emissions by imposing a financial charge on those tons still emitted, or promote certain purchases or investments through financial incentives (climate finance) [27]. By doing this, policy action generates binding targets for the private and public sectors, that will help reduce national and global emissions and possible negative effects on the environment. This way, environmental compliance drives climate action and fortifies mitigation and adaptation plans and commitments.

5. Conclusion

A net-zero emissions economy is essential to maintain a stable global climate. The private sector has a critical role and there is evidence that having climate action relates to good business. HP is among the most sustainable technology companies, given its challenging science-based targets and their progress through the application of emissions reduction methods and correct GHG Protocol implementation. The company has decreased its Scope 1 and 2 emissions, and renewable energy usage is a key aspect of its operations.

By applying literature review and report analysis (necessary to complement with site visits, consultant-client verification and discussion, and monitoring), this case study highlights the necessity of verifying the emissions calculations, associated percentages, and the proposed intensity indicators to objectively evaluate environmental impact. For a more conclusive and assertive carbon management strategy, HP should update data analysis (i.e. renewable energy consumption) and show investment figures on emission reduction methods for transparency and better internal decision. In this sense, they could incorporate more renewable energy systems and diversify on the abatement initiatives (e.g. conservation/plantation projects) and/or establish energy mix sources, to further decrease their demand for fossil fuels and their emissions. Furthermore, life-cycle assessment could be improved through transportation schemes, innovation, and consumer engagement to accomplish greater recycling goals. Additionally, it is vital to generate a more robust evaluation and monitoring process for suppliers and support them in reporting practices and their growth on renewable energy applications. This, in addition to the crucial step of consolidating techniques and proposals to reduce Scope 3 emissions and tackle primarily materials extraction through manufacturing.

Through this HP case study companies from all industry sectors, will be aware that improving corporate climate and environmental response by measuring and disclosing their impact, is essential to manage global carbon emissions and climate risk. Consequently, corporate sustainability and environmental performance will be enhanced through green investment, public pressure, and national and international policy and carbon markets. In this sense, climate strategies such as environmental education, renewable energy implementation, process optimization, and purchase of carbon offsets/credits need to be part of a company's annual commitment. This ultimately should generate corporate consciousness about protecting the environment and future generations, by reducing carbon emissions and consolidating a transformative change.

Abbreviations

Abbreviation	Definition
ADF	Arbor Day Foundation
CDP	Carbon Disclosure Project
CO_2	Carbon Dioxide
ESG	Environmental, Social, and Corporate Governance
FSC	Forest Stewardship Council
GHG	Greenhouse Gas(es)
GRI	Global Reporting Initiative
HFC	Hydrofluorocarbons (refrigerants)
HP	Hewlett Packard

HPE	Hewlett Packard Enterprise Company
IREC	International Renewable Energy Certificate
IT	Information Technology
LPG	Liquified Petroleum Gas
MPS	Managed Print Service
MW	Mega Watt
MWh	Mega Watt per hour
NDC	Nationally Determined Contribution
PC	Personal Computer
PFC	Perfluorocarbons
PPA	Power Purchase Agreements
REC	Renewable Energy Credits
SBTi	Science-based Targets
TCFD	Task Force on Climate-related Financial Disclosures
tCO_2	Tons of Carbon Dioxide
UNFCCC	United Nations Framework Convention on Climate Change
US$	United States Dollar
WRI	World Resources Institute
WWF	Worldwide Fund for Nature

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