CIRCULAR ECONOMY: RESEARCH AND INNOVATING FOR A SUSTAINABLE FUTURE

The expression "circular economy" has entered our ears and has become indelible in our professional, family and lives as a citizen. However, the concept and its implications may not have been fully internalized yet. In addition to the basic principles, we need to better understand the implications of this concept in production systems and research, where it should be embraced as a new paradigm.

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Imagine that it is time to replace your washing machine. After a first selection made online, you go to a store where the machines you pre-selected are on exposition. It is in the final stage of your decision. You open the "Sustainability" application on your smartphone and point the camera at one of them. The application recognizes the model and presents you with information previously customized by you as important when purchasing an appliance. This includes, amongst others: information on energy efficiency (average electricity and water consumption costs), expected life span for the main components and respective probability of replacement at the end of that period, comparison of the collection services of the old machine in terms of the incentives received or the reduction of packaging and transport materials. The application also shows a ranking of the brand and respective models, related to the Product's Environmental Footprint (through LCA models - "Life cycle analysis") and its social assessment of the life cycle (social-LCA). Based on this information, you will decide what your next washing machine will be, with the satisfaction of being able to decide not only based on individual economic criteria, but also taking into account environmental and social sustainability aspects.

What is the circular economy?

In this context of increasingly digitalised products, we are led to imagine, just as in the scenario described above, a world where, as consumers, we have the power to participate actively and positively in the management of the life cycle of products we buy, resulting in less of an environmental impact on the planet and promoting greater sustainability. It is thus possible to create a virtuous cycle in which organizations (companies, public entities, non-governmental organizations, associations, etc.) can collaborate and then assist consumers, who, as a result of their awareness, start to model their behaviours and decisions in a properly informed manner. But what does "Circular Economy" mean? One of the international non-governmental organizations that has been working actively and with high visibility to foster a world based on Circular Economy principles is the Ellen MacArthur Foundation[1], which defines Circular Economy as "A new way of designing, developing and using goods and services, respecting the boundaries of the planet. It involves decoupling economic activity from the consumption of finite resources and eliminating waste from the system by principle. It must be based on a transition to renewable energy sources, in an economic, natural and social way". Three fundamental principles are defined: design out waste and pollution, keep products and materials in use, regenerate natural systems. The adherence of products and the respective activities carried out in production with these principles, came about in the observance of norms, techniques and good practices, define their "circularity", that is, the way they contribute to managing the cradle-to-cradle life cycle. Due to the recent international policies, agreed by dozens of nations, together with a greater awareness of the citizens, the Circular Economy paradigm is gaining more and more attention, with multiple initiatives embraced by organizations, accelerating its implementation. New terms and words are gradually entering the vocabulary of consumers, such as the "circularity" of products and materials, or the promotion of renewable energy sources (such as in photovoltaic electricity for self-consumption). We are

heading, hopefully at a faster pace, to a near future in which a consumer has easy access to the "circularity" information of a given product through a simple QR code, which he/she accesses via smartphone, to have information in quantities, degrees of recyclability or reuse of raw materials, relevant data on the manufacturing of the product, expected lifetime, and possibilities for retrofitting or upgrading. These will be fundamental to the future phases-of-use of the product, or to the best way to manage its end-of-life e.g., where to discard it properly.

Circular production: the link between value chains

Production systems, technological companies and waste treatment and recovery companies play a key role in the transition and should act in the direction of wide decarbonisation of their activities and the carbon footprint of new products throughout their use. A key aspect of this process is to base the design of new products on principles of Sustainable Design (also known as EcoDesign) and integrating new design approaches for Circularity, providing multiple product use cycles, via facilitated upgrades, reconfigurations, simplified reconditioning and repairs, or even components reuse. The design for circularity implies not only production systems designed with the objective of minimizing the consumption of materials and energy, but also putting in place enriching and socially fair work practices. Emerging information and production technologies are a key factor in the evolution towards a full circular model. For example, the need to establish interconnected value chains, consolidated in an "industrial symbiosis" is complex, requiring advanced coordination and information systems, using technologies such as the Industrial Internet of Things, Blockchain, Digital Platforms, techniques for handling large amounts of data and securely, reliable and distributed information systems.

The circular economy as a paradigm for R&D in the industrial area

To accelerate and widen the implementation of the Circular Economy paradigm, building capabilities for Research and Development (R&D) in industrial companies is fundamental, not only for the design of new products and services based on circularity, but also for reformulating and redesigning their production systems and, more broadly, the entire industrial ecosystem. From research on new synthetic materials, substitutes for non-renewable resources or materials whose production is harmful in environmental terms, to research about new business models, R&D in the industrial area should be governed by the circularity paradigm, aiming at much more than just contributing to economic sustainability. In fact, there are many products, such as mechatronics, textiles, footwear, where the production phase represents high environmental impacts, whether through the materials and processes used, or the energy intensity involved. It is therefore essential to research strategies for life cycle assessment in production systems, measuring in particular their impact on carbon footprint and water footprint depending on their products. It is also important to coordinate the design of new products oriented to material circularity and carbon neutrality, with more sustainable production systems (economically, environmentally and socially).
INESC TEC's multidisciplinary approach to research, intersecting industrial engineering and management, robotics, artificial intelligence, information systems and energy systems management has contributed decisively to innovate and adopt the circular economy paradigm. An example is the innovative platform for product life cycle management (PLM) developed in collaboration with INEGI as part of the Produtech_SIF mobilizer project[2].

[1] http://www.ellenmacarthurfoundation.org
[2] http://mobilizadores.produtech.org/pt/sif