

Key enabling technologies for a circular economy

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Abstract— Key Enabling Technologies (KET) support the adoption of Industry 4.0 (I4.0) and could act as facilitators of the Circular Economy (CE) transition. Nevertheless, research and reports on the most suitable technologies to guide enterprises and industry to lead the twin digital and green transition are still poor. This work is aimed at contributing to this matter, defining the most implemented I4.0 technologies with the purpose of accelerating CE practices within the industry. From the analysis, the most used technologies with CE objectives and the industry sectors where they are implemented are identified. As conclusion, a set of recommendations are provided as a guide for policymakers, researchers, and industry managers on how to foster the CE through the implementation of KET.

Keywords— key enabling technologies; circular economy; industry 4.0; twin transition

I. BRIEF TECHNICAL CONTENT DESCRIPTION OF THE WORK

First, the basic elements for this research were established, i.e., its objective and methodology, through preliminary research about the topic. Secondly, a review bibliography process was carried out. The methodology used is based on the UNE 166006 Technology Watch System, used by CETEM (Technological Centre of Furniture and Wood, affiliation of some of the authors of this work). A review of the bibliography, inventions, innovation activities, policies, etc. related with the twin digital and green transition was performed. Different databases were consulted in accordance of the reviewed materials: scientific papers (Web of Sciences, Scopus, Dialnet Plus), Patents (Espacenet, USPTO, Japanese Patent Office JPO, WIPO), Research projects (CORDIS, Erasmus+, Interreg Europe), and current technological solutions implemented (Eurostat, EUR-Lex, site of the Advanced Technology for Industry). The review was done using different keywords, such as Key Enabling Technologies (KET), Circular Economy (CE), Industry 4.0 (I4.0), Twin Transition, etc. After a first scanning of the extracted information, it was defined a total of 12 European projects, 5 patents, and 9 commercial solutions where I4.0 technologies are implemented with sustainable purposes.

After the analysis of the selected projects, patents and commercial solutions, it has been identified which I4.0 technologies are used for supporting the CE transition and the different industry sectors where they are applied. This identification allows to classify KET regarding their knowledge/use to foster CE practices, and industry sectors regarding their level of twin transition implementation.

As result of the detailed research process, it is defined three technologies most used as enablers of CE practices: Big Data, Artificial Intelligence and Internet of Things, mainly used to monitor energy consumption and dynamic analysis to support CE energy management. Moreover, two additional technologies also implemented with sustainable purposes are Robotic, mainly used to facilitate waste sorting and assembling processes: and Additive Manufacturing, as key facilitator of eco-design practices. Regarding industry sectors, waste management has been rapidly transformed through the application of the mentioned technologies to improve the efficiency of its different processes. Other industry sectors where it has been detected practices of implementing I4.0 technologies to accelerate CE practices are automotive, construction, electrical and electronics, mobility and manufacturing industry sectors such as furniture or textile. Finally, as conclusion of this research a set of recommendations (Fig. 1) for the improvement of the twin digital and green transition are proposed as a guide for policymakers, researchers, and industry managers on how to foster the CE through the implementation of I4.0, ensuring that the society reaches a sustainable and smart industry model. Recommendations are classified on three different levels to facilitate its future implementation by the according actors: industry, technological, and knowledge. For each operational category or level, it has been set two concatenated recommendations, allowing all actors to follow a logic order on their integration.

II. RELEVANCE AND NOVELTY

At a European policy level, accelerating the twin digital and green transitions has been set a European priority, in line with the EU's new growth strategy, the European Green Deal, that will be key to build a lasting and prosperous growth. In this way, the European Commission states that Europe must leverage the potential of digital transformation, which is a key enabler for reaching the Green Deal objectives.

Nevertheless, besides all the recent efforts to boost and promote the necessary digital and green transition within the industry, there is a lack of information and examples on how KET could support the circular transition towards a smart and sustainable industry. Therefore, the goal of this work is to analyse the most used KET with the objective to facilitate CE transition and the industry sectors where these practices are most implemented. From the analysis, a set of recommendations are reported as a useful guideline for policymakers, researchers, and industry managers, on the necessary steps for a successfully twin transition.

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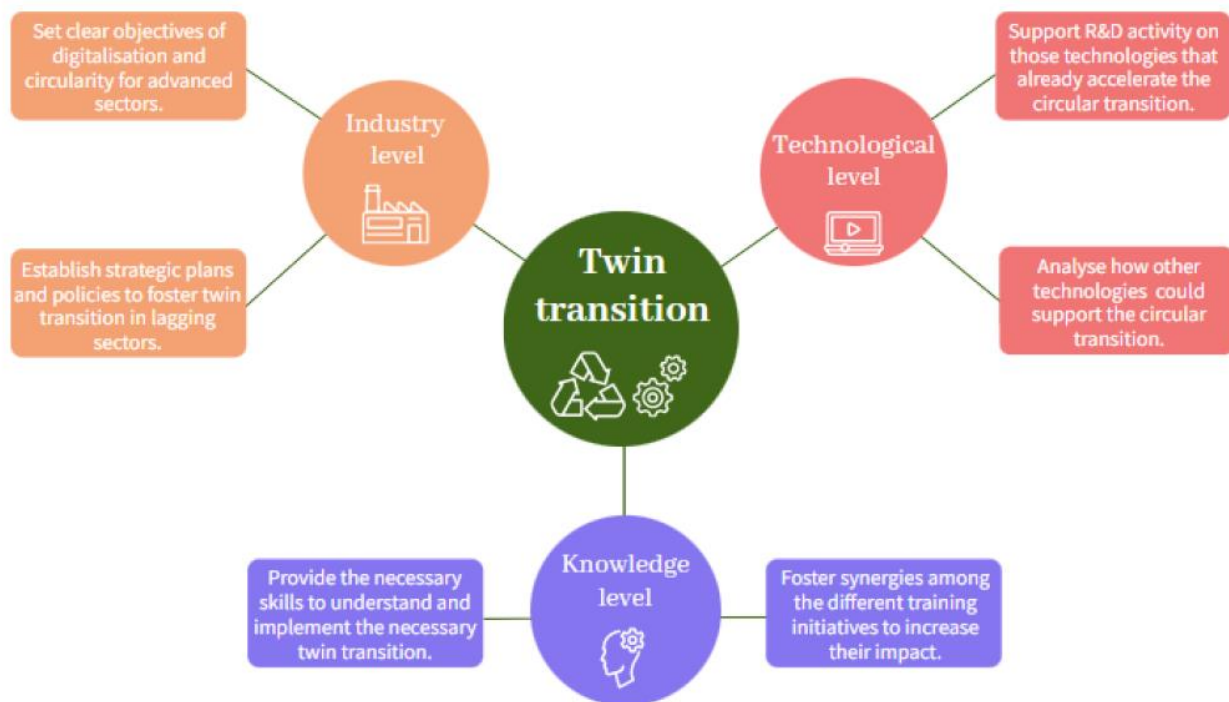


Fig. 1. Set of recommendations for the improvement of the twin digital and green transition through the implementation of I4.0 (Ortega-Gras et al., 2021)

This research and its conclusions offer to the ICT4S community the opportunity to discuss about how ICTs or KET could foster the CE transition, aligned with the European key objectives regarding a twin digital and green digital, while establish future lines of collaboration and research in order to get a common understanding between KET and CE practices that accelerate the twin transition and guarantee the achievement of the European Commission objectives for the next years.

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