CIRCULAR ECONOMY AS A DRIVER OF ENERGY TRANSITION AND CARBON NEUTRALITY

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Abstract
Circular economy is the new economic model which is intended to hopefully replace the still prevailing linear economy one, described as "take, make, dispose".

The aim of the circular economy is to reduce the environmental, climate and energy footprint of any human activity to preserve the resources of the planet and their overexploitation. Key resources of the planet, such as the critical raw materials, are instrumental for the energy transition as they are needed for eco-innovation, AI, RES, energy storage and electromobility. They need to be managed efficiently and recovered from waste containing them.

Circular economy is not only reuse and recycling of waste or wastewater. It is to be conceived holistically to cover all the sectors of the economy and to be mainstreamed in all of them. It requires circular economy plans both vertically and horizontally. From the national to the local level - we should be speaking about « circular city » - and in the business sector, as circular entrepreneurship and Circular ESG, C-ESG.

Circular economy is a new narrative and a new culture. We have one planet that we need to protect in the framework of the Sustainable Development, the SDGs, the Green Deal, the UNFCCC and the Paris Agreement. Circular economy becomes instrumental in serving all the above and is also a key element of the Taxonomy Regulation of the EU on Green projects and Green financing.

It is the « umbrella » of Green growth, Blue economy and Digital economy and as such it will boost the Green transition and by reducing substantially the emissions, enable us to reach climate neutrality by 2050, while protecting the environment, biodiversity and ecosystem services which are vital for the planet.

Key words: *circular economy, ESG, energy transition, net zero.*

Introduction

The planet is currently facing several challenges due to different causes, which often interact and lead to a spillover effect. The major one is climate change which has reached a critical level and is thus referred to as climate crisis, combined with the energy crisis, exacerbated by the wars, a food crisis, risks of pandemics and health related risks, and with a new flow of migration due to the wars, to the climate impacts and to political instability and human rights violations in different parts of the globe. All the above are exacerbated by the overpopulation

problem the planet is confronted with, which exceeds its carrying capacity and undermines the needs of the current and *a fortioti* the future generations. The circular economy as the new economic model is the only one that can preserve the resources of the planet, ensure resource efficiency, protect its environment and the quality of life, and preserve biodiversity and the ecosystem services that the green capital of the planet is providing. As it contributes significantly to the reduction of greenhouse gases and of pollution, it constitutes the key driver of the energy transition towards carbon neutrality.

I. The Circular economy concept

Circular economy is the new generation economic model aiming at progressively overriding the still prevailing linear economy one, described as "take, make, dispose", in other words use resources that are often scare to produce products which have a short life cycle, are not repairable and become rapidly waste, are difficult to reuse, valorize or recycle. Often those products have a high environmental, climate and energy footprint and in certain third countries are produced in violation of CSR and ESG patterns which do not institutionally exist there.

As the environment has no borders, any human activity that leads to pollution or uncontrolled emissions of CO2 and methane affects the quality of the environment of the planet, its biodiversity and boosts the climate crisis. Circular economy in its holistic concept can clearly reduce the environmental, energy and climate footprint of any human activity with the view to preserving the resources of the planet, their sustainability and reduce their overexploitation. It promotes resource efficiency by using less, in a more selective manner, resources, reintroducing resources into the economy through reuse, recycling, industrial symbiosis and waste to energy processes.

Key resources of the planet, such as the critical raw materials and rare earths are instrumental for the energy transition as they are needed for eco-innovation, AI, Renewable energy sources, energy storage, carbon capture storage and electromobility. They are also instrumental for the development of the *Net Pro-sumer* concept, from the words energy producer and energy consumer also in a net metering framework, which in practice encourages the production of RES by companies or households, mainly through solar panels and batteries storage of the energy produced during the day to be used during the night or sold to other entities or back to the grid, using digital and AI devices.

Circular economy *lato sensu* has started as a sound waste management model, managing solid - hazardous, industrial, and municipal - and liquid waste - industrial and sewerage - as raw materials or secondary products, in a zero-waste perspective, with the view to reintroducing them into the economic cycle and avoid downstream waste management. In this context the reverse waste hierarchy pyramid is the model to follow: waste prevention, reuse, recycling, waste to energy and a minimum landfilling fraction of the residue only - 10% under the revised EU waste framework directive, by 2035.

In this context industrial symbiosis is key; it covers what is industrial waste for company A, to be taken care of under the extended producer responsibility, and enables it instead to be used as a resource - raw material or secondary product - by company B and/or C, in a win-win situation. Industrial symbiosis is instrumental to promote circular economy through the development of Industrial Symbiosis Data Banks using digital economy and AI tools. As solid waste management is at the heart of circular economy, the development of the

appropriate framework of the extended producer responsibility and of the other economic tools is key to serve the waste hierarchy: The *Pay as you throw* and the *Deposit Return Systems (DRS)* reduce the production of waste, encourage reuse and promote recycling, and are key for the separate collection of waste and for collection at source.

In parallel, circular economy in liquid waste - industrial and sewerage - can lead to the extraction of raw materials and secondary products, and when it comes to municipal wastewater treatment - especially tertiary - to the reuse of treated wastewater or grey water for irrigation or industrial purposes. The relevant EU legal framework is established by Regulation (EU) 2020/741 of 25 May 2020, on minimum requirements for water reuse (OJ L 177, 5.6.2020, p. 32-55). The Water Reuse Regulation (WRR) will increase the trust of consumers and farmers in this circular approach to the use of water, ensuring it is safe and reducing the pressures of abstractions on increasingly scarce water resources. It will also help preserve the water resources needed by the aquatic and terrestrial ecosystems. This is a tool to help protect biodiversity, for achieving zero pollution and adapting to climate change. This new Regulation requires that urban wastewater, which has already been treated in accordance with the Urban Wastewater Treatment Directive (UWWTD), is further treated to meet the minimum quality standards of the Regulation to be suitable for agricultural use. As water stress is exacerbated by climate change impacts, the use of this reclaimed water in agriculture can play an important role in tackling water scarcity and drought. By setting minimum quality standards, the WRR promotes the safe use of reclaimed water in agriculture and ensures the protection of human and animal health and the environment. Circularity in the use of water for increased resilience is instrumental. Good quality water in sufficient quantity is vital for the sustainable growth of European society and economy and for the protection of the environment. However, freshwater resources in EU countries are increasingly coming under pressure, leading to water stress and poorer water quality. Climate change, with its unpredictable weather patterns and more frequent and severe droughts, is contributing significantly to lower water availability. In line with the European Green Deal and the principles of the Circular Economy, water reuse for agriculture can help preserve our freshwater resources and increase our resilience to water stress by reducing the water abstraction from rivers, lakes, and groundwater.

Agriculture supports the production of food and other agricultural products necessary for the health and prosperity of European citizens. EU is the global leader of agri-food exports, employing over 40 million people. However, the EU agriculture sector is also one of the major users of freshwater resources in Europe, accounting for approximately 50% of total annual water consumption. Water demand from agriculture is highest in late spring and summer when water availability is at its lowest in many parts of Europe. Water reuse can ensure that farmers have access to a more predictable supply of clean water and help them adapt to unpredictable water availability, as well as improve resilience to climate change and mitigate its impacts. In addition, reusing water can increase investment in innovative treatment technologies and competitiveness on the market. The Water Reuse Regulation sets out minimum standards to give EU citizens and businesses confidence in the quality of reclaimed water and agricultural products. It also sets out common monitoring requirements, risk management provisions for possible health and environmental risks, and ensures transparency, so that key information about any water reuse project will be available to the public. The Water Reuse Regulation is applicable as of 26 June 2023. The Regulation sets out: Minimum water quality requirements in the European Union for the safe reuse of treated

urban wastewaters in agricultural irrigation; Harmonized minimum monitoring requirements, notably the frequency of monitoring for each water quality parameter, and validation of monitoring requirements; Risk management provisions to assess and address potential additional health risks to human and animals, and possible environmental risks; Permitting requirements for producing and supplying reclaimed water; Transparency, whereby key information about any water reuse project is made available to the public. The Member States have been preparing for the application of the new rules, with many choosing to integrate the new rules into relevant national laws or strategies. Some are also regulating water reuse for applications beyond agricultural irrigation. Where treated wastewater is reused for irrigation in agriculture, this has to be done in accordance with the new rules.

However, the Water Reuse Regulation allows Member States to decide not to practice water reuse in their territory or to limit the water reuse in certain areas. Some Member States, where freshwater resources are abundant and irrigation demand is low, have planned not to allow water reuse for irrigation in their countries. Other Member States have not yet made a final decision, as resource and infrastructure costs still are being evaluated.

Apart from the higher standards of the WRR, treated water can also be used for industrial purposes - cooling - and to possibly support a secondary network of water to be used for washing boats and yachts in marinas.

Finally, the dried - ideally through RES - sludge from the Wastewater treatment plants can be used for the production of compost or for alternative fuels.

As regards solid waste, the amended 2008/98/EC waste framework directive establishes ambitious reuse and recycling targets: by 2025 the preparing for re-use and recycling of municipal waste shall be increased by weight to a minimum of 55%. The target by 2030 is 60% and by 2035 65%, while by 2035 landfilling cannot exceed 10%. Only the residue can be landfilled, while there is a percentage of approximately 25% to 35% of residual waste that could be incinerated in line with the waste to energy communication. To reach those targets, economic instruments are key. The *Deposit and Refund Scheme (DRS)* and the *Pay as you throw (PAT)* in combination with the *extended producer responsibility (EPR)* are to be fully implemented as they lead to separate collection and to clean recyclables streams, avoiding thus detergents to clean the sorted waste, and additional mechanical sorting.

EPR schemes require producers to take responsibility for the entire lifecycle of their products, in particular at the end of the product's life. The level of the financial contributions of the producers will be based on the circularity and environmental performance of the products concerned.

As regards non-hazardous construction and demolition waste, the target for re-use, recycling, and other material recovery by 2020 was 70% by weight.

The most recent amendment of directive 2008/98/EC is presented in the 2023 proposal of the Commission which regulates prevention of food waste generation in primary production, in processing and manufacturing, in retail and other distribution of food, in restaurants and food services, as well as in the households. The proposal foresees that the Member States shall review and adapt their food waste prevention programs to achieve by 31.12.2030 the following targets: a) reduce, by 2030, the generation of food waste in processing and manufacturing by 10% in comparison to the amount generated in 2020; b) reduce by 2030 the generation of food waste per capita, jointly in retail and other distribution of food, in restaurants and food services and in households by 30% in comparison to 2020.

The proposal also establishes an extended producer responsibility (EPR) scheme for textiles and footwear products. Under such schemes, textile producers will contribute to the management of used and waste textiles. By being responsible for the end of lifetime of the products they sell, producers will be encouraged to design longer-lasting textile products that are easier to be reused, repaired, and recycled and thus promote circular economy in the sector. In the proposal it is foreseen that Member States shall ensure by 1 January 2025 the separate collection of textiles for re-use, preparation for re-use and recycling. The first *Whereas* of the proposal refers to the Green Deal and the Circular Economy Action Plan which call for action to ensure sustainability of the textiles and food sectors as they represent top resource intensive sectors that cause significant negative environmental externalities. On 18 February 2025 a provisional agreement was reached. The amended directive will promote circular economy throughout the EU, notably by fostering innovation and moving towards more sustainable industrial and consumer practices as regards textile and food waste.

Circular economy is to be conceived *lato sensu*, i.e. in its broadest sense, covering not only solid and liquid waste, but also sustainable production and consumption patterns, Renewable energy sources (RES), electromobility, energy storage and eco-innovation. The idea is to produce new generation products which use circular economy resources, originating from recycling, have a longer life cycle, are repairable and can be easily recycled at the end of their life cycle. Important to that effect is the proposal for a Directive on common rules promoting the repair of goods and amending Regulation (EU) 2017/2394, and Directives (EU) 2019/771 and (EU) 2020/1828. This is part of the Green Deal objective of sustainable production and consumption in a comprehensive manner, combined with various other initiatives that tackle different aspects of premature disposal of goods on both the supply and demand side.

On the supply side, the Regulation (EU) 2024/1781, of 13.6.2024, establishing a framework for the setting of ecodesign requirements for sustainable products, sets the framework for product reparability at the production phase, in particular on product design requirements and the availability of spare parts. The aim is to make sustainable products the norm and to reduce the overall carbon footprint and environmental footprint of products over their life cycle. This proposal results from the Circular Economy Action Plan of 2020. The plan underlines that, for citizens, the circular economy will provide high-quality, functional, and safe products, which are efficient and affordable, last longer and are designed for reuse, repair, and high-quality recycling.

On the demand side, the proposal for a Directive (COM/2022/143 final, 30.3.2022) on empowering consumers for the green transition through better protection against unfair practices and better information, provides for better information on the durability and reparability of goods at the point of sale. This enables consumers to take informed sustainable purchasing decisions. This Directive is complemented by another Commission proposal, adopted on 22.3.2023, for a Directive on new rules on substantiating green claims, which tackles false environmental claims, and the wide expansion of public and private environmental labels. The two aforementioned proposals establish a regime for environmental claims and labels with the aim of combatting greenwashing.

Another relevant proposal is the Regulation on harmonized rules on fair access to and use of data (Data Act), under which users of connected products shall have access to data they generate during their use and have the right to give such data to a third party of their choice. Such data access will be relevant for independent repairers.

II. Energy transition and green transition towards carbon neutrality

Climate change and environmental degradation are an existential threat to the EU and to the world. To overcome these challenges, the European Green Deal is the new growth strategy of the EU, aiming at transforming the Union into a sustainable, resource efficient and competitive economy. The goal is to make the EU climate neutral by 2050, boost the economy through green technologies, develop sustainable industry and transport, cut pollution, and create green jobs. The road map is to reduce greenhouse gas emissions by 55% in 2030, 90% by 2040 and reach net zero by 2050. The Greek climate law foresees an 80% reduction target by 2040, established when the EU had no 2040 target foreseen.

The energy and green transition are the process towards climate neutrality. Turning climate and environmental challenges into opportunities will make the transition just and inclusive for all.

The energy or green transition is thus a road map on how progressively the greenhouse gas emissions can be reduced and the economy transformed with the view to reducing the environmental, energy and climate footprint of any human activity. It also encompasses the promotion of RES against hydrocarbons, the production of alternative fuels, the electromobility, and the development of green energy in general, including hydrogen, as well as storage capacity. This process combined with zero pollution and the protection of biodiversity is enshrined in the Green Deal and in its implementing rules: the Fit for 55 package and REPowerEU. The European Commission helps Member States design and implement reforms that support the green transition and contribute to achieving the goals of the Green Deal. Moreover, the EU is fully committed to being a front runner in implementing the 2030 Agenda for Sustainable Development, jointly with its Member States. The 17 sustainable development goals (SDGs) aim at protecting the planet from climate change and environmental degradation and at improving quality of life, so that it can support the needs of present and future generations, the very notion of sustainable development. As of 2020 the European Commission has reinforced its analysis and monitoring of the achievement of SDGs in the European Semester process. In parallel Member States are mainstreaming SDGs in their policy making and developing targeted policies to move towards sustainable development.

The green transition is broader than the energy one as the former is holistic in terms of transformation of the economy and management of human activities, while the latter refers to the transition of the energy sector. Decarbonising the energy system is critical to reach the EU's climate objectives in 2030, 2040 and 2050. At the same time energy needs to be secure and affordable for consumers and businesses. To that effect, Member States must transform their energy systems into a fully integrated, digitalised and competitive component of an EU energy market that is based largely on RES. In addition to regulatory reforms, Member States need to enable and promote further investments in clean energy, including energy efficiency. In that respect the promotion of green hydrogen, as the fuel of the future, is key for the energy transition and is eligible for financial support by the European Hydrogen Bank, a financing instrument to accelerate the establishment of a full hydrogen value chain in Europe, by creating investment security and business opportunities for European and global renewable hydrogen production. Trans-European Networks of Energy (TEN-E) supported financially by the Connecting Europe Facility (CEF) are instrumental in promoting the green transition and developing through Projects of Common Interest (PCIs) and/or Projects of Mutual Interest

(PMIs) the appropriate new cross-border energy infrastructure in Europe or rehabilitating and upgrading the existing one.

III. The interaction between circular economy, green transition, and carbon neutrality.

The still prevailing linear economy model is the one that leads to the still prevailing unsustainable production and consumption patterns, to the overuse of the planet's resources exceeding its carrying capacity, to environmental degradation, loss of biodiversity and to the climate crisis. It is only thanks to circular economy, the new economic model, that all the above challenges can be successfully addressed. Indeed, circular economy will preserve the already scare resources of the planet, ensure resource efficiency, reintroduce in the economy the so much needed for the energy transition and digital economy critical raw materials, and most importantly reduce the climate, environmental and energy footprint of any human activity, while creating green jobs. As regards the latter, the International Labor Organization estimates that transitioning to a circular economy could increase global employment by 7-8 million jobs by 2030.

The key main pillars of EU action are green growth, blue economy, and digital economy. The overarching umbrella is circular economy which needs to be mainstream to all these three pillars to make them circular and promote interaction amongst them: ensuring thus circular digital green growth and circular blue, green growth economy. This mainstreaming needs to be both vertical - top down and bottom up - and horizontal. Vertical from the EU level, to the Member State level, covering the central, regional and municipal level, and horizontal in mainstreaming circular economy into all EU and national policies with the view to making them circular: circular agriculture, fisheries and aquaculture, circular tourism, transport, energy, etc. Circular economy has also to be mainstreamed in the business sector as circular entrepreneurship, and in the Environmental and Social Governance, ESG to upgrade it into CESG, i.e. circular environmental and social governance. Indeed, moving to a circular model can benefit businesses. By redesigning business models, production processes and products, circular businesses can significantly reduce their material, energy, and waste management costs, resulting in higher yields and competitive advantages, and benefit from green financing for their projects.

Promoting circular economy within the three aforementioned pillars of EU action and mainstreaming it vertically and horizontally ensures also compliance with the EU Taxonomy Regulation which promotes green projects and ensures green financing. The implementation of all the above requires circular economy strategies and plans, at national, regional and local level. As regards the last one, it is important from now on to promote the holistic concept of circular city, instead of the narrower smart city one. It also requires circular economy plans at company level through Circular ESG, to promote circular entrepreneurship. New EU reporting requirements are foreseen to that effect, together with the interdiction of green washing.

The circular economy contributes to climate neutrality by fundamentally changing *inter alia* the production process, the use of resources and the way we dispose of resources. About 45% of global greenhouse gas emissions come from product manufacturing and use, along with food production. Applying circular economy strategies in just five key areas - cement, aluminum, steel, plastics, and food - could eliminate almost half of global greenhouse gas

emissions from the production of goods - 9,3 billion tonnes of CO2 by 2050. This is equivalent to cutting current emissions from all transport to zero (Circular economy Overview 2024, EIB).

In concrete terms the contribution of circular economy is deployed in the following terms:

a) Reduction of the greenhouse gas emissions by keeping products and materials in use longer - through reuse, repair, remanufacturing, and recycling the circular economy cuts emissions associated with raw material extraction, production, and waste management.
b) Minimization of waste. Landfills and mass burning incineration release significant CO_2 and methane. Circular strategies reduce waste generation, thus reducing emissions from waste treatment.
c) Lowers demand for virgin resources. Extracting and producing new materials (like steel, aluminum, or plastic) is energy intensive. Using recycled materials or designing for longevity cuts this demand, saving energy and reducing emissions.
d) Encourages renewable energy and sustainable design. Circular models often align with clean energy use and eco-design principles, which further support climate neutrality goals.
e) Promotes carbon capture through biological cycles. In the bio-based part of the circular economy (e.g., composting, regenerative agriculture), carbon is absorbed and stored in soils and biomass, acting as a natural carbon sink.

In short, the circular economy supports climate neutrality by decoupling economic growth from resource consumption and emissions, helping to build a low-carbon, resilient, and sustainable future.

To boost green transition, eco-innovation, AI, robotics, RES investments and energy storage are instrumental. They require mostly for their production critical raw materials for which the EU is in need: they are scarce and the rare earths in the EU are seldom. Critical raw materials are also key for aerospace and defense.

It is thanks to the circular economy and the recycling pillar of waste management that such critical raw materials can be identified, recovered, and reintroduced in the economy. To that effect, Regulation (EU) 2024/1252 of 11 April 2024 establishing a framework for ensuring a secure and sustainable supply of critical raw materials was adopted (OJ L, 2024/1252, 3.5.2024).

IV. Conclusions

Notwithstanding the declaratory emblematic importance that circular economy has gained in the EU thanks to the Green Deal and its implementing legal framework, as well as worldwide thanks to the references to it in the last COPs under the UNFCCC, and in the SDGs, the rate of circularity worldwide is declining. In the last five years up to 2023, humanity consumed 500 billion tonnes of materials, nearly equal to what was consumed during the entire 20th century. The global circularity rate has fallen steadily from 9.1 in 2018, when Circle Economy Foundation began measuring, to 7.2% in 2023. More virgin materials are consumed than ever, while the share of secondary materials is in decline. This results in exhausting more and more the carrying capacity of the planet and making the threat that two planets will be needed by 2050 seem unfortunately realistic.

At the EU level, the aim is to double recycled material use, in terms of its share of the economy's total material use, between 2020 and 2030, as set in the 2020 Circular Economy Action Plan. Increasing the use of secondary materials would reduce the extraction of primary raw materials and related environmental and carbon impacts. Recycled material accounted for 11.8 % of material used in 2023, an increase of 1.1% from 2010, a rate which is considered low, indicating the economy is still mostly linear. This slight positive trend is mainly due to increases in waste recycling rates driven by Member States to meet EU recycling targets. Nevertheless, the EU is not currently on track to double the circular material use rate by 2030 and more generally to transform progressively its economy into a circular one.

The circular transition process goes hand in hand with the energy and green transition ones and requires all the adopted pieces of legislation under the policy framework of the Green Deal to be fully implemented at EU level and within the Member States. The circular economy transition process is both a top down and a bottom up and has a strong social component represented by the social circular economy, as regards the latter. Energy communities promoting RES and social cooperative initiatives are key to fully involve in the process the civil society in a circular entrepreneurship mode and to enable it to gain ownership in the implementation of circular economy. Moreover, the phasing of fossil fuels, in particular of coal is supported by the Just Transition Fund in the territories expected to be the most negatively impacted by the transition towards climate neutrality.

The exacerbation of the climate crisis and the limited mainstreaming of the circularity in the economy requires additional efforts for a vertical and horizontal mainstreaming at all policy levels and in all the sectors of the economy through tailored circular economy plans and CESG as regards circular entrepreneurship. The new narrative requires the holistic model of circular economy to become the rule and to prevail, not only at EU but also at global level. Key drivers to that effect can become the citizens of the planet shaping the new concept of circular citizen and of circular household leading to a reduction of the environmental, carbon and energy footprint of any human activity. The environment has no borders and in this combat against climate change only a universal response can provide the solution through circular economy.

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