Industry 4.0: A Key Enabler of the Circular Economy

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Key messages

- Digitisation activities associated with Industry 4.0 and the Internet of Things are prompting a step change in the efficiency of industrial processes.
- Real-time automated monitoring of factory processes facilitated by Industry 4.0 platforms enables manufacturers to improve productivity, and energy and resource efficiency, with a one-year return on investment.
- Interconnecting Industry 4.0 systems could help to create real-time digital marketplaces for production waste, enabling diverse by-product exchanges and resource sharing across industries.

Introduction

Industry 4.0 refers to real-time data exchange enabled by the interconnection of humans and machines through the Internet of Things,[1] creating a digital virtual copy of the real world. It is the next phase of digitisation in manufacturing, following on from the advent of lean manufacturing in the 1970s, outsourcing in the 1990s and automation in the early 2000s (see Figure 1).[2]

Industry 4.0 represents a major opportunity to use real-time data to improve productivity, and energy and resource efficiency. It is a key strategy for decoupling growth from material input. Developing a digital single market is worth around €415 billion per annum to the European economy, making it a key political priority for the European Commission.[3] Furthermore, between now and 2020, global industrial companies are likely to invest around US$907 billion (€834 billion) per year in digitisation activities.[4]

The activities associated with Industry 4.0 and the Internet of Things will play a key role in enabling the reconfiguration of linear industrial systems, such that materials, components and products cycle in virtuous circles as efficiently as thermodynamically possible (a circular economy). However, the transition to a circular economy in Europe requires industry to overcome digitisation challenges associated with inter-operability, standardisation and data security, in addition

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to maintaining system stability when industrial information and communication technology (ICT) systems are interconnected.

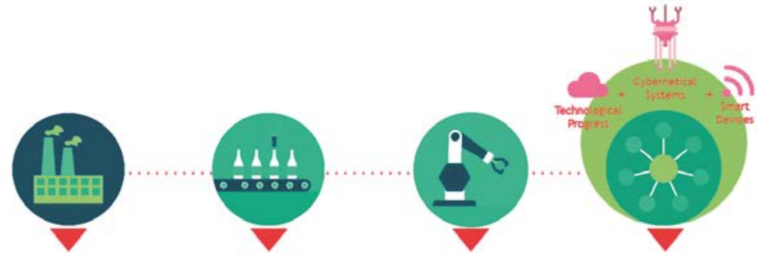
This *Insight* introduces the key characteristics and challenges associated with adopting Industry 4.0, exploring the key benefits perceived by small and large companies using these systems in their factories from the perspective of edinn, a Spanish Climate-KIC partner and technology leader in this field. The *Insight* highlights the potential for Industry 4.0 to enable increased and more diverse product exchanges through the creation of real-time digital marketplaces, concluding with the criteria for selecting an appropriate Industry 4.0 platform recommended by edinn.

Maximising total efficiency: the edinn Industry 4.0 platform

As one of several businesses working in this emerging space, edinn has developed an Industry 4.0 platform that seeks to maximise the total efficiency of production activities. This technology is composed of a cyber-physical system connecting different processes, from machines and humans to complete factories. The platform helps to manage and control (via its Manufacturing Execution System) and optimise (through operational intelligence, which refers to applying business intelligence principles to operations) production in factories of all sizes and from any sector.

The edinn Industry 4.0 platform is unique in that it includes energy and resource consumption metrics in the *de facto* ratio to measure the production efficiency of a process, referred to as overall equipment effectiveness. The metric used by edinn is referred to as the overall production and consumption effectiveness (OPEC) ratio, which measures the total efficiency of activities. Today, edinn's technology, which is compliant with International Society of Automation standards for integration of computerised industrial systems, is helping more than 3,000 users from different corporations around the world to increase their total efficiency from 5 to 40 per cent within less than a year of implementation.

Figure 1: Evolution from Industry 1.0 to Industry 4.0



Source: edinn

Characteristics of Industry 4.0 and potential challenges to its implementation

For a factory or system to be considered an example of Industry 4.0, four key characteristics need to be met:

- **Interoperability:** The exchange and use of information among machines, devices, sensors and people, enabled by effective standardisation.
- **Information transparency:** To contextualise the data collected using sensors, there needs to be a virtual copy of the physical world.
- **Technical assistance:** The system needs to support human decision making and problem solving by assisting with tasks that are too difficult or unsafe for users to accomplish.
- **Decentralised:** Cyber-physical systems need the capacity to make simple decisions and to develop an appropriate level of autonomy.

Some of the key challenges associated with adopting an Industry 4.0 model are:

- **Data/ICT security issues:** As ICT systems become integrated across organisational boundaries, it becomes necessary to ensure the protection of production-related intellectual property.
- **Reliability and stability:** As cyber-physical systems are used more often, they become more critical for production and, therefore, they need to become increasingly reliable and stable.
- **Integrity of production process:** This must be maintained and expensive production outages must be avoided.
- There is potential for **a loss of jobs** as new forms of automation are introduced.

Source: Marr (2016)[5]

Martínez y Cantó, a leading Spanish small/medium-scale enterprise in the infusions sector, is one of edinn's clients. The company makes automatic infusion bag packaging for tea brands, producing 8 million infusions per day, which equates to more than 1,872 million per year, sold across five continents.[6] The edinn platform enables Martínez y Cantó to automatically monitor and acquire data from around 40 machines within their 15,500 m^2 packaging plant. Real-time data collected relates to the quantity of saleable versus scrap products produced, quality variables, electrical signals and many other useful production metrics.

According to Javier Alted, Martínez y Cantó Production Manager, the value of having this information in real time is that it provides precise figures on factory processes. For example, it helps them to understand why machine downtimes occur. The edinn platform also allows them to detect frequency patterns and understand underlying problems and this helps to reduce downtime and improve overall productivity.

The benefits articulated by small/medium companies like Martínez y Cantó are reiterated by edinn's larger clients. For example, the multi-national Suntory Group, a global leader in soft drink production,[7] has integrated the edinn platform with its SAP software enterprise resource planning system across its production sites worldwide. José Luis Gutiérrez, Suntory Operational Excellence Coordinator, describes the edinn platform as "essential to determine, analyse and improve" Suntory's productivity and efficiency.

The edinn platform allows client companies to measure the total CO_2 generated by factory activities, given that achieving a 10 per cent reduction in OPEC is roughly equivalent to a 10 per cent reduction in CO_2. Once CO_2 generation from industrial systems can be measured automatically, ways to further reduce emissions can be evaluated. These may include investing in renewable energy or increasing local carbon sequestration by planting trees near the source of CO_2-producing activities.

Real-time digital marketplaces for by-product exchanges

Industry 4.0 platforms provide real-time information about when, where and what has been consumed or produced. Interconnecting Industry 4.0 systems from different factories could therefore help to create real-time digital marketplaces for the exchange of by-products and sharing of resources between factories and across industries. Such activities would allow companies to source and price by-products from the production processes of other factories and use them as alternative secondary or raw material inputs. This could prove highly cost effective.

edinn Industry 4.0 platform tablet interface

While digital platforms enabling product and by-product exchanges already exist,[8] they tend to require additional manual work to upload information relating to the quantity and quality of the materials, components or products available, rather than connecting factories and potential supply chains in real time. The inevitable time lag resulting from a manual system makes it difficult to match supply with demand, creating supply reliability issues.

In contrast to the digital platforms already in existence, edinn is prototyping a digital marketplace that interconnects the multiple Industry 4.0 systems of different factories, thus matching available supply and demand automatically and increasing the potential for by-product exchanges to occur. Users of the edinn platform view the application as having the potential to revolutionise the marketplace for both supply-chain partners and end users. According to José Luis, IT Manager at Quimi Romar, a Spanish household goods and cosmetics company,[9] a real-time digital marketplace would allow production plans to be shared with relevant providers, thereby allowing the delivery of materials to be scheduled according to fluctuations in real-time demand.

Considerations when adopting an Industry 4.0 system

From experience gained when working with hundreds of companies on their Industry 4.0 journeys, edinn considers that one of the best ways to begin is to start measuring ratios like OPEC automatically and in real time. This is a useful entry point because it creates the basic platform from which the other Industry 4.0 functions can be built. Establishing the OPEC of a production line is quick and easy to accomplish since it takes only five days to start monitoring and calculate the OPEC of one line. This is a feasible goal with a one-year return on investment, making it an ideal first step to sell internally. All the factories that have worked with edinn have increased their overall total efficiency within this time frame.

It is important to engage actively with employees when implementing a new Industry 4.0 system. Managers need to take them on the journey to adoption, ensuring their buy-in and allaying their fears along the way to prevent them becoming a barrier to implementation.

Conclusion

By implementing Industry 4.0 systems, companies can maximise the productivity, and energy and resource efficiency of their production activities and contribute to the reduction of associated CO_2 emissions. The creation of real-time digital marketplaces for by-product exchanges is likely to play a key role in accelerating the transition to a circular economy.

Given the wide range of systems available on the market, edinn argues that the following criteria should be considered when selecting an Industry 4.0 platform.

- It should be relatively quick and easy to install with minimal investment, for example it should take one professional around five days to monitor one individual production line.
- It is crucial to ensure that the system's measurable benefits can be validated, for example during a trial period of monitoring its performance, before making a large financial investment.
- An established Industry 4.0 system with an existing platform of active users is a good indicator of an effective user interface that is producing the desired results.

Furthermore, to maximise the resource and energy efficiency gains made possible by Industry 4.0, it is important to select a certain type of system: a) one that can monitor or calculate, in real time, the total CO_2 generated by production activities, at a minimum notifying users when CO_2 limits have been exceeded; and b) one that allows material by-products, components or products to be sourced or sold via a digital marketplace, detecting and informing the user automatically about available supply and demand.

While Industry 4.0 systems help users to maximise their efficiency, there is a physical limit, known as the total possible efficiency. It follows that efficiency gains associated with Industry 4.0 and the Internet of Things will not be sufficient to remain within safe planetary boundaries.[10] Increasing resource efficiency at the production level is a key factor in making the transition to a low-carbon, circular economy, but maintaining levels of resource use that are within planetary limits will also require action to promote sustainable consumption and production systems.

Endnotes

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3. See European Commission communications (2015): *A Digital Single Market Strategy for Europe* (http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1447773803386&uri=CELEX%3A52015DC0192) and Digital Single Market for business and consumers (https://ec.europa.eu/growth/single-market/digital_en).
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5. Marr, B. (2016) *What everyone must know about Industry 4.0*, Forbes, (https://www.forbes.com/sites/bernardmarr/2016/06/20/what-everyone-must-know-about-industry-4-0/#31678b9f795f).
6. See Martínez y Cantó website: http://www.martinezycanto.com/empresa-en.php.
7. See Suntory website: http://www.suntory.com/.
8. See for example: Conectando para una Economía Circular (Spain): http://www.suschem-es.org/2013/eventos/encuestas/economia_circular.asp; Smile Resource Exchange (Ireland): http://www.smileexchange.ie/; and National Industrial Symbiosis Programme (UK): http://www.nispnetwork.com/.
9. See Quimi Romar website: http://www.quimiromar.com/en/.
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Climate Innovation Insights is a platform for reflection and discussion on the lessons, challenges and opportunities of addressing climate change through innovation. It brings together key insights, informed opinion, best practice and methodological approaches to understand how research, education, business and government can, together, accelerate the transition to a zero-carbon economy. The series is developed and published by Climate-KIC, Europe's largest public–private partnership focused on climate innovation. We would like to thank the Series Editor, Dr Geraldine Brennan and the two external reviewers, Dr Carmen Ruiz Puente and Dr Inês dos Santos Costa.

About Climate-KIC

Climate-KIC is Europe's largest public–private partnership addressing climate change through innovation. With a focus on sustainable production systems, Climate-KIC is building a new foundation for industry in Europe – developing climate-friendly and economically viable circular models of manufacturing for a zero-carbon economy. Climate-KIC is supported by the European Institute of Innovation and Technology (EIT), a body of the European Union.

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About edinn and CEEDR

edinn develops solutions that help to increase productivity and total efficiency. The edinn Industry 4.0 Platform is used in 11 countries by SMEs and global corporations. The Centre for Enterprise and Economic Development Research (CEEDR), Middlesex University Business School, has been a leading research centre on small business and regional development policy for over 25 years and is currently leading research on sustainable enterprise for the Economic and Social Research Council Centre for the Understanding of Sustainable Prosperity.

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