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The application of circular economy in the defence sector

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Abstract:

The current linear economic model implies lack of resources and excess of residues that the planet cannot stand. As an alternative model, circular economy has been proposed. There's a collective effort in the development of circularity in order to achieve economic, social and environmental sustainability. The interrelation of the phases of the model, the process and product design, the remanufacturing, the waste management and the cooperation of the defence sector with other economic agents are essential towards a circular economy.

Keywords:

Circular economy, energy transition, sustainability, defence, security.

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***NOTE:** The ideas contained in the Opinion Papers shall be responsibility of their authors, without necessarily reflecting the thinking of the IEEE or the Ministry of Defense.

Introduction

Nature and its resources are an indispensable part of our social and economic systems. They affect our health, food system and security. The well-being of any population group is linked to the supply capacity of environmental goods and services. Moreover, no value chain is possible without the contribution of nature.

Climate change is the main environmental problem facing humanity because its most worrying consequences include the degradation of ecosystems; adverse weather events and other natural hazards such as fires, ice melting, desertification and drought resulting from rising temperatures; and sea level rise and flooding.

The deterioration of the environment together with the loss of biodiversity and its ecosystemic services cause difficulties in the regulation of air quality, water management and its resources, and food systems with harmful effects on health and the emergence of pandemics. On the other hand, they force migration of people and depopulation of rural areas, increasing conflicts with significant impact on the economy.

Although the linear system has been a fundamental element in industrial, social and economic development since the Industrial Revolution, it has reached its end as it is unable to cope with the challenges facing humanity: climate change, depletion of natural resources and fossil fuels, landscape degradation, loss of biodiversity in ecosystems, pollution, inequality, overpopulation, etc.

The linear economic model was based on the premise of the existence of a constant and economically viable supply of natural resources, without considering either their limited nature or the impact of productive activity on the environment. It was based on the massive, unhealthy and uncaring extraction of raw materials and fuels, their transformation into goods and services for consumption and the final disposal of the resulting waste. In recent times, the growing concern within the economic and environmental sphere has led to the development of a sustainable, resource-efficient, low-carbon, toxic-free and competitive circular economy.

By means of the circular economy, the life cycle of products is altered as it no longer has a beginning, middle and end. It seeks to maintain the value of goods, materials and resources in the economy for as long as possible. By keeping products and components

in use within the economy at their highest value and utility at all times, energy is conserved for longer, the need for new production and end-of-life disposal is reduced and greenhouse gas emissions are significantly reduced.

The circular economy provides a vision that is attractive to the defence sector as it allows it to remain competitive within the industry but in a more sustainable way, reducing both the environmental impact and the logistical footprint. The implementation of the circular economy in the defence sector implies not only a change in production and consumption patterns but also an improvement in military performance, greater material security, efficiency and industrial-technological integration.

This new economic model, in which the development and promotion of strategic materials is important, will offer a series of advantages based on green management: sustainability, preservation of the environment, security of supply, job creation, reduction of costs related to military action and therefore an increase in profitability, etc. Circular initiatives exist in relation to uniforms and equipment, remanufacturing, repairability and reverse logistics.[1] In addition, the defence sector is composed of companies that can create synergies by discussing the requirements, opportunities, constraints and barriers for the introduction of the circular economy in defence.

The promotion of the circular economy in the defence sector

Regulatory framework

The international scenario is constantly changing to address the growing risks and threats facing today's strategic context: disruptions in the global order coupled with the evolution of a society in which there is increasing competition and interdependence for limited resources; demographic and climatic changes; state fragility; and increased demand for technological services. To counteract the pernicious effects of these circumstances and instabilities, as there are currently multiple fragmented defence markets, it is desirable that both governmental authorities and other independent bodies implement joint security policies.

In line with the Global Strategy for the European Union’s Foreign and Security Policy, the

[1] https://eda.europa.eu/webzine/issue20/in-the-field/advancing-circular-economy-in-defence

economic model in defence focuses on the efficient use of strategic materials considered critical resources. Therefore, given that the EU is the international institution leading the global transition to a circular economic model, this objective could be achieved with concrete targets in the short-medium term. Specific funding instruments can promote technological innovation and new circular business models based on sustainable production and consumption, with good waste management in the value chain.[2]

The European Defence Agency (EDA) is an organisation which assesses current demands and helps create courses of actions. Its efforts include the *Energy and Environment Programme* and the *Go Green* project. The first one states that the principles of circular economy can be used to decarbonise the military sector and achieve energy efficiency: the extraction of critical resources is highly polluting and their reuse rates are not high. The second one seeks to produce energy from renewable sources. The EDA recently took the initiative to create the *"Incubation Forum for Circular Economy in European Defence"* to help achieve the European Green Deal and the New Circular Economy Action Plan within the defence sector.

The *European Green Deal aims to* make the European Union climate neutral not later than 2050 by making the economy more sustainable while transforming any climate and environmental challenges into an inclusive growth opportunity, making it more competitive.[3] *The "Closing the Loop" Plan* consists of a package of 54 measures on the European transition to a circular economy to achieve a sustainable, competitive, low-carbon and resource-efficient economy.

Other initiatives include diversifying energy sources, strengthening the supply chain, innovating infrastructures and addressing economic, political and military threats and vulnerabilities in sustainable energy supply security. At the end of 2016, the European Commission proposed the creation of energy communities to engage all actors in the society in the energy transition and promote new business models for renewables, thus breaking down energy barriers. [4]

Although there is no single circular model, a long-term perspective has to be formed in

[2] https://eda.europa.eu/webzine/issue11/opinion/circular-economy-matters
[3] European Commission.
[4] https://energia.gob.es/es-es/Participacion/Paginas/DetalleParticipacionPublica.aspx?k=462

which energy, unusable or difficult-to-treat waste and natural resources are optimised from the beginning of the production process. In order to change the habits of economic agents (consumers, companies, authorities, etc.) and the functioning of the economy, the 7Rs model is a good tool because it involves redesigning, remanufacturing, repairing, reducing, reusing, renewing and recycling. Efficiency in managing and ensuring the supply of natural resources is essential for the defence sector, and if their use is optimised, facilities and instruments are adapted and critical materials are managed, new incentives for technological and productive innovation can be generated.

As already mentioned, the development of our society is characterised by an increasingly intensive use of certain minerals, which are necessary and irreplaceable in the value chain of leading industrial sectors (renewable energies, electric vehicles, defence, aerospace industry, manufacture of other new digital equipment, etc.). Their characterisation as "strategic" is given by their economic importance in the production of certain goods subject to restrictions such as geographical location, deposits of the materials necessary for such production, their substitutes and recycling.

Countries that are able to manage these problems will be able to generate opportunities, well-being and prosperity for society as a whole. Failure to manage the risks arising from increased demand for these resources will have consequences for the sustainability of ecosystems, leading to environmental degradation with negative effects on land and water; violation of human rights in the rise of conflicts and migration (inequality, poverty, corruption). As these strategic resources are vital for the functioning of the world economy, their potential scarcity implies that renewables will not be free of geopolitical tensions bringing conflicts and fragility to some states: dependence on countries with greater availability of certain materials with a consequent rise in prices, insecurity of supply or market inefficiencies.

Many economies and industries are subject to the export of these materials by third countries due to the high concentration of production in certain areas of the globe. The associated risks are compounded by low substitution and recycling rates. Even so, the identification of these minerals should lead to strategic business and governmental plans that seek to enhance innovation; strengthen competitiveness and globalisation with trade

negotiations; reduce supply dependency with new mining and recycling methods[5]; and implement the Sustainable Development Goals. In other words, the implementation of a circular economy would solve the economic tension as a smart use of resources would considerably decrease the dependence and vulnerability of industrial actors worldwide.

To meet the goals of the Paris Agreement[6], a transition to green and renewable energy is required. This is closely linked to the procurement of these elements as they are essential in the manufacture of solar panels, electric vehicles, wind turbines and in energy storage and batteries. Therefore, although access to natural resources is already relevant today, it will become even more important in the coming years in the development of security strategies. Increased demand and competition for those minerals and metals is not free from uncertainty about the global energy market and the risks associated with their extraction.

One study that shows how the circular economy can be introduced in the defence sector is the one developed by the Dutch Ministry of Defence. It sets out four phases to achieve an effective transition along the lines of *"Smart Defence"*: raising public awareness, analysing the requirements of the sector, establishing regulations and setting up financing plans subject to existing needs. In doing so, it is estimated how the efficiency and effectiveness of military operations can be increased. Although the initial costs are high, in the long term, advances in technological innovation, operational capabilities and security where economies of scale are important will boost the economy while reducing both other costs and waste[7] .

In this context, climate change mitigation is among NATO's main objectives[8] and is vital to eliminate the threat it supposes to the energy and environmental aspects of security, while preserving the environment and human well-being. Existing extreme weather conditions and the forecast of worsening weather conditions if no action is taken in the

[5] According to *New-Mine*, there are between 150,000 and 500,000 landfills in Europe, where *Enhanced Landfill Mining* could transform waste streams into materials and energy. This would reduce environmental catastrophes and mitigate the problems of supplying raw materials and energy resources.

[6] It is an international agreement adopted during the Conference of the Parties 21 held in 2015 in Paris. In order to achieve the goal of limiting global warming to 1.5ºC, it was proposed to achieve a climate-neutral world by 2050. Therefore, this treaty provides a multilateral framework for technological development, transparency, financial and social support to address the challenges of climate change (United Nations).

[7] The European Financial Review, "A Roadmap to Circular Economy in EU Defence inspired by the Case of the Dutch Ministry of Defence".

[8] https://www.nato.int/cps/en/natohq/official_texts_185174.htm

short term have a negative impact on military infrastructures and equipment, competition for geographical areas,...

Due to regional instabilities, some countries do not have the funding or capacity to attract external investment to meet the demands of the circular energy transition. This gives rise to a strategic dimension to be considered in the development of military activities: operational efficiency, capability development and public-private and international partnerships. The International Energy Agency is working with NATO to achieve energy efficiency, data integration and logistics management supported by the circular economy (design of circular systems, use and recycling of low-carbon circular materials to conserve critical materials)[9]. To achieve such efficiency and make countries energy secure, investment in innovative energy infrastructure and the use of new technologies to reduce CO_2 emissions are needed . The reduction of fossil fuels in favour of sustainable energies, such as hydrogen and electricity, together with the autonomy of armed forces to produce, supply and transport their own energy are initiatives with multiple environmental, economic and social benefits.[10]

Sustainability is a strategic imperative for the UK as a security provider. The paper called *"Sustainable Digital Technology and Services. Strategic Approach 2021-2025"*[11] sets out the challenges the country faces and how it intends to structure a long-term plan to decarbonise its economy while the military sector takes advantage of operational opportunities in a sustainable way.[12] UK defence, which is responsible for 50% of the country's emissions, aims to reduce them by protecting biodiversity and natural capital through good data management to anticipate challenges, awareness-raising to bring about a change in the current culture and technological solutions in the industry.

In France, to counter existing environmental and social problems resulting from being one of the most polluting countries in the European Union, a waste management law was approved in 2020. The law has introduced a ton of measures, some of which are world firsts, to shape the transition to a circular economy: it aims to eliminate single-use

[9] https://europeansting.com/2022/02/24/3-ways-the-circular-economy-is-vital-for-the-energy-transition/
[10] https://enseccoe.org/en/studies-and-publications/225/journals/energy-security-forum-9
[11] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/996095/20210616-Sustainable_Digital_Technology_and_Services-FINAL.pdf
[12] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/973707/20210326_Climate_Change_Sust_Strategy_v1.pdf

packaging by 2040, end planned obsolescence, encourage reuse through better waste management and reduce pollution from process and product design. France is the first country to ban the destruction of unsold non-food products; and to introduce a mandatory reparability index for electronic and electrical products. This regulation aims at involving any population group and also it will introduce this new model in a transparent way in businesses in multiple sectors, including the defence sector.[13]

In Spain, the Spanish Circular Economy Strategy 2030 was approved in 2020, which lays the foundations for promoting this new production model[14] . This strategy identifies six priority sectors of activity in which to incorporate this challenge for a circular Spain: construction sector, agri-food sector, fisheries and forestry, industry, consumer goods, tourism and textiles and clothing.

This growing importance of the concept of circular economy is also reflected in the National Security Strategy 2021 (ESN 21), which constitutes the political framework that defines the threats and risks of a changing Spanish strategic environment. It establishes the importance of "*the drive towards a circular economy with a production model based on reusing, renewing and recycling materials and products. This model will help to reduce pressure on the environment, improve the security of supply chains through a more effective use of existing resources and stimulate business development in the field of R&D&I".* [15]

The ESN 21 also argues that the energy transition towards a more sustainable model, incorporating a higher share of renewable energies and contributing to climate neutrality and greater strategic autonomy entails the incorporation of new technologies and, consequently, the broadening and/or deepening of dependence on them.

Supply problems

Global trade has been affected by a sharp spike and growth in demand for consumer goods during the pandemic. This, ccombined with government restrictions in response to

[13] Ellen MacArthur Foundation.
[14] https://www.miteco.gob.es/es/calidad-y-evaluacion-ambiental/temas/economia-circular/espanacircular2030_def1_tcm30-509532_mod_tcm30-509532.pdf
[15] National Security Strategy 2021. Available at: National Security Strategy 2021 | DSN

COVID-19, has put a great deal of pressure on the global supply chain[16] .

According to *GlobalData's* Supply Chain Vulnerability Index, the US and the UK rank first and second, respectively, in supply chain vulnerability. They are followed by Australia, France and Russia**.** In contrast, Germany is the least vulnerable, followed by China, South Korea, Ireland and the Netherlands in the top five[17] .

The COVID-19 pandemic has also highlighted vulnerabilities in the supply of raw materials considered key to national security and economic competitiveness. In addition, disruptions in the supply of critical materials can have serious negative repercussions for businesses, consumers and economies. Those critical materials are essential for the development of renewable energy and electric mobility. For example, rare earth elements such as neodymium, dysprosium and praseodymium are involved in the manufacture of permanent magnets used in high-performance wind turbines. Gallium, germanium and indium are important components for solar photovoltaics (PV), while cobalt and lithium are necessary for the manufacture of batteries used in electric vehicles.

In this scenario, dependence on these resources and the security of their supply has a direct impact on the geopolitical interests of major powers. In addition to the development of alternatives or increased production from additional sources, this potential vulnerability of supply chains can also be addressed by seeking to increase the sourcing of these materials through increased recovery and recycling. For this reason, many companies that may be challenged by a lack of supply of critical materials are implementing circular economy principles in their supply chain[18] .

Securing a sustainable supply of raw materials is a key priority for the EU. Raw materials, such as metals and minerals or forestry materials, have become increasingly important for the EU's economy, growth and competitiveness[19] . In this respect, the transition towards a circular economy is essential in efforts to reduce dependence on raw material supply and create sustainable growth[20] . Recycling will have to evolve from a side stream

[16] https://www.ics-shipping.org/news-item/leadership-insights-live-the-role-of-maritime-trade-in-the-post-covid-recovery-europe-focus-round-up/
[17] https://www.investmentmonitor.ai/analysis/supply-chain-vulnerability-index-2022
[18] Genovese A, et al. *Sustainable supply chain management and the transition towards a circular economy: Evidence and some applications*. Omega (2015), http://dx.doi.org/10.1016/j.omega.2015.05.015i
[19] https://ec.europa.eu/growth/sectors/raw-materials_en
[20] Gaustad G. et al. "*Circular economy strategies for mitigating critical material supply issues*" Resources, Conservation and Recycling. Volume 135, August 2018, Pages 24-33

to an important pillar of raw material supply if we are to protect our planet and make business sustainable, which implies a solution from a systemic point of view[21] .

The New Incubation Forum for Circular Economy in European Defence (IF CEED)

The European Defence Agency, created in 2004, is responsible for the management of different cooperative projects among its member states to help them develop their military assets and improve their operational capabilities. On 1 October 2021, it presented the New Incubation Forum for Circular Economy in European Defence (IF CEED), which aims to foster innovative collaborative projects with an impact on business models while mitigating the environmental impact of the defence sector. The participating countries are all EU countries except Denmark. The forum consists of two *clusters* that focus on materials and process management; eco-design and digitalisation.[22] Those include a number of areas:

- **Raw materials:** Ending the exploitation of certain raw materials plays a key role in the evolution to a circular society. After assessing the applications of critical raw materials in defence and their recycling rates, the aim is to optimise the current supply chain in which circular materials abound. The European Defence Agency's *CapTechs* are working with the European Union to develop initiatives such as the *European Raw Materials Alliance* in order to diversify the production process, create jobs, attract investment and promote technological innovation.
- **Additive manufacturing:** The potential that additive technologies have on defence capabilities is manifested in mobility, environmental sustainability and security. In turn, they make efficient use of resources, optimise design and production with increased reusability, repairability and remanufacturability of products and thus significantly reduce the "military logistics footprint" in terms of cost, infrastructure, personnel and availability.
- **Circular materials for defence:** The use of circular materials in defence is key to eliminating at least 90% of the hazardous substances that cause biodiversity and environmental degradation. The *Cradle to Cradle Products Innovation Institute*

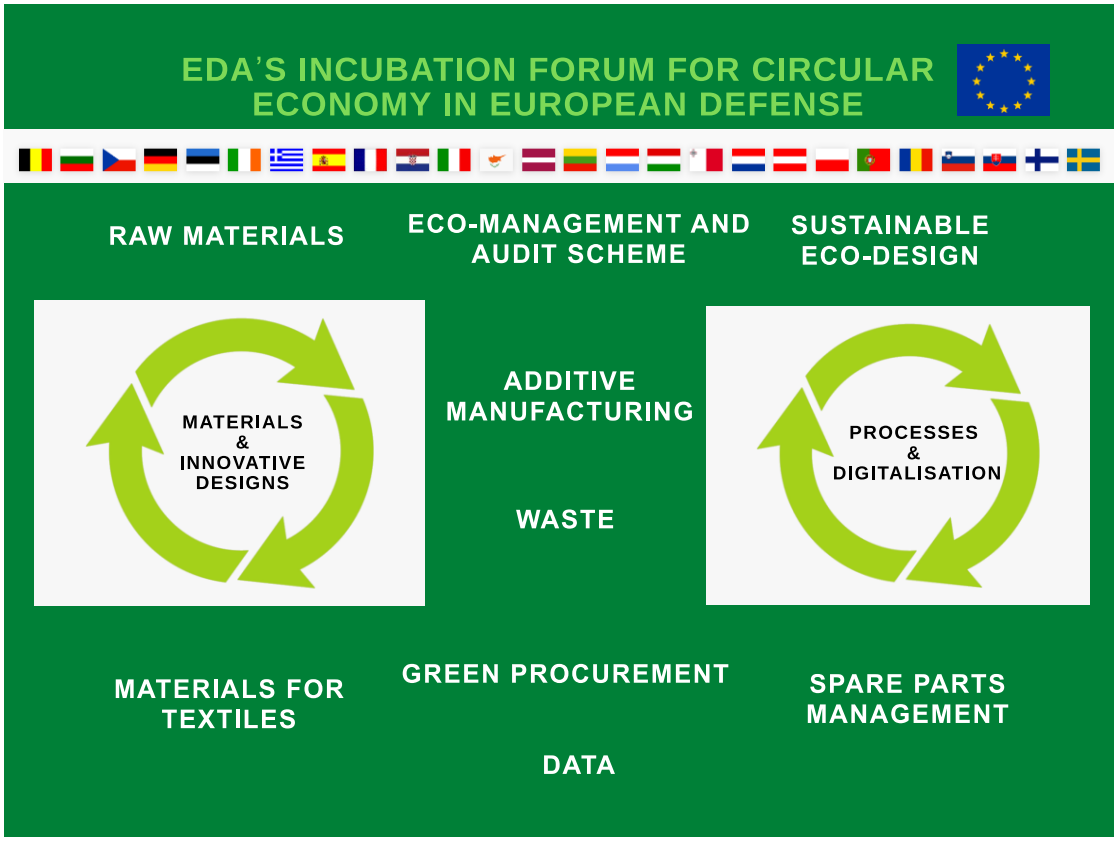
[21] https://eitrawmaterials.eu/developing-raw-materials-into-a-major-strength-for-europe/
[22] https://eda.europa.eu/what-we-do/eu-policies/if-ceed#

identifies materials that follow the circular cycle, since once a good has fulfilled its function, the waste can be converted into nutrients in another system. In defence, it is necessary, as a roadmap, to define lines of development from the current scenario towards textronic-based textiles. The materials *CapTech* of the EDA is working on multifunctional smart textiles which, together with the standardisation of recycling processes, will improve circularity processes.

- **Sustainable eco-design:** Eco-design in this sector addresses all defence domains (maritime, land and aerospace) and aims to increase military capabilities by complying with circularity within the supply chain. It includes a reduced use of resources for the manufacture of parts and increasing their life cycle, the recycling of strategic materials and the establishment of mechanisms for the improvement of energy efficiency, including the minimisation of energy losses in non-productive activities.
- **Waste:** In May 2020, the EDA launched a study on the impact of EU regulations on chemicals and waste on defence. Article 9(1)(i) of the Waste Framework Directive (WFD) decrees that the reduction of the content of hazardous substances in materials and products shall be encouraged. Given the high complexity of defence systems and their related supply chains, the EDA is committed to regulating and developing specific solutions for defence products and components.
- ***Eco-Management* and *Audit Scheme:*** EMAS implementation in military installations can optimise their environmental management. It is considered essential for framing the circular economy in the development of innovative, efficient and effective defence systems: environmental protection, hazardous waste management, resource efficiency, sustainable development and support for the local economy.
- **Green procurement:** This action circle aims to support the Ministries of Defence of the EDA member states in green procurement of goods, services and works with reduced environmental impact. Both *Green Public Procurement* and the Circular Economy Action Plan contribute to closing the life cycles of materials and energy, minimising environmental pressure and waste creation.
- **Data sharing:** In the booming digital economy, defining a roadmap for the processing of "circular data" requires transparent information sharing without

undermining intellectual property rights and data protection. Digital inventory management in military supply chains and other dimensions related to logistics efficiency would facilitate the repair or re-use of product components and substances used in this sector at the EU.

- **Spare parts management:** Increased reuse and exchange of military spare parts could contribute significantly to circular economy objectives. Smart warehouse management, where logistics activities are reduced in terms of storage and transport, would contribute to reducing the carbon footprint while reducing unnecessary exploitation of natural resources.



Source: Own elaboration

Conclusions

The predominant linear production model in today's society is detrimental to the environment as it causes the deterioration of nature through overexploitation of forests and fisheries, atmospheric pollution, loss of biodiversity, etc. The only viable future is to establish a circular model on a global scale, in order to preserve natural resources and

guarantee a sustainable socio-economic model in the medium and long term. It is a model that makes it possible to continue to improve living standards while reducing the impact of human activity on the planet.

Industrial and technological advances are changing the natural environment and the strategic-military environment, and have led to an increase in the list of elements in the periodic table that are considered essential for their intrinsic properties. Increasing consumption by industrialised countries puts pressure on coveted reserves of those limited natural resources.

The circular economy offers the opportunity to make not only companies but also supply chains more sustainable by increasing the value chain of goods and services, minimising the rate of waste generation, creating markets for secondary raw materials, using renewable energies and manufacturing products that are easily repairable. On the other hand, the importance of public-private partnerships should be underlined along with increased R&D&I activities in the development of defence systems. Aligning the circular economy strategies of each country with the objectives set by the European Union would also encourage green jobs, raise the awareness of economic agents and the emergence of new opportunities for circularity in certain sectors.

The transition of the defence industry towards more sustainable production models is unavoidable and could benefit the entire industrial and economic fabric, as well as the activities of capability acquisition, life-cycle management and employment of military assets. Both the institutions and countries within the European Union and NATO should refine their energy agenda in line with the new requirements of production management and service delivery to fight against climate change and achieve a green transition.

The creation of working groups such as those developed by the New Incubation Forum for Circular Economy in European Defence could improve circularity by analysing the trajectory of resources as well as the potential reuse of end products after their use as technological nutrients in other production processes. By focusing the efforts of defence ministries on energy and technology development, innovative solutions could be developed in the operational dimension, in the development of military capabilities and in encouraging large companies to update their business model.

Improved energy efficiency based on the implementation of the 7Rs model with efficient management of natural resources and supported by the use of renewable energies

together with new technologies (integrated into military logistics) can help establish better production management processes to strengthen the supply chain and reduce the carbon footprint of companies in the sector.

The path towards circularity has only begun and further progress is needed in the legislative sphere so that legislators, public administrations and actors in the economic fabric produce and implement measures to halt the worsening of the problems that threaten society. This new vision seeks a sustainable development of the economy, making it compatible with the preservation of the environment and the natural environment, within the limits of our planet.

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