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Creating a digital roadmap for a circular economy

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Terminology

APPLICATIONS OR APPS are computer software or programmes designed to perform a specific function, and most commonly used and designed for mobile devices.

ARTIFICIAL INTELLIGENCE (AI) is broadly understood as a machine's capability to perform tasks which would normally require human intelligence. It allows machines/programmes to 'learn' and alter their operations based on previous 'experience'.

BIG DATA are large datasets that can be used to analyse and reveal patterns, trends and associations.

BLOCKCHAIN is a distributed ledger that can be used to record and share information securely and enable online transactions. Information is managed in a decentralised way and made available to those with access.

CIRCULAR ECONOMY (CE) is an economic system which aims to maintain the value of products and materials for as long as possible, minimise resource use and waste by increasing the repair, recovery, reuse and recycling of materials and products. It is enabled by novel business models and responsible consumers.[1]

DIGITALISATION of our economy and society builds upon increased connectivity and data gathering, sharing and analysis; to maximise its value to produce better products and services. It starts with digitisation, i.e. converting information from a physical format (e.g. paper, images) into digital data. Digitised data and digitally-enabled solutions can be used to improve business models, processes, products and services, to change thinking and even disrupt current practices.[2]

DIGITALLY-ENABLED SOLUTIONS include physical hardware combined with software (e.g. computers, IoT) or virtual software (e.g. apps, AI) that use data and can be continuously modified. Some solutions are already in use (e.g. apps, sensors, online platforms), while others (e.g. related to AI, IoT, blockchain, 3D printing) are still under development.

DIGITAL TWINS are virtual models or digital replicas of something that exists in the physical world, like a good, a process or a service. They can be used to e.g. predict and optimise production systems before eventually investing in prototypes.

INTERNET OF THINGS (IOT) AND 'CONNECTED DEVICES' are everyday physical objects or devices connected to the Internet, and which can identify themselves to other objects. IoT can be used e.g. to predict when machines need maintenance or to micromanage energy usage.

LIFE-CYCLE ASSESSMENT is the compilation and evaluation of the inputs, outputs and potential environmental impacts of a product throughout its life-cycle.

MACHINE LEARNING is a subpart of AI, whereby a machine is trained to use large amounts of data and algorithms to find connections and perform tasks.

ONLINE PLATFORMS are used for a variety of activities such as information exchange, trading and price comparison.

SENSORS are devices that detect and respond to input from or changes in its physical environment (e.g. light, heat, motion, pressure). The data/information they gather is often transmitted to other electronic devices, such as a computer.

3D PRINTING/ADDITIVE MANUFACTURING are computer processes which join or solidify materials to create a three-dimensional object, often using less material in comparison to traditional manufacturing methods.

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List of acronyms

AI	artificial intelligence
B2B	business-to-business
B2C	business-to-consumer
CE	circular economy
DSM	Digital Single Market
ECHA	European Chemicals Agency
EPR	Extended Producer Responsibility
EU	European Union
GDPR	General Data Protection Regulation
GHG	greenhouse gases
ICT	information and communications technology
IoT	Internet of things
IPCEI	Important Projects of Common European Interest
IPR	intellectual property right
IT	information technology
LCA	life-cycle assessment
MFF	Multiannual Financial Framework
QR	Quick Response
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals (regulation)
RFID	radio-frequency identification
R&D	research and development
SDG	Sustainable Development Goal
SME	small- and medium-sized enterprise
UN	United Nations
VAT	value-added tax

Executive summary

Europe is currently in the midst of two transitions: the creation of a more circular economy and the digital revolution. These two major developments have the power to transform our economy and society. Major efforts are currently being taken by the European Union (EU) and national policymakers to promote both transitions – however, these efforts are rarely aligned.

This Discussion Paper shows that it is high time to manage them together. In so doing, the ultimate goal should be to ensure that they contribute to long-term sustainable economic, social and environmental prosperity, in alignment with the United Nation's Sustainable Development Agenda and Paris Agreement. They should share the objectives of mitigating climate change, addressing environmental challenges like resource depletion and pollution, increasing competitiveness and innovation, contributing to industrial modernisation and security, and supporting social cohesion.

Data and digitally-enabled solutions like digital platforms, smart devices, artificial intelligence, the Internet of Things and blockchain are already contributing to the circular economy. They are used *inter alia* to improve the use of natural resources, design, production, consumption, reuse, repair, remanufacturing, recycling and the overall waste management (*Figure 1*).

Fig. 1

It is important to recognise that digitalisation will not automatically lead to greater sustainability. In fact, there is a risk that if it is not guided well, it will result in unwanted rebound effects, such as an overdrive of a linear 'take-make-dispose' economy, and increase in greenhouse gas emissions. However, if adequately steered, data and digitally-enabled solutions could certainly boost the transition to a circular economy. They could help enhance connectivity and the sharing of information; make products, processes and services more circular; and empower citizens and consumers to contribute to the transition by increasing their awareness and enabling them to make sustainable choices and co-create knowledge.

The EU has the foundation to be ambitious: Europe is already an innovation hub using data and digitally-enabled solutions for greater sustainability. However, as many of these solutions are still small-scale or emerging, it is important to continue to build on this potential. With this in mind, why not set an EU-wide goal to become a global leader in using data and digitally-enabled solutions, for a more sustainable, circular economy?

To get this transition right, the EU must:

1) **think systemically, define a vision and act**. Maximising the synergies between digitalisation and circular economy, and preventing negative externalities will require i) *a digital review of the circular economy transition* and ii) *a sustainability review of the digital transition*.

2) **provide an adequate governance framework and economic incentives** for a (digital) transition to a (digital) circular economy. It is important to recognise that this expands far beyond the traditional digital and environmental agendas; measures will need to be aligned with climate action and the wider sustainability agenda, and be supported by single market tools, industrial agenda, research and development, and social and consumer policy.

3) **encourage collaboration** across European society and economy as well as globally, and empower its citizens to contribute to the transition. This implies using existing European and global platforms to raise awareness of the linkages and exchanges, especially on improving information sharing across the value chains.

Introduction

One of the greatest benefits of digitalisation is its ability to address complexities, and the European Union (EU) is indeed faced with a complex challenge. Ensuring long-term sustainable prosperity which is in alignment with the United Nation's (UN) Sustainable Development Goals,[3] Paris Agreement,[4] and becoming climate-neutral by 2050[5] – and using the transition to a circular economy (CE) as the means to achieve these ambitions – is the challenge of our lifetime. While the EU institutions are yet to actively link digitalisation to the transition to a sustainable economy when developing policies and financing projects, there is a growing awareness that more could be done to align these agendas. It is in the EU's interest to use data and digitally-enabled solutions to change the mindset, processes, products and services needed for the creation of a more sustainable, circular economy.

The EU cannot wait. Sustainability challenges – from climate crisis to resource depletion – are already affecting Europe. A CE that would maintain the value of products and materials for as long as possible; minimise resource use and waste; and increase repair, recovery/reuse of materials and products as well as recycling rates would reduce pressures on Europe's (and global) resources and decrease greenhouse gas (GHG) emissions.[6] It would allow Europeans to control materials better and create more value from their use. It would enhance Europe's competitiveness and industrial modernisation. The transition would create new markets, jobs and products, boost EU GDP by 7% and generate a net economic benefit of €1.8 trillion by 2030.[7] As such, there are plenty of economic, societal and environmental reasons to act.

At the same time, the EU is building a digital economy. While data and digitally-enabled solutions can be used to change thinking and processes and even disrupt current practices, this is not without problems. If not properly guided and governed, there is a risk that digitalisation will result in unwanted rebound effects, such as an overdrive of a linear 'take-make-dispose' economy if people use e.g. e-commerce platforms to consume more. The energy and raw materials required for digitalisation and electrical and electronic waste (e-waste) also raise sustainability challenges. Moreover, the EU risks falling behind in the digital race (e.g. in 5G services, the Internet of things (IoT) and artificial intelligence (AI) vis-à-vis China and the US), which could have significant negative implications on its competitiveness, security and prosperity. With a fragmented digital single market (DSM) and timidity to invest in emerging technologies, Europe risks becoming a follower rather than a shaper of future solutions and global standards.

However, the game is not lost – on the contrary. Europe has valuable human capital and a strong innovation base it can build upon. Combining digitalisation with the values of privacy, trust and sustainability could help the EU to create its own model for digitalisation. As the EU is finding its way to use and improve digitalisation and capture its value for society and the economy, it should recognise that digitalisation is not the end goal. Developing and deploying digitally-enabled solutions for greater sustainability and circularity and aligning these efforts with social and cohesion objectives may be just what the EU needs if it is to tackle the shared challenges mentioned above. They carry a great potential for designing the best system-wide solutions, which are desperately needed.

This Discussion Paper will reflect on how maximising the value of data and using existing and new digitally-enabled solutions can tackle some of the main barriers to a CE and accelerate the transition. The case studies listed in this paper aim to raise attention on the wide scope of possibilities that already exist or are emerging, while also considering the challenges and needed measures for aligning the two agendas. The different approaches to using digitalisation in the transition to a CE have been divided into three categories and will be elaborated in the relevant chapters (*Figure 2*).

As this paper will demonstrate, there is a strong rationale for coordinated action at the EU-level. Europe is already a hub for digitally-enabled solutions for a CE. If the EU manages to use data and develop, deploy and scale-up digital technologies for a more sustainable CE – one of its most complex challenges today – this will come with multiple benefits.[8] It would help the EU address not only its own sustainability challenges but also create a competitive advantage when supplying the market with products and services for a CE, which are increasingly demanded also beyond the EU.

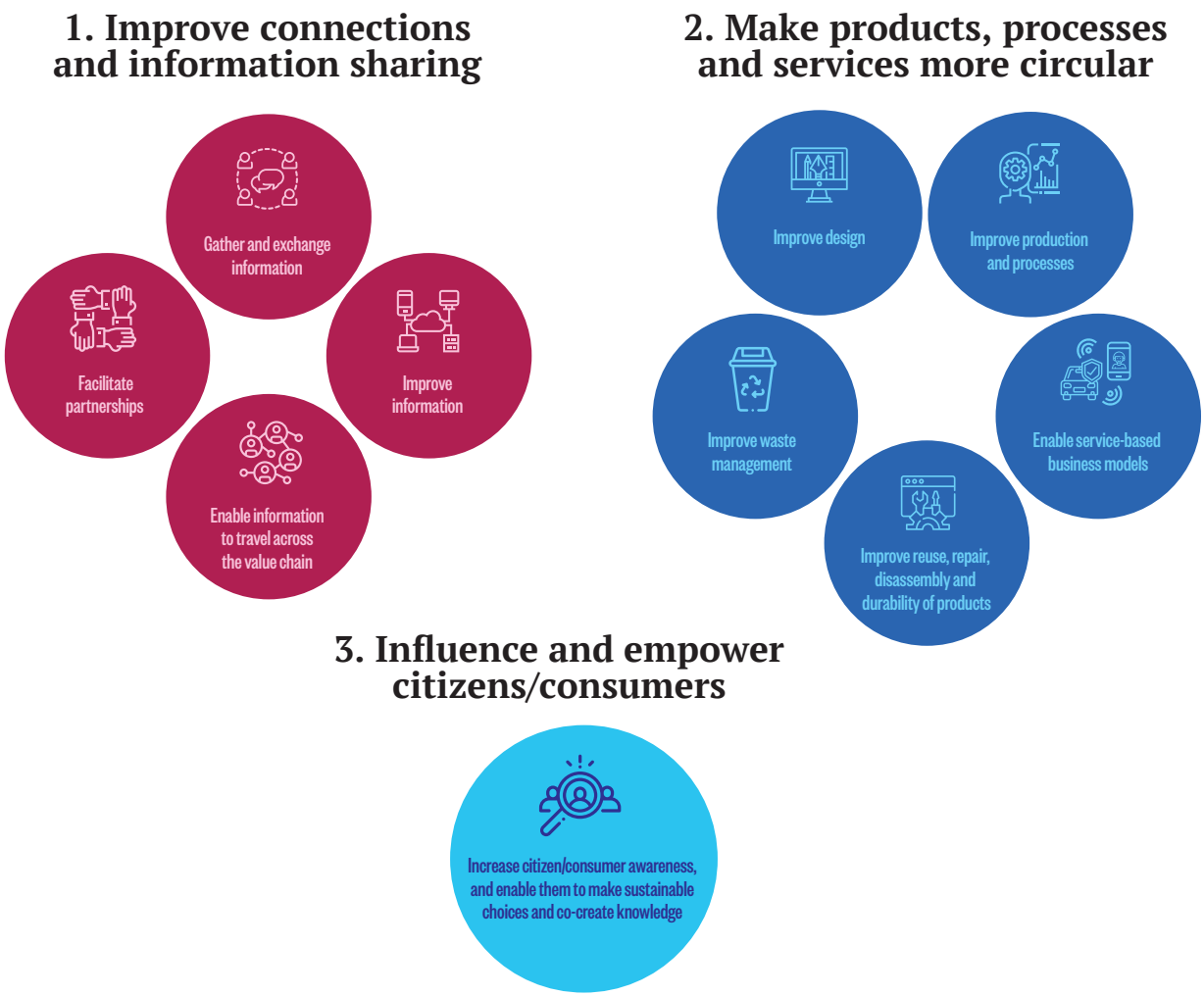
Like the EU, its member states, public and private sectors, and civil society are engaged in advancing the two – circular and digital – transitions, there is a need to bring a more systemic and comprehensive approach to these efforts. This is best done by using the Union's convening power – its fora and platforms – to bring together the relevant stakeholders as well as its governance and economic instruments to guide and incentivise change. EU-level coordination can help to create a level playing field for businesses and make the EU a global leader and standard-setter in developing a digitally-enabled CE.

The EU's Strategic Agenda for 2019-24 calls for a climate-neutral, green, fair and social Europe while developing a strong and vibrant economic base with digitalisation at its core.[9] As the EU institutions prepare for the next five years, it is time to ensure that the EU benefits from the digital revolution, while seeking to achieve its climate and wider sustainability goals.

The **OBJECTIVES** of this publication are to:

- **link and align two**, often separate, **discussions** that are taking place **amidst experts on the CE and digital transition**, while recognising that both transitions should provide the means to greater sustainability and competitiveness;

Fig. 2



- **demonstrate what digitalisation means in the context of a CE** (e.g. how data, 'big data', digital platforms, smart devices and apps, digital services and emerging technologies such as IoT, AI and blockchain are already supporting and could further support the transition to a CE), while also considering the related barriers, challenges and risks;

- **consider what a greater focus on sustainability would mean for the digital transition**, including challenges and opportunities for the information and communications technology (ICT) industry;

- **consider the role of EU policy framework, tools and initiatives** in steering a (digital) transition towards a (digital) CE and make recommendations for EU institutions for the next five years, focusing on areas with the biggest room for improvement and low-hanging fruits.

The **STRUCTURE** of this Discussion Paper is as follows:

Chapter 1 explores how better data management and digitally-enabled solutions could improve connectivity and information sharing by enhancing the gathering and exchanging of information, improving information, facilitating partnerships and enabling information transfer.

Chapter 2 explores the potential of digitalisation to make products, processes and services more circular by improving the design, production, reuse, repair, disassembly and durability of products; incentivising service-based business models; and improving waste management.

Chapter 3 investigates ways to influence and empower citizens and consumers in the transition.

Chapter 4 considers some of the fundamental barriers to a CE and the digital economy, and challenges and risks related to the ongoing CE transition and digital revolution, which will need to be addressed if the EU is to avoid unwanted consequences when linking digitalisation with a CE.

Chapter 5 provides an overview of the EU policy framework for action and considers some of the relevant governance and economic instruments linked to e.g. climate action, CE, digital agenda, single market, industrial agenda, research and development (R&D), and consumer affairs.

Following 'reflections for the way forward' (Chapter 6), the Paper concludes with a set of key recommendations for the EU institutions for the next five years.

1. Improve connections and information sharing

The digital revolution implies that more digital data is being generated than ever before. Numerous digitally-enabled solutions (e.g. digital sensors, mobile phones, connected devices, satellites) are used to generate and collect new data, including for specific purposes such as a CE. For this data to be turned into information and gain value, it must be managed – that is, mined, systematised, processed and shared.

A transition to a CE could benefit greatly from better data management, enhanced access to better information, improved connections between relevant stakeholders across the value chain, and solving issues around information sharing – currently major hurdles to achieving a CE. Data and digitally-enabled solutions can be used to improve policymaking and the implementation of and compliance with existing rules. Several solutions are already used to support the different stakeholders – producers, recyclers, public sector authorities, consumers – in their CE efforts. In the future, should we find a way to ensure efficient and secure information sharing while respecting e.g. companies' intellectual property rights (IPRs), this could provide a breakthrough for creating a CE. The case studies below have been selected to demonstrate the scope of these possibilities. While some of the barriers, challenges and risks related to their use are mentioned here, they are elaborated further in Chapter 4.

1.1 GATHER AND EXCHANGE INFORMATION

Several databases and platforms already exist for collecting and exchanging data for the benefit of a CE and are targeted for different stakeholders. These can raise awareness as well as help stakeholders comply with EU rules, and thus improve the implementation of policies.

RAISING AWARENESS:

Existing solution: **Trash to Trend** is an Estonian ***online platform*** that provides information about the sustainable production of garments and textile upcycling.

Existing solution: The **European Resource Efficiency Knowledge Centre** ***platform*** provides information to businesses, especially small- and medium-sized enterprises (SMEs), about improving resource efficiency.

COMPLIANCE WITH EU RULES:

Existing solution: The European Chemicals Agency's (ECHA) **IUCLID** ***database*** traces information on chemicals and is used for reporting under REACH.[10] However, this does not automatically lead to the adequate enforcement of this regulation,[11] and while the database is well-developed, the collected information is lost along the value chain.

Existing solutions: Several industries have created ***databases*** to record substances used by the industry, manage their supply chains and comply with EU requirements. Examples include **BOMcheck** and **International Material Data System** (IMDS) for automotive companies, providing a valuable basis for discussions on information sharing systems.

Existing solution: **EC4P** is a British cloud-based ***platform*** that helps companies comply with recycling requirements for electrical and electronic equipment waste, batteries and packaging across the EU and world.

Emerging solution: The recently amended Waste Framework Directive[12] stipulates that the **ECHA** should develop a ***database*** on hazardous substances in products and materials. It is envisaged to be used primarily by consumers for information and waste operators to improve waste treatment.[13]

1.2 IMPROVE INFORMATION

Managing data can help convert it into valuable information and knowledge for the benefit of a CE. Having quicker access to more accurate and quality information can support decision-making, monitoring and evaluation processes, and help businesses and public authorities to promote a CE more effectively.

ACTIONABLE KNOWLEDGE:

Existing solution: **Evolution3** is an advanced ***sensor system*** for tires developed by Michelin: tires communicate their temperature and pressure conditions in real-time via e.g. email and text messaging. Thus the data is turned into actionable knowledge that can be used to prevent overheating, a major cause of tire damage.

IMPROVED POLICYMAKING:

Existing solution: As part of the Horizon 2020 project (H2020) **CLAIM**,[14] **FerryBoxes** are installed on boats, collecting samples and monitoring environmental parameters – that is, ***big data*** – on marine litter and water quality. Collected data and subsequent analytics can support policymaking and the needed measures to clean seas and prevent further littering.

Existing/emerging solutions: Comprehensive **life-cycle assessments** (LCAs) can be an important information tool for more sophisticated decision-making while improving data management can help to make LCAs more efficient and accurate. ***Softwares*** like **SimaPro**, **GaBi** and **openLCA** are already used in e.g. industries and academia to execute LCAs, and digitally-enabled LCAs surely carry potential to support also policymaking. Simultaneously, it is worth recognising the importance of consistent and quality data for better LCAs.

1.3 FACILITATE PARTNERSHIPS

Partnerships and collaboration between stakeholders – including business-to-business (B2B) and business-to-consumer (B2C) relationships – are central in facilitating the CE. For example, online platforms enable buyers, sellers, and citizens to connect and exchange information, good practices and resources, also across borders. Europeans have traditionally been strong in B2B partnerships and in using digitalisation for this aim, but there is potential to improve these and B2C partnerships.

REUSING, RECYCLING AND MINIMISING WASTE:

Existing solution: ***Apps*** like **FoodCloud** and **Too Good To Go** tackle food waste by connecting consumers and charities with restaurants and retailers.

Existing solution: The European ***database*** **Urban Mine Platform** shows valuable materials made available from high tech products through "urban mining", to improve the recovery and value retention of secondary raw materials.[15]

SHARING ASSETS:

Existing solutions: New business models that support a **sharing/collaborative economy** (e.g. sharing, renting, swapping products and services in peer communities) can support circular objectives. Think Airbnb for apartments, or Zipcar for cars, which often rely on ***online platforms*** to connect service providers to customers. This sharing of assets can reduce material consumption and decrease associated emissions, but may also have rebound effects that need to be considered (e.g. increased car rather than public transport usage).

Emerging solution: **BE CIRCLE** is a web-based ***platform*** supporting industrial symbiosis. The software enables users to visualise nearby industrial facilities and their materials, and water and energy stocks and flows, given exploiting potential synergies. The project is currently in its experimental phase and involves the industrial zones of the Port of Dunkirk, INSPIRA (France) and Höchst (Germany).

1.4 ENABLE INFORMATION TO TRAVEL ACROSS THE VALUE CHAIN

Information sharing is one of the major barriers to achieving a CE. Consumers would benefit from having the necessary information on how to e.g. maintain, repair and recycle a product. The reuse of materials and products could be encouraged if there was better information about their quality and lifetime maintenance. Recycling could be improved if waste operators had the necessary knowledge on used materials or substances.

Digitalisation can play a central role in these efforts. For example, Quick Response (QR) codes, barcodes, watermarks and radio-frequency identification (RFID) chips, and data-sharing systems like **Circular Content Management System** (CCMS) for textiles are already used to improve the tracking of materials. Solutions that could provide stakeholders in a value chain – like consumers or recyclers – the specific information each require to buy, use, maintain, repair, reuse and/or recycle a product, while still allowing companies to safeguard their commercial and strategic information, are currently being developed. For example, blockchain-enabled solutions can store and share data in a secure and efficient way, and should they be adopted on a large scale. They could enhance information flows across value chains and improve monitoring and verification processes. Additionally, specific algorithms could be used to verify the data travelling with the product and ensure that the necessary information is included.

The prospects for information sharing are interesting, but it is worth recognising that several hurdles remain to be addressed, including access to qualitative data and its interoperability, ensuring trust between stakeholders across the value chain, and finding a fair balance between accessing and sharing data. These challenges are further elaborated in Chapter 4.

TEXTILES:

Existing solution: **CCMS** is an ***online platform***, developed by Dutch Awearness, which closes the textile cycle by encouraging collaborating across the value chain, maintaining a ***database*** and tracking materials. CCMS relies on QR codes to trace data throughout a product's life-cycle.

PLASTICS:

Existing solution: **FiliGrade** is a Dutch company which has developed a system to imprint ***watermarks*** onto plastic products. They can be scanned via e.g. smartphone in order to retrieve valuable information on the product.

ENABLING FEEDBACK LOOPS:

Existing solution: **TagItSmart** are smart tags that allow stakeholders – from the factory to recycling; producer to individual customer – to track items and provide additional information using ***QR codes***. This technology is already in use across Europe.

REVERSE LOGISTICS:

Emerging solution: The French group **Auchan** uses *RFID* technology to track crates for reverse logistics. It recently announced that it would introduce ***blockchain*** technology to its operations, following successful local testing.

ENABLING SECURE INFORMATION SHARING:

Emerging solution: The Dutch **Circularise** uses ***blockchain*** to improve transparency and communication across circular value chains. Its Smart Questioning technology enables stakeholders a Q&A on a product via secure communication. It allows for more efficient data sharing while also addressing the industry's need for data protection.

2. Make products, processes and services more circular

A transition to a CE will require making products, processes and services more circular, in terms of how we design, produce, use, reuse, repair and recycle products. It will require new circular business models. Digitalisation can make a significant contribution to all these components of CE; it is already affecting how businesses operate, and the products and services they provide.

The case studies below aim to give a taste of some of these possibilities. It is also worth noting that there are some sectors, including construction, plastics, textiles, food systems and automotive, where a (digital) transition to a (digital) CE could be greatly beneficial, even in the short term.[16] While some of the barriers, challenges and risks related to greater digitalisation are mentioned here, they are also further elaborated in Chapter 4.

2.1 IMPROVE DESIGN

Designing products and materials that are more sustainable, durable, reusable and easily disassembled, upgraded and/or recycled is central to creating a CE. Much work remains to be done, but innovative approaches like using AI in design processes are promising.[17] AI can be used to improve the processes, as it allows designers to play with numerous materials and structures and test and refine design suggestions. It can help to manage the complexity that comes with harmful chemicals and materials and be used to suggest new materials, based on LCAs. As is often the case with data, however, limited access to relevant information can hinder the use of AI solutions in design processes.

Emerging solution: The **Accelerated Metallurgy project** funded under H2020 aims to identify environmentally-friendly metal alloys and create new materials via ***AI***.

2.2 IMPROVE PRODUCTION AND PROCESSES

The production of materials, components and final products can be energy- and resource-intensive and lead to significant amounts of waste. Digital tools can optimise processes by preventing waste and emissions and reducing energy and resource consumption. New technologies can also boost the development of local bottom-up solutions by helping local manufacturers produce and deliver products and services to customers on-demand. E.g. 3D printing helps cut costs, optimise production and increase environmental performance by using only the exact amount of material needed.

Existing solutions: **Google** is applying ***machine learning*** to their data centres to improve their energy efficiency.

Existing solutions: **GreenLab Skive** is an industrial park developed as a public-private partnership in Danish Skive Municipality. Park members rely on the ***integrated intelligent infrastructure*** that enables energy exchanges between businesses and optimises its usage.

Emerging solution: The Shanghai-based company **Winsun** applied ***3D printing*** in Suzhou Industrial Park's garden villas. Using 3D printing meant construction material usage was cut by 30 to 60% and costs by half.[18] However, the company faces challenges in commercialising the solution due to a lack of regulatory standards and the designers', project developers' and owners' scepticism about the products' safety.

Emerging solutions: Companies such as **Bosch** and **Siemens** are developing and rolling out **smart digital factories**, built on ***AI*** and ***machine learning***, which can reduce energy consumption and waste during production.

2.3 IMPROVE REUSE, REPAIR, DISASSEMBLY AND DURABLITY OF PRODUCTS

Extending the life-cycles of products like electronic appliances through e.g. repair, remanufacturing and reuse is central to a CE, and several new and emerging digitally-enabled solutions already contribute to these efforts. Durability can be enhanced and repair facilitated e.g. via connected machines that provide real-time information on the condition, state and availability of products. When data is used to identify problems with the functioning of products, thus contributing to predictive maintenance, cheaper and more efficient reparations become possible.

As another example, remanufacturing entails a complex set of interventions on the end-of-life product or component, so that it can match or exceed its original function. Remanufactured products are accompanied by a warrant and are generally more valuable compared to secondary raw materials obtained via recycling or energy recovery. Digital technologies like 3D printing can improve the remanufacturing of products by manufacturing the necessary spare parts. Data exchange via online platforms, IoT or blockchain could enable the identification and safe recovery of equipment that can be remanufactured; and avoid it from being recycled, dismantled or repurposed for a lower value function.

As the European industry has been strong in industrial AI – using AI in B2B relations – and industrial IoT – machine-machine/ predictive maintenance – this provides a strong basis for further development in this field.

ENCOURAGING REUSE:

Existing solutions: Several ***online trading platforms*** serve as marketplaces for used products (e.g. **eBay**, **Gumtree**), specialised replacement parts or excess materials. Danish **Gen Byg Data** provides data on the available materials and enables asset-tracking in a building prior to its demolition with the help of the geographic information system developed by Skive Municipality. **Excess Materials Exchange** enables companies to exchange excess materials with each other. Reusing products can be affected by people's concerns over their condition and personal information left on electronic devices, while reusing materials can be undermined by a lack of information on their quality.

ENABLING REPAIR:

Existing solution: **iFixit** is an open-source ***online platform*** for repairing electronics, machinery and car components mostly. It contains repair guides, Q&A forums and user-generated updates on existing and prospective equipment. Their challenge is that they do not provide any guarantee on the reliability of the information posted.

Existing solution: ***Augmented reality glasses***, such as the ones developed by **DAQRI**, can provide workers with the necessary information to repair a product.

IMPROVING PREDICTIVE MAINTENANCE AND DURABILITY:

Existing/emerging solutions: ***Connected machines*** can be used to conduct predictive maintenance – a machine can inform the maintenance staff about potential problems via IoT. E.g. German **thyssenkrupp** gathers elevator data and uses IoT to enable predictive maintenance.

2.4 ENABLE SERVICE-BASED BUSINESS MODELS

Business models are increasingly shifting from producing goods to delivering services, and digitalisation plays a major role in this development. An example of a service-based business model that has a strong circular component is 'products as a service', where products are owned by suppliers and customers pay for their usage. Such practices encourage product longevity, reusability and sharing, which in turn can reduce demand for materials and negative externalities like waste. Servitisation often benefits from digital solutions: customers access information about the availability of a product, while suppliers can continuously monitor product performance and take timely, predictive maintenance measures.

Existing solution: Mobility as a service is attracting growing interest, especially in cities, and can be provided via e.g. ***apps***. For example, in Helsinki, citizens can use the app **Whim** to access multiple transportation modes (e.g. train, taxi, bicycle). Users can either opt for monthly subscriptions or the pay-as-you-go method. The service is an example of how public data can be of valuable use when made available.

Existing solutions: "Clothing as a service" ***online platforms*** are growing in Europe and beyond. **Tale Me** is a Belgian rental service for maternity and children's clothes. The Dutch brand **MUD Jeans** rents and recycles denim clothing. **Urban Outfitters** is starting a rental service, Nuuly.

Existing solution: **HP Instant Ink** is an ink cartridge replacement service that enables printers to send ink level information to HP, thanks to ***connected machines***. When ink levels get low, the company automatically ships replacement cartridges.

2.5 IMPROVE WASTE MANAGEMENT

Another key component of a CE is improving and modernising waste management. If done properly – starting with waste prevention as laid out in the 'waste hierarchy', followed by reuse, recycling, energy recovery and (as a last resort) landfilling –, waste management can retain the value of end-of-life products and materials, keep them within the economy and avoid pollution and other costly externalities. Waste collection, sorting and recycling as well as innovative business models, such as resource recovery – producing secondary raw materials from waste –, can benefit greatly from digitally-enabled solutions. They carry the potential to help the EU solve its own waste problems.

IMPROVING WASTE COLLECTION:

Existing solutions: Waste collection can be made more efficient with real-time, waste-monitoring sensors. Bulgarian-based **ConnectedBin** uses ***sensors*** and ***IoT*** systems for smart waste management. Waste collectors can access data (e.g. on waste quantities) from all bins, thus optimising waste collection.

Existing solution: **Rezycl** is a custom-designed software for companies to handle their waste. The ***online platform*** and ***app*** facilitate access to pertinent data and waste statistics, and the ordering of waste collection; and decrease the administrative burden for businesses (e.g. waste disposal reporting).

IMPROVING WASTE SORTING AND RECYCLING:

Existing solution: **SUEZ** is applying advanced waste characterisation with multi-sensor data to improve waste sorting and recycling in its facilities. SUEZ applies ***infrared technologies*** to increase waste sorting efficiency, while ***digital twin*** technology enables sorting machines to learn based on the digital image of waste items provided by the software.

Emerging solution: Finnish **ZenRobotics** uses ***robots*** for fast and precise waste sorting.

3. Influence and empower citizens and consumers

The transition to a CE will depend on the contributions of consumers and citizens: how they live, consume, reuse and recycle products and materials. Data and digital solutions are already used to educate and influence people, increase their awareness and enable sustainable choices e.g. by sharing information about the products' environmental footprint. Encouraging citizens to use and collect data converts them into active participants in the data economy and co-creators of knowledge and evidence that decision-makers, businesses, investors and other citizens can use. They are also influencing the market when demanding solutions that are sustainable, convenient, safe and reliable, and that contribute to the transition.

Overall, digitalisation can empower citizens to play a decisive role in the transition to a CE – if digitally-enabled solutions are accessible (starting with access to the Internet) and citizens have the needed skills to use digital tools. At the same time, not all uses of digitalisation would necessarily work for Europeans. China's social credit-score is an alarming example of how people could be monitored, rewarded and punished based on their behaviour.[19]

PROVIDING INFORMATION:

Existing solution: **Amazon's** Second Chance ***webpage*** provides user-friendly instructions for recycling packaging, repairing equipment and buying (certified) refurbished products.

Existing solution: **Bext360** uses ***blockchain*** technology to monitor the critical supply chains, like timber, minerals, cotton, in a comprehensive and measurable way, and traces the consumer to the producer to encourage greater sustainability.

Emerging solution: The **AskREACH** project aims to develop a ***database*** with information on substances of concern in articles provided by suppliers. The database will be connected to a smartphone ***app*** to facilitate access to the information.

NUDGING BEHAVIOUR CHANGE:

Existing solution: The German FP7 co-funded project **myEcoCost** aims to estimate a consumer's ecological footprint by using ***data*** across the whole value chain of a product.

Existing solution: ***Apps*** like **My Little Plastic Footprint**, launched by the Dutch Plastic Soup Foundation, help consumers reduce their personal plastic footprint by e.g. providing information about plastic waste and encouraging them to reduce their plastic consumption.

Existing solution: **SIRPLUS** is a German ***IoT***-based project which sells surplus, expired and deformed groceries for up to 70% less than its usual price, thus combatting food waste.

INCENTIVISING RECYCLING:

Existing solution: ***Chatbots*** like **Oscar** can be used to assist in waste sorting.

Existing solution: The Canadian **Plastic Bank** project incentivises people to bring plastic waste to recycling export collection areas, in return for ***digital currency***.

CO-CREATING KNOWLEDGE:

Existing solution: **LitterGram** is an online ***app*** which seeks to reduce the litter in the UK. Citizens are connected to their local authorities and can share photographs and locations of litter via the app with the latter, who then takes care of it.

4. Barriers, challenges and risks to be addressed

As previous chapters have shown, digitalisation can help to tackle barriers and accelerate a transition to a CE. However, the digital and circular transitions are not without their problems. This chapter notes some of the barriers, challenges, existing contradictions and risks that must be overcome if Europe is to develop a successful digital roadmap for a CE and avoid unwanted consequences for the climate, environment, competitiveness, economy and society as a whole. Moreover, as will be shown in Chapter 5, many of these issues can be addressed with the help of the EU's governance and economic instruments.

4.1 BASIC BARRIERS TO ACHIEVING A CIRCULAR ECONOMY

Fundamental challenges to a CE which demand attention, with or without digital support, are:

- the existing *economic model* which does not value natural capital, nor internalise externalities of measures taken (e.g. price negative and reward positive social and environmental impacts);
- the lack of incentives for companies to *design more circular products and use secondary raw materials*;
- products, materials and substances on the EU market contain banned *substances of concern*, either because they were introduced before being banned or due to the lack of enforcement of REACH;
- *information which does not travel* with products and materials, hampering circular practices like maintenance, reuse, repair and recycling;
- *the overload or lack of information* on products, complicating consumers' ability to make sustainable choices;
- the misalignments in *EU chemicals, product and waste* legislation, and the presence of certain chemicals, hampering efforts to recycle and re-use products;[20]
- the insufficient *quality criteria for secondary materials* and *lack of demand for recycled materials*, like plastics;
- the lack of *common definitions for waste*, and hazardous waste hinder shipments of waste across member states;
- *illegal waste burning or shipments*, different levels of ambition across the EU in reducing *landfills* and meeting the agreed *recycling targets*, and the overall underdeveloped *waste management infrastructure*;
- *the global market and value chains* which complicate policy steering at the EU level.

4.2 BASIC BARRIERS TO ACHIEVING A DIGITAL ECONOMY

Better data management and use of digitally-enabled solutions for a CE are not always straightforward. Many of the basic challenges are the same as for the digital transition in general:

- The EU has inadequate *digital infrastructure* for connectivity, Internet coverage (i.e. high-speed broadband, 5G, fibre) and cybersecurity.[21] If the EU fails to invest in this basic infrastructure, other related developments will come to a halt.
- *Data* is not always standardised, comparable nor digital. Different data formats or low-quality data lead to poor outputs. The lack of clarity on data ownership, degrees of freedom on data flow, and the continuous search for a balance between information sharing and protection of citizens' and businesses' sensitive data impact data economy developments, too.
- The private and public sectors', and citizens' concerns on the *privacy, security* and *trust* related to the use of data can limit access and its usage.
- The lack of *interoperability* between systems and data can impair data flows and analysis. Difficulties to update old hardware with new software spurs faster turnover of hardware.
- The *public sector's capacity* to apply digitally-enabled solutions is a hindrance to societal developments.
- *Slow development and deployment of emerging technologies like AI and IoT* due to a lack of investments, innovation and digital skills.[22]
- The lack of basic *digital skills* and e-literacy in over a third of Europeans in the active labour force.[23] Furthermore, the lack of information technology (IT) and AI professionals is a hindrance to the digital transition.[24]
- The *barriers to digital services* such as geo-blocking, procurement rules (i.e. favouring products over services) and the difference in fees for services and products. Donations (e.g. unused or reusable products from e-commerce) are discouraged when charged with additional value-added tax (VAT).

The EU is investing greatly in blockchain development (see Chapter 5), and considering that these solutions could provide a breakthrough in sharing information needed for a CE, it is worth recognising some of the technology-specific challenges:

- There are doubts about the scalability and efficiency of these solutions.
- While blockchain-enabled solutions could provide an attractive platform for data sharing, companies still need to be incentivised to share their data (i.e. regulations, financial incentives).
- The current 'generation' of blockchain requires significant amounts of energy, and now, a contractual blockchain with a smaller number of mutually trusted parties is likely to be more interesting from a sustainability perspective.[25]
- The initial information uploaded on a blockchain must be accurate, as the quality of the initial input cannot be addressed by the blockchain itself.
- Sharing data via blockchain may cause problems in terms of data privacy, liability and competition; especially regarding who should have access to what data, when and how.
- International standards and a common understanding of blockchain development are still lacking. This is an opportunity as well as a challenge for the EU if it wishes to encourage the technology's development and global usage.

4.3 RISKS TO BE RECOGNISED

In addition to the basic barriers to both a CE and a digital economy, there are also several risks and potential contradictions that must be addressed in order to avoid unwanted consequences and build a comprehensive framework for action.

CE MEASURES DO NOT ALWAYS LEAD TO GREATER SUSTAINABILITY:

While a greater circularity can help achieve a more sustainable, competitive and climate-neutral economy, the **measures taken do not always help to reduce emissions or change production and consumption patterns**. Recycling is a good example: increasing it alone does not ensure the quality of recycled materials or demand for secondary raw materials. Product features like greater durability or recyclability do not automatically lead to lower energy use or emissions. For example, tethered caps on plastic bottles may increase GHG emissions, since more plastic is required for such design. Longer use of electric appliances may also lead to increased emissions since older models may be less energy-efficient than new ones.

DIGITALISATION CAN LEAD TO UNSUSTAINABLE PRACTICES

Greater use of data and digital solutions do not automatically contribute to reducing GHG emissions and smarter use of resources. In fact, digitalisation can very likely cause the opposite if not guided and governed well.

Firstly, **sharing data and using digitally-enabled solutions do not automatically lead to more sustainable production and consumption**. Data must be actionable in order to provide the basis for change. Digital services, such as e-commerce can also contribute to increasing (unsustainable) consumption. Products imported from outside the EU carry the risk of containing materials and substances that are not permitted in the EU and will be difficult to reuse and/or recycle.[26]

Secondly, **the digital/ICT industry has a significant environmental footprint**. Data centres, digital devices and digital infrastructures require (often critical) levels of energy and materials.[27] ICT accounts for 5 to 9% of the total electricity demand (associated with GHG emissions) with a potential increase to 20% by 2030, as the demand for data centres, cloud computing and other energy-intensive technologies (e.g. blockchain) increases. Considering the amount of energy digitalisation requires, these developments must be coupled with a transition in our energy system (e.g. increasing energy efficiency and share of renewables).

Simultaneously, resource use and waste are a problem. The world produces annually 50 million tonnes of e-waste, and the amount is increasing due to rapid technical development. This is a missed economic opportunity, as enormous amounts of valuable, critical materials are thrown away. Landfilling and informal recycling of e-waste also have unwanted health and pollution impacts.

Thirdly, the digital transformation of our economy and society can have unwanted **implications for security** (e.g. cyberattacks) **as well as health** (e.g. radiation, hazardous substances).[28]

DIGITALISATION IS NOT AN AUTOMATIC PATH TO PROSPERITY

Digitalisation comes with the risk of a **digital divide**, where only the wealthy can access and utilise available technologies. There is a growing gap in labour markets between high-skilled specialists who can use complex technologies and low-skilled workers that may become unemployed due to automation. The digital gap may also widen between large companies and SMEs that do not necessarily have the same resources to invest in reskilling programmes and in adopting new technologies. Failing to take this challenge seriously could lead to social polarisation.

5. The EU framework for action

Improved use of data and the ongoing development and uptake of digital solutions are fundamentally reshaping our economy and society. Whether the changes will be positive or negative can be guided. Policymakers have the tools to steer and incentivise digitalisation to help create a more sustainable, circular economy, which could bring enormous benefits and help to address Europe's – and global – sustainability challenges. Some of these governance and economic instruments are listed in this chapter.

5.1 CLIMATE ACTION AND THE WIDER SUSTAINABILITY AGENDA

In 2015, world leaders committed to the **UN's 2030 Agenda for Sustainable Development and Paris Agreement**. Together they set a clear direction and goals to be achieved, including sustainable production and consumption, and climate action. The European Commission's long-term vision for a prosperous, modern, competitive and climate-neutral economy by 2050,[29] the support of a large majority of EU member states for 2050 climate-neutrality goal, and reflection paper towards a sustainable Europe by 2030[30] provide important starting points for dialogue and action, as CE will have a central role in the transition. The global SDGs and Paris Agreement aims should be reflected across EU policies, and the EU should align digitalisation with these efforts.

As digitalisation helps to manage complexity, it should be used to support **new economic and system thinking**

and facilitate the collection of data needed for better policymaking and implementation. It should be used to capture societal needs and environmental value, and reduce negative externalities and reward wanted results (e.g. CO_2 savings). LCAs should be improved and integrated into decision-making. A good starting point is the ongoing work on the EU Product Environmental Footprint (PEF) which should integrate data on all relevant environmental impacts.[31]

The 7th Environment Action Programme aims to guide the EU's environmental policy until 2020.[32] The Commission's work on the **8th Environment Action Programme** will likely start at the end of 2019,[33] and it should use the occasion to explore cross-linkages between the industrial and digital agendas.

With the scale of global sustainability challenges in mind, it should be in the EU's interest to **engage and collaborate from the onset with international partners** in using digitalisation to improve global sustainability. Several fora, including the UN, World Trade Organization (WTO) and Group of Seven (G7) can be used for this aim. One of the goals should be to ensure that information created outside the EU on products and materials is reliable and safe to use, while building on existing international work on information sharing.[34]

5.2 CIRCULAR ECONOMY AGENDA

The EU's toolbox for achieving a CE contains a wide range of instruments to improve e.g. design, production and waste management.[35] The EU has also set indicators for achieving a CE.[36] The Juncker Commission made valiant efforts to raise awareness on CE, but much remains to be done in terms of implementation. There are basic issues to be addressed and relevant policies to be implemented (see section 4.1.), while the potential for digitalisation to accelerate the transition is perhaps overlooked. It is important to remember that the CE transition should contribute to achieving a sustainable, climate-neutral and competitive economy[37] and that the respective measures must be based on a comprehensive assessment in order to avoid unwanted consequences. The following ongoing developments are especially interesting for this Paper, and should be coupled with a 'digital review':

The **EU Action Plan for the Circular Economy**,[38] also known as the Circular Economy Package, adopted by the European Commission in 2015, provides an outline of policy and legislative measures for improving production, consumption, waste management, markets for secondary raw materials, innovation, investments and monitoring. It has led to new legislation (e.g. Single-Use Plastics Directive[39]) and amendments into existing ones (e.g. the Waste Framework Directive[40]). However, the work has only started, and one would expect that a review of the Circular Economy Package will become necessary. It should *inter alia* contribute to reducing the EU's emissions, resource dependency and waste; improving reuse, remanufacturing and recycling; keeping valuable materials in Europe; and recognising the linkages with digitalisation.

As **product design** is a key to a CE, companies must be incentivised to design with circularity in mind. Sharing best practices and encouraging the use of digital solutions like AI would be important. While the Ecodesign has been an effective instrument in making products more energy-efficient, the Commission should explore whether the Ecodesign Directive[41] and product design guidelines could be better aligned with a (digital) transition to a (digital) CE. The Commission should consider the introduction of requirements for new product categories, to enable the greater durability, reparability and recyclability of products on a case-by-case basis and based on existing scientific evidence. The possibility of integrating digital tools into products to support e.g. information sharing could also be investigated.

Extended producer responsibility (EPR) is a policy approach which assigns producers responsibility for their products, even past the consumption stage. While the focus has primarily been on the end-of-life phase (e.g. producers covering waste management costs), EPR can also be used to incentivise producers to design more sustainable products.[42] Possibilities to use data and digitally-enabled solutions to improve the functioning of the EPR (e.g. by enabling more efficient information sharing between producers and recyclers) should be further explored.

EU ecolabel can help highlight a product's environmental footprint to consumers (e.g. PEF), while digitally-enabled solutions like QR codes, apps or online platforms can be used to clarify and communicate the information within the label to answer consumers' questions and help them make sustainable choices.

Recognising that **sharing information on products, materials and substances** across the value chains is pivotal for a CE, the EU should start developing guidelines and build on existing practices. For example, it is important to ensure that the extensive data on chemicals on the ECHA's IUCLID database is not lost across the value chains, but is turned into valuable information for relevant stakeholders instead. At the same time, Europe is already home to a number of initiatives where information flows across value chains, and in the short term, B2B partners should be encouraged to form 'coalitions of the willing' to improve the information sharing based on the principle of "freedom of contract".[43] The longer-term aim should be to establish an EU-wide standardised system for information sharing across the value chains, where sensitive personal and corporate information is safeguarded.

The EU should use **stakeholder platforms** (e.g. the European Circular Economy Stakeholder Platform, the European Technology Platform for the Future of Textiles and Clothing, Smart Specialisation Platform for Industrial Modernisation and other S3 platforms, European Innovation Partnerships, Urban Agenda for the EU, EU Blockchain Observatory and Forum, Digital Innovation Hubs) to increase awareness among member states, subnational authorities, academics and businesses regarding the interlinkages between digitalisation and a CE. They should also be used to encourage interested

businesses to collaborate, especially on required standards and the means to improve the sharing of information across value chains.

The EU could consider establishing an **Observatory**, e.g. as an extension of the European Circular Economy Stakeholder Platform or European Environment Agency, to monitor and follow up on the efforts of the EU and its member states in linking digitalisation with a CE. Collecting and sharing comparable data and information would contribute to mapping the problem as well as the solutions.

Regarding financial support, it is worth to highlight the proposed **LIFE programme**[44] under the upcoming 2021-2027 Multiannual Financial Framework (MFF). While it envisages support for a CE (€1.3 billion), possibilities of benefitting from data and digitally-enabled solutions should be explored further.

Certain instruments should also be assessed from a digital CE perspective – think the envisaged review of the **Waste Shipment Regulation**[45] or the **directive on public access to environmental information**[46] that requires administrations to make environmental data available. The **INSPIRE Directive** lays down the rules aimed at "the establishment of the Infrastructure for Spatial Information […], for Community environmental policies and policies or activities which may have an impact on the environment."[47] The Directive covers monitoring facilities, production, industrial and agriculture facilities as well as energy and mining, and has several implementing acts on how to standardise the generated CE and waste-related data. It could serve as a valuable basis for a future standardised information system.

A **market for secondary raw materials** is a pre-condition for greater uptake of used materials. Instruments such as taxation rules (e.g. no VAT on secondary materials) and public procurement could be used to increase demand for these materials. Quality standards for recycled materials would improve the offer. Moreover, these efforts can be supported by digitally-enabled solutions like online platforms to improve information sharing on and trading of valuable waste materials.

The EU has comprehensive policy framework for **waste management**, but still more needs to be done to modernise its waste infrastructure, facilitate legal shipments within the EU and put an end to illegal ones (e.g. by harmonising the electronic notification procedure). The EU has a serious waste challenge, worsened by China's ban on waste imports,[48] and it should step up its ambition for carrying responsibility for its own waste and aim to become a global leader in using advanced solutions for managing waste.

5.3 DIGITAL AGENDA

The EU has promoted a digital agenda for almost a decade, with a central element of the EU's digital agenda being the development of a true DSM in Europe. A wide array of DSM legislation was introduced during the Juncker Commission to remove existing barriers,[49] and the member states' progress is evaluated via a digital scoreboard.[50] However, digital transformation has not been approached holistically and e.g. investments have often been made without sustainability considerations. Aligning digital initiatives with a sustainable, climate-neutral and circular economy would require a two-fold approach: guiding and incentivising the digital/ICT industry to become more sustainable, climate-friendly and energy-efficient, as well as using data and digitally-enabled solutions to benefit a more sustainable, circular economy. Promoting a (digital) transition to a (digital) CE should start with addressing the barriers, challenges and risks listed in Chapter 4. In addition, there should be a sustainability review of especially the following ongoing developments.

Under the Commission's proposal for the **2021-2027 MFF**,[51] it is envisaged that 15% of the budget would be allocated to the single market, innovation and the digital, and thus could also contribute to a (digital) transition to a (digital) CE. For example, the **Digital Europe programme** aims to boost digital capacities and contribute to the deployment of digital technologies in Europe. It is to focus on the five key areas: supercomputers, AI, cybersecurity and trust, digital skills, and ensuring the deployment and the uptake of digital technologies. As detailed discussions on the projects continue, more should be done to incentivise and support development and deployment of digitally-enabled solutions for a sustainable CE. It is also worth noting that it is not only large, new and costly solutions which bring about great opportunities for a CE. Existing and sometimes even small solutions can be equally useful.

A CE would benefit from a **more open data economy and a free flow of data**. Thus e.g. the regulation on the free flow of non-personal data[52] and the **Open Data and Public Sector Information Directive**[53] should be reviewed from a CE perspective. The former needs to be implemented in order to remove data localisation requirements that hinder new business models and are costly, especially for SMEs. In the latter case, the information most pertinent for the CE could be explored and be made available while respecting sensitive information. The EU should also push for global guidelines on the free flow of non-personal data; and assess the extent to which rules such as the **General Data Protection Regulation (GDPR)**,[54] **Copyright Directive**[55] or proposed **ePrivacy Regulation**[56] may add unnecessary restrictions and represent additional administrative burdens for businesses (especially SMEs and start-ups), and thus hinder circular practices.

Blockchain and distributed ledgers could play a prominent role in enabling the sharing of data on substances, materials and products in a secure environment and across value chains. While the EU is lagging in AI in global comparison, it is stronger in blockchain, also thanks to EU developments. The European Blockchain Partnership established in 2018 aims to create a European Blockchain Services Infrastructure to support the delivery of cross-border digital public services. The EU has also launched the EU Blockchain Observatory and Forum with the objective of mapping out the main initiatives, and monitoring and

discussing relevant policies. In 2019, the Commission also facilitated the creation of the International Association of Trusted Blockchain Applications, a forum bringing together developers, users and regulators to steer further development of distributed ledgers. While EU initiatives should address the main challenges to blockchain development and deployments (Chapter 4), they should also explore ways to make blockchain more sustainable and turn it into a driver for a CE, with a focus on enabling secure and efficient information sharing.

The EU has put ethics and human-centred considerations at the centre of its approach to **AI**. This was underlined in the Commission's AI Strategy in April 2018, the coordinated AI plan from December 2018, the AI Communication from April 2019, and the guidelines of the High-Level Expert Group on AI. However, AI also has the potential to impact CE, especially through product design, operations and infrastructure optimisation.[57] The EU should recognise the opportunity to lead the way to developing and using AI for the benefit of a CE.

5.4 SINGLE MARKET & INDUSTRIAL AGENDA, R&D AND CONSUMER POLICY

The EU has in place a set of rules and financial instruments that could be used to help the European industry in its ongoing transition and to roll out the digitally-enabled solutions for CE on a bigger scale. There are also some useful tools to help the public sector, citizens, consumers and other stakeholders contribute in the (digital) transition to a (digital) CE.

FRAMEWORK CONDITIONS FOR THE INDUSTRY

The starting point is the EU's **Single Market** for goods and services. This is a home market for European solutions to compete and grow, but unfortunately, integration into the single market varies greatly across member states, and the national and regional barriers to trade – such as technical requirements, requests for additional documentation or testing – are serious and in some instances growing challenges to be addressed.[58]

Public procurement accounts for 14% of EU GDP, and if used properly, could stimulate the development of a market for valuable solutions. The Commission has introduced rules and guidelines for member states to make full use of public procurement, but they have been slow to act. First, greater efforts are needed to digitalise procurement as it could help to simplify the processes, increase transparency, and enhance interaction with the SMEs, which would be valuable for their business development. Second, using procurement as an investment tool for digitally-enabled solutions for a CE would require that the governments provide a political mandate for such use; goals are incorporated in the processes; and procurers have the expertise to consider not just the price, but also the life-cycle costs and environmental and social sustainability when allocating contracts. A specific barrier for digitally-enabled solutions for a CE is the current rules which favour goods over (digital) services.

Standards for products, systems and services have proven to be powerful tools in promoting innovation, fostering competition and in guaranteeing consumer safety in the single market.[59] Taking the rapid development of emerging technologies and the speed at which goods and services are entering the European market, there is much scope to make better use of EU standards, especially for services (currently only 2% of EU standards), with an aim to become a global standard setter for digitally-enabled solutions for a CE.

The Commission is helping **to digitise European industry**[60] via e.g. Digital Innovation Hubs, public-private partnerships, and the promotion of digital skills. The aim should not be to digitise all industries for the sake of digitalisation, but rather to support those that contribute to achieving EU's sustainability, circularity and competitiveness goals, with a focus on start-ups (who often develop innovative solutions) and SMEs (to make them more competitive, sustainable and circular). The COSME programme,[61] and Startup Europe initiative and Digital Innovation and Scale-up initiatives[62] could also be used for this purpose.

ENCOURAGING COLLABORATION AND INNOVATION

As the EU is currently negotiating the next MFF,[63] this is the occasion to ensure that money is actually invested in projects that help to enhance the EU's competitiveness and sustainability.[64] Using **research and innovation** support e.g. under Horizon Europe (around €100 billion envisaged), the Digital Europe programme (around €9 billion envisaged) and platforms like European Innovation Partnerships, to encourage the multidisciplinary development of digitally-enabled solutions for a CE would be welcome.

The EU's **Important Projects of Common European Interest (IPCEI)**[65] framework allows member states to support innovative projects in compliance with the EU's state aid rules and initiatives are currently developed for example on batteries, high-performance computing and automated vehicles. It makes sense to use the current momentum to push for new areas for collaboration, including aligning digitalisation efforts with a CE. **European Investment Bank (EIB) financing, Emissions Trading System (ETS) Innovation Fund**[66] and **InvestEU Programme**[67] should also be used to leverage public and private funding in order to support innovative solutions for a sustainable CE.

EMPOWERING PEOPLE AND SOCIETY

The **European structural and investment funds (ESIF)** and especially the Cohesion Fund, the European Regional Development Fund, the European Social Fund and Erasmus+ (possibly around €400 billion in 2021-2027[68]) can contribute to economic and societal transition by supporting research and innovation, SMEs, digital technologies, low-carbon economy and sustainable management of natural resources. For example, the **Smart Specialisation Platform** supports member states and regions with smart specialisation strategies and could be used to increase their awareness on the linkages between

a CE and digitalisation, and their capacities to implement innovative, sustainable and circular solutions.[69]

The EU aims to **empower consumers** to make optimal consumer decisions, know their rights, and be able to seek redress when necessary.[70] Taking the increasing information overload, consumers need guidance on contributing to a more sustainable economy (e.g. via different mandatory and voluntary labelling schemes[71]). The extent to which digitally-enabled solutions (e.g. online platforms, chatbots, games, apps) could be used to inform consumers better and incentivise sustainable behaviour should be explored. As the EU also uses information from consumers (i.e. Consumer Conditions and Single Market scoreboards)[72] to develop new consumer policies, it could be interesting to explore whether any new data and indicators may be needed to achieve a (digital) CE.

In order to empower citizens to co-create knowledge, the EU should continue to support **citizen science** activities via Horizon Europe, as was the case with H2020. The aim should be to ensure that citizens provide reliable data.

Looking ahead, ensuring people's trust in digitally-enabled solutions is key. Initiatives on **ePrivacy** and **cybersecurity** and the eventual **GDPR** review should ensure that data is collected, processed and shared in a trustworthy and secure environment, and thus help ensure social trust in the new digital environment. Education people (also via digitally-enabled solutions) on how to safeguard ePrivacy is an important component of this process.

With the importance of necessary **skills** for the transition and the risk of a digital divide in mind, it is essential to invest in people's skills. This should build on ongoing initiatives, such as the new Skills Agenda for Europe[73] and be coupled with support from ESIF (including the European Social Fund) and e.g. Erasmus+.

6. Reflections for developing a digital roadmap for a circular economy

Climate crisis, environmental challenges, a lack of competitiveness, falling behind in the digital race, and competition over resources – the EU faces multiple challenges that it will need to address if it is to ensure long-term sustainable prosperity for Europe. At the same time, there are two ongoing transitions – the creation of a CE and a digital transformation – that could provide the means to address these challenges, if they are managed well.

As this Discussion Paper has shown, Europe is already a hub for digital solutions for a CE, and it is time to use this as the basis to increase the ambition on action. Numerous stakeholders across the EU are maximising the value of data and are developing and deploying digitally-enabled solutions to improve the connectivity and information sharing; to make products, processes and services more circular; and to empower citizens and consumers to participate in the transition actively. Yet, more can be done to use digitalisation to help the European economy and society become more sustainable and improve CE-related policymaking and implementation. More can also be done to ensure that the digital developments, including the digital/ICT industry itself and technologies like blockchain, become more sustainable. By demonstrating the wide scope of possibilities and challenges in using data and digitally-enabled solutions, this Paper highlights the rationale for coordinated EU action.

If the EU manages to enhance the creation of a data economy and development, deployment and scale-up of sustainable digitally-enabled solutions necessary for a more circular economy – one of the most complex challenges to be addressed today –, this will bring multiple benefits. It would refocus the EU's digitalisation efforts from pushing for technologies to using them to solve its greatest climate, environmental and societal challenges. Europe would gain a competitive advantage in providing the market products and services for a CE that are increasingly in demand outside of the EU, too.

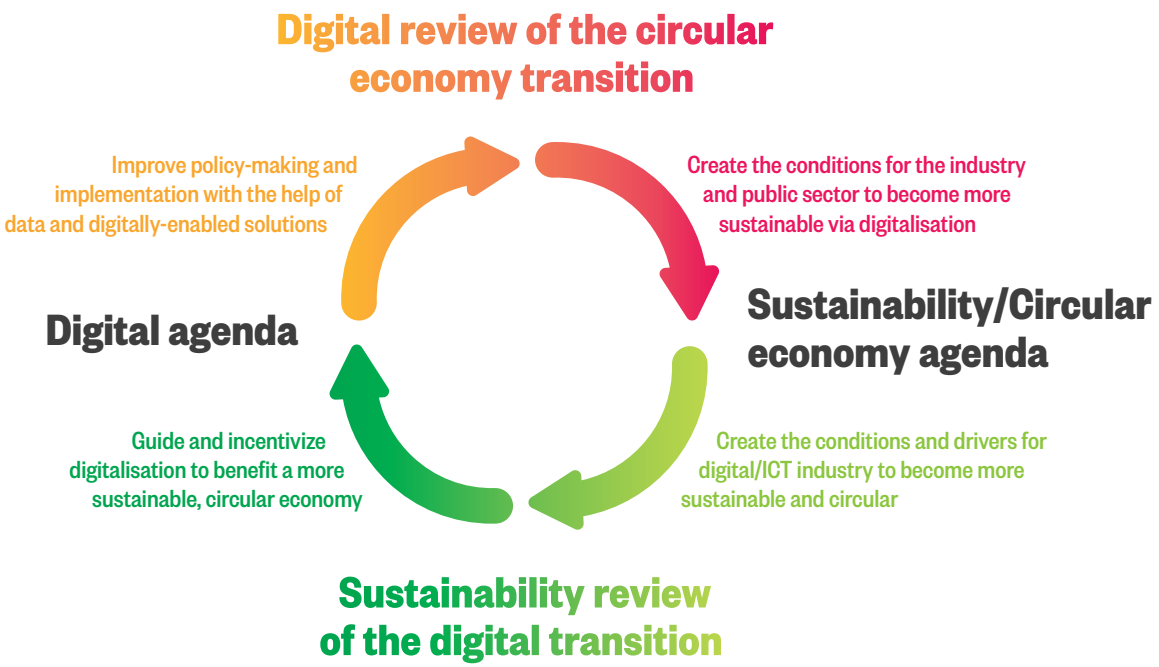
It is high time to recognise that a CE and digital transitions must be co-managed and employed as the means to help the EU ensure long-term prosperity in accordance with the SDGs, the Paris Agreement and climate-neutrality goals. The following considerations set the basis:

- Achieving a successful (digital) transition to a (digital) CE requires *ambition and vision, political will* and *commitment* at the highest level. It requires fundamental changes to the design and implementation of policies, and collaboration across sectors and value chains. The necessary actions go far beyond the standard environmental and digital agendas.

- The transition will be disruptive and will affect all levels of society. Managing this will require *partnerships, capacity building and skills*, and considering stakeholders' different developmental stages when designing measures.

- The EU needs to use the *governance and economic instruments* to create the framework conditions for the transition. It should build on its strengths, including its value-base, multi-disciplinary approaches and technological knowledge.

Fig. 3



- Setting *targets* can help to guide the direction, increase ambition and drive innovation, but before developing concrete targets for aligning the digital agenda with that of the CE, there should be a comprehensive scientific assessment and a clear set of indicators to monitor progress. Modern value chains are complex and global. Products on the European market comprise components and materials from across the world. The EU can aim to be a leader in using digitalisation to make its economy more sustainable and circular, and use the related benefits to attract wider interest in its approach, but in the end, enhancing sustainable production and consumption with a real impact will require international collaboration.

- Becoming more consistent in aligning the digital and CE agendas, must start with:

  1) *A* **digital review** *of the circular economy transition*:

  i) Encourage the use of data and digitally-enabled solutions to improve policymaking and implementation, with the aim to create a more circular economy at the EU, national and sub-national levels (e.g. by using data and digitally-enabled solutions to monitor compliance, evaluate progress and support reporting);

  ii) Create conditions for the European economy and society, industry and public sector to become more sustainable and circular via digitalisation (e.g. by using data and digitally-enabled solutions to improve information sharing, processes, products and services, and empowering citizens/consumers to change their behaviours and become active participants in co-creating knowledge for a circular economy).

  2) *A* **sustainability review** *of the digital transition*:

  i) Guide and incentivise the development and deployment of sustainable digitally-enabled solutions (e.g. AI, blockchain, IoT) in alignment with a more sustainable, circular economy. Ensure that digital and data-related legislation (e.g. on the free flow of data and data protection), investments and public procurement support the transition.

  ii) Create the conditions and drivers for the digital/ICT industry to become more sustainable and circular, thus reducing its negative externalities on the environment, climate and natural resources (e.g. with the help of financial tools).

Key recommendations for the EU institutions in 2019-24

This collection of key recommendations for the EU institutions for the next five years suggests what must be done if the EU wishes to become a global leader in using digitalisation to support a circular economy, to avoid the unwanted consequences and enjoy the related benefits.

1. THINK SYSTEMICALLY: DEFINE A VISION AND TAKE COHERENT ACTION

1.1. **Set a goal to make the EU a global leader** in the utilisation of data and digitally-enabled technologies, to achieve a sustainable, circular economy.

1.2. **Define a vision for a (digital) transition to a (digital) CE** that builds upon maximising the value of data and developing and deploying digitally-enabled solutions, to enable the sustainable use of resources and to maintain the value of products and materials for as long as possible. The priorities must include improving the design, production, products and services and encouraging more sustainable consumption patterns. The vision must be aligned with the UN's SDGs and EU's climate commitments under the Paris Agreement, with a view to become climate-neutral by 2050, while contributing to the creation of a more innovative, competitive and socially-cohesive Europe. The transition needs to happen within the limits of our planet and create added value for the economy.

1.3. **Take action** to tap into the synergies between the digital and circular agendas by carrying out *a digital review of the CE transition and a sustainability review of the digital transition*.

2. USE GOVERNANCE, POLICIES AND REGULATION TO PROVIDE A FRAMEWORK FOR ACTION

2.1. Review the required **data and indicators** for achieving a (digital) CE and update the monitoring framework for a CE, and Digital, Consumer Conditions and Single Market scoreboards accordingly.

2.2. Examine, under the revised Open Data and Public Sector Information Directive, which **public data** is pertinent for the transition to a CE and should be provided free of charge without compromising data privacy interests. Encourage public administrations to provide businesses with practical examples demonstrating how data can be made available and shared while respecting the GDPR and IPRs.

2.3. Explore how data and digitally-enabled solutions could be used, on a case-by-case basis, to improve **EPR schemes**, to foster trust and sharing of relevant information between stakeholders on materials and products to enable their sustainable use, re-use, repair, recycling and minimise their environmental and climate footprint.

2.4. Ensure **ecodesign** rules contribute towards and benefit from a (digital) transition to a (digital) CE. Based on existing scientific evidence, the Commission should consider the introduction of new product requirements and guidelines for new categories of products to support the design of circular products on a case-by-case basis; and building on comprehensive assessments, it should explore the possibilities to integrate digital tools (e.g. tags) within products to support information sharing.

2.5. Incentivise and enable **fair access to and sharing of data/information**.

- Put in place an EU framework for the **free flow of non-personal data**, which encourages innovative circular business models. The EU should push for global guidelines within e.g. the WTO.
- Start developing guidelines for **tracking products, materials and substances across the value chains**, while using the lessons learned from current practices. They should be feasible, with a set of minimum criteria for sharing data. The aim should be an adequate balance between safeguarding companies' commercial and strategic information (including IPR and know-how) and providing e.g. consumers and waste operators access to needed information on a product to enable their safe and sustainable use.
- In the short term, B2B partners, "coalitions of willing", should be encouraged to improve the sharing of information based on the principle of "freedom of contract". The long-term aim (by 2030) must be to establish a **standardised EU system for information sharing** across value chains that ensures both the fair access to data ("data sharing") and fair protection of data ("data privacy") in B2B and B2C markets (by using e.g. blockchain-enabled solutions).

2.6. **Facilitate public procurement** of digitally-enabled circular solutions. The rules should not favour goods over (digital) services; and life-cycle costs, as well as environmental and social sustainability impact, should be considered.

2.7. Under the upcoming **8th Environment Action Programme**, consider how the industrial and digital agendas could contribute to the smarter use of natural resources and a CE. Explore the need to **review the CE package** to link it better with the digital agenda.

2.8. **Address barriers that hinder the development and deployment of digitally-enabled services** and new circular business models. Issues to be considered are standards, service fees, geo-blocking, procurement and taxation rules.

2.9. Facilitate legal **waste** shipments within the EU and put an end to illegal ones with the help of digitally-enabled solutions (e.g. finalise the harmonised electronic notification procedure). Ensure that the envisaged review of the Waste Shipment Regulation benefits from digital developments.

3. USE ECONOMIC INSTRUMENTS TO INCENTIVISE AND ENABLE THE TRANSITION

3.1. Consolidate the EU's **financial tools**, including under the 2021-2027 MFF, to support the development and deployment of innovative digitally-enabled solutions for the CE. EIB financing, the EU's IPCEI framework and ETS Innovation Fund should be used to leverage further private and national funding.

- EU investments in existing and emerging digitally-enabled solutions (e.g. AI, robotics, digital twins, industrial symbiosis, blockchain) should be made **conditional** and contribute towards sustainability and circularity goals.
- Invest in **digital infrastructure** for connectivity and Internet coverage, as well as cybersecurity measures to ensure that businesses and consumers are safely connected and benefit from digitally-enabled solutions for a CE, both within and outside of urban areas.
- Support a **sustainable industrial transition** which builds upon existing initiatives (e.g. the Digitising European Industry initiative) and provides a framework to decrease the industry's environmental/climate footprint through digitally-enabled solutions (e.g. AI).
- Support the **public sector's** application of digitally-enabled solutions (e.g. asset tracking) to improve resource and waste management and reduce waste.
- Ensure that citizens, workers and SMEs have the necessary **digital skills** to contribute to this transition, building on existing initiatives such as the new Skills Agenda for Europe. Especially Cohesion funds should be used to address the growing digital gap in Europe.

3.2. **Create a market** for existing and emerging digitally-enabled solutions for the CE.

- Promote **public procurement** at EU, national and sub-national levels as an investment and innovation tool.
- Explore and share good practices on using **tax incentives** for this aim.

4. STRENGTHEN PARTNERSHIPS AND EMPOWER CITIZENS FOR BETTER RESULTS

4.1. **Use existing stakeholder platforms** to increase the awareness of member states, subnational authorities, academia and businesses on the interlinkages between digitalisation and the CE. Use them to convene intelligence and facilitate the scaling up of existing solutions. Showcase good practices within the private sector (e.g. improving design, business models and industrial symbiosis with digitally-enabled solutions) and public sector (e.g. using public procurement, tax incentives to encourage development and deployment of innovative solutions). Encourage businesses to exchange on required standards and means to improve information/data sharing.

4.2. Increase **citizens' and consumers' trust** in new digitally-enabled solutions. Educate them about the benefits of data exchange and use of digitally-enabled solutions for the environment/CE, and ways to safeguard ePrivacy.

4.3. Use **global fora** to showcase political leadership and promote global collaboration in the (digital) transition to a (digital) CE.

- Adopt a set of **global ethical and sustainability guidelines** for emerging technologies, such as AI. Europe's global approach should build upon the work of the High-Level Expert Group on Artificial Intelligence.
- Establish **international norms for sharing information across global value chains**, building upon existing international standards and databases.

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[2] See e.g. Ahmad, Nadim and Jennifer Ribarsky (2018), "Towards a Framework for Measuring the Digital Economy", Paris: Organisation for Economic Co-operation and Development, p.6.

[3] *United Nations*, "The Sustainable Development Agenda" (last accessed 02 July 2019).

[4] *United Nations Climate Change*, "What is the Paris Agreement?" (last accessed 02 July 2019).

[5] European Commission (2018a), A Clean Planet for all: A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy, Brussels.

[6] See e.g. Material Economics (2018), "The circular economy – a powerful force for climate mitigation: Transformative innovation for prosperous and low-carbon industry", Stockholm.

[7] Ellen MacArthur Foundation (2015), "Growth within: A circular economy vision for a competitive Europe", Cowes, p.12.

[8] See e.g. Ellen MacArthur Foundation (2019), "Artificial intelligence and the circular economy: AI as a tool to accelerate the transition", Cowes.

[9] European Council (2019), A new strategic agenda 2019-2024, Brussels.

[10] The REACH regulation stands for Registration, Evaluation, Authorisation and Restriction of Chemicals. See European Parliament and of the Council (2006), Regulation 1907/2006 of the European Parliament and of the Council concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC, Brussels.

[11] See Oertel, Angelika; Katrin Maul; Jakob Menz; Anna Lena Kronsbein; Dana Sittner; Andrea Springer; Anne-Katrin Müller; Uta Herbst; Kerstin Schlegel and Agnes Schulte (2018), "REACH Compliance: Data availability in REACH registrations Part 2: Evaluation of data waiving and adaptations for chemicals ⩾ 1000 tpa. Final Report (Final Report)", Dessau-Roßlau: German Federal Institute for Risk Assessment, p.172.

[12] European Parliament and Council of the European Union (2018a), Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on waste, Brussels.

[13] *European Chemicals Agency,* "New database on Candidate List substances in articles by 2021" (last accessed 24 June 2019).

[14] CLAIM is short for Cleaning Litter by developing and Applying Innovative Methods in European seas.

[15] The platform is a result of the ProSUM project that has encountered several challenges ranging from data availability and access to harmonisation, and these lessons have been turned into specific policy recommendations. See Downes, Sarah; Jaco Huisman; Pascal Leroy; Maria Ljunggren Söderman; Duncan Kushnir; Amund N. Løvik; Patrick Wäger; Vera Susanne Rotter; Paul Mählitz; Perrine Chancerel; Johanna Emmerich; Anders Hallberg; François Tertre and Daniel Cassard (2017), Prospecting Secondary Raw Materials in the Urban Mine and mining wastes (ProSUM) Recommendations Report, Brussels: ProSUM.

[16] These sectors will be examined closer in the final study to be published in autumn 2019.

[17] See Ellen MacArthur Foundation (2019), *op.cit.*

[18] Ellen MacArthur Foundation (2018), "The circular economy opportunity for urban & industrial innovation in China", Cowes, p.47.

[19] Kobie, Nicole, "The complicated truth about China's social credit system", *Wired*, 7 June 2019

[20] European Commission (2018b), Communication from the Commission to the European Parliament, the Council, the European, Economic and Social Committee and the Committee of the Regions on the implementation of the circular economy package: options to address the interface between chemical, product and waste legislation, Strasbourg.

[21] European Commission (2019a), Commission's report shows that targeted investment and robust digital policies boost Member States' performance, Brussels.

[22] See e.g. World Intellectual Property Organization (2019), "WIPO Technology Trends 2019: Artificial Intelligence", Geneva.

[23] European Commission (2019a), *op.cit.*

[24] *European Commission*, "Artificial intelligence" (last accessed 24 June 2019).

[25] Ufacik, Esra (2016), "Making Blockchain Real for Business: Explained", Istanbul: IBM.

[26] See e.g. Bird, Jon, "What a Waste: Online retails big packaging problem", *Forbes*, July 29 2018.

[27] See e.g. Enerdata (2018), "Between 10 and 20% of electricity consumption from ICT sector in 2030?". Baldé, Cornelis Peter; Vanessa Forti; Vanessa Gray; Ruediger Kuehr and Paul Stegmann (2017), "The Global E-waste Monitor – 2017:; Quantities, flows and resources", United Nations University (UNU), Bonn/Geneva/Vienna: United Nations University, International Telecommunication Union (ITU) & International Solid Waste Association (ISWA), p.19.

[28] See e.g. World Health Organization, "Electromagnetic fields (EMF) > Electromagnetic fields and public health: Exposure to extremely low frequency fields" (last accessed on 22 June 2019).

[29] European Commission (2018a), *op.cit.*

[30] European Commission (2019b), Reflection Paper: Towards a sustainable Europe by 2030, Brussels.

[31] See *European Commission*, "Environment > Sustainable Development > Single Market for Green Products > Results and deliverables of the Environmental Footprint pilot phase" (last accessed 24 June 2019).

[32] See European Commission (2014), Living well, within the limits of our planet: 7th EAP – The new general Union Environment Action Programme to 2020, Brussels.

[33] See Gancheva, Mariya; Sarah O'Brien; Catarina Monteiro and Alessia Valentino (2018), "Towards an 8th Environment Action Programme – Local and regional dimension", Brussels: European Committee of the Regions.

[34] E.g. the United Nations rules for Elec¬tronic Data Interchange for Administration, Commerce and Transport (UN/EDIFACT) standards, as well as the Global Material Flows Database and Global Resources Outlook.

[35] E.g. the Ecodesign, Industrial Emissions, Single-Use Plastics, Waste Framework, Packaging and Packaging Waste, Waste Electrical and Electronic Equipment, and End-of-Life Vehicles directives; and REACH and CLP (Classification, Labelling and Packaging) regulations.

[36] See European Commission (2018c), Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on a monitoring framework for the circular economy, Strasbourg.

[37] The CE's role, along these lines, is recognised in *ibid.*; and the European Commission (2018a), *op.cit.*

[38] European Commission (2015), Closing the Loop – An EU action plan for the Circular Economy, Brussels.

[39] European Parliament and Council of the European Union (2019a), Directive of the European Parliament and the Council on the reduction of the impact of certain plastic products on the environment, Brussels.

[40] European Parliament and Council of the European Union (2018a), *op.cit.*

[41] European Parliament and Council of the European Union (2009a), Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products (recast), Brussels.

[42] *Organisation for Economic Co-operation and Development*, "Environment Directorate > Environmental policy tools and evaluation > Extended producer responsibility" (last accessed 25 June 2019).

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[44] European Commission (2018d), Proposal for a Regulation of the European Parliament and of the Council establishing a Programme for the Environment and Climate Action (LIFE) and repealing Regulation (EU) No 1293/2013, Brussels.

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[46] European Parliament and Council of the European Union (2003a), DIRECTIVE 2003/4/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 28 January 2003 on public access to environmental information and repealing Council Directive 90/313/EEC, Brussels.

[47] European Parliament and Council of the European Union (2007), Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE), Brussels, Article 1, p.4.

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[51] European Commission (2018e), "A Modern Budget for a Union that Protects, Empowers and Defends: The Multiannual Financial Framework for 2021-2027", Brussels.

[52] European Parliament and Council of the European Union (2018b), Regulation (EU) 2018/1807 of the European Parliament and of the Council of 14 November 2018 on a framework for the free flow of non-personal data in the European Union, Brussels.

[53] European Parliament and Council of the European Union (2003b), Directive 2003/98/EC of the European Parliament and of the Council of 17 November 2003 on the re-use of public sector information, Brussels. This Directive is currently undergoing revision; see *European Commission*, "Strategy > Digital Single Market > Policies > European legislation on the re-use of public sector information" (last accessed 24 June 2019).

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[56] *European Commission*, "Strategy > Digital Single Market > Policies > Proposal for an ePrivacy Regulation" (last accessed 24 June 2019).

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[58] *European Commission*, "The EU Single Market > Single Market Scoreboard > Integration and Market Openness > Trade in Goods Services > Trade in Goods and Services" (last accessed 24 June 2019).

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[62] *European Commission*, "Strategy > Digital Single Market > Policies > Startup Europe" (last accessed on 25 June 2019).

[63] European Commission (2018e), *op.cit.*

[64] Hedberg, Annika (2019), "The EU budget – including the CAP – should be used to finance the Union's priorities" in Rebecca Castermans (ed.), *Yes, we should! EU priorities for 2019-2024*, Brussels: European Policy Centre.

[65] European Commission (2018f), Decision of 30 January 2018 setting up the Strategic Forum for Important Projects of Common European interest, Brussels.

[66] *European Commission*, "Energy, Climate chage, Environment > Climate Action > EU Action > Innovation Fund" (last accessed on 25 June 2019).

[67] European Commission (2018g), The InvestEU Programme: Questions and Answers, Brussels.

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[69] *European Commission*, "Smart Specialisation Platform > S3 Platform > What is Smart Specialisation?" (last accessed on 25 June 2019).

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[72] *European Commission*, "Policies > Consumers > Consumer protection > Evidence-based consumer policy > Consumer scoreboards" (last accessed on 24 June 2019).

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The European Policy Centre's project "**Digital Roadmap for Circular Economy**" explored the linkages between digitalisation and the circular economy, the opportunities created by data and digitally-enabled solutions and the challenges associated with harnessing their full potential for the transition to a circular economy. The project consisted of ten multi-stakeholder workshops in 2017-19 and brought together representatives of public and private sectors, academia and civil society, and experts on digital as well as environmental issues to have an open exchange on the linkages. The project has been a pioneering endeavour in exploring the linkages and considering implications for EU policymaking.

This Discussion Paper builds on the project findings and makes recommendations for the EU institutions in the next five years. It aims to promote discussion and provoke reactions, which the EPC analysts are happy to consider when finalising a more extensive version of this study, scheduled to be published in the late autumn of 2019.

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