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An innovation policy to meet the EU's Green Deal Circular Economy goals

Editors: Jorge Núñez Ferrer, Cristian Stroia

Abstract

The shift towards a circular economy requires considerable political will. Fortunately, both the national and EU Covid-19 recovery packages offer a way to accelerate this shift. A dynamic and coordinated circular economy research and innovation approach across EU member states will form one pillar of this transition. Technical and societal challenges also demand economies of scale and impact. It is the mission of the Circular Economy Platform for the European Priorities Strategic Agenda (CICERONE) H2020 project to propose solutions to all these challenges.

This paper is addressed to policymakers and presents the key policies and actions required to further develop, along with stakeholders, a roadmap for a successful European circular economy.

CICERONE This report is part of the Circular Economy Platform for European Priorities Strategic Agenda (CICERONE) project, aimed at developing the strategic coordination of objectives and programming of regional, national and European funding programmes in the area of circular economy. The project does this by assessing and benchmarking the current performance of circular economy research & innovation funding and developing a strategic research and innovation agenda for circular economy in Europe. Findings will ultimately result in the creation of a joint programming platform for programme owners and initiators.

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While the key stakeholders and contributors listed in the acknowledgements provided significant input to the development of this report, their participation does not necessarily equate to endorsement of the report's contents or conclusions.

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Building a roadmap for a successful European Circular Economy RDI

Stakeholder and expert inputs edited by:

Jorge Núñez Ferrer, Cristian Stroia

1. Introduction

Moving towards a circular economy (CE) has formally been a key EU objective since 2015, when a Circular Economy package was published by the European Commission. Circular Economy is also a core pillar of the Green Deal strategy adopted by the present European Commission under President von der Leyen. In this context, a new Circular Economy Action Plan was adopted in March 2020[1] to scale up the market transformation and make an essential contribution to the EU's efforts to achieve climate neutrality by 2050. Research, innovation and digitalisation are considered to be key drivers of change in this new plan. The Covid-19 pandemic may shift the immediate priorities of governments, but it will not change the climate change process, even if temporary emissions fall, nor will the excessive use of resources be altered by it.

Ultimately, the shift towards circular economy solutions needs to be achieved and this crisis may also offer new impetus, provided there is political will. Large national stimulus packages or 'recovery' packages, along with EU funding, will be released to counteract the economic shock of the Covid-19 crisis.

One positive avenue is to use the stimulus to revive the economy to its pre-pandemic level or to invest the substantial funds in the energy and industrial sectors of the future, instead of resuscitating jobs and companies that would have to be phased out anyway to achieve the EU and Paris Agreement objectives, the funding can redirect employment and investment to develop and maintain key technologies and value chains that need developing for the future. This is not only a technological decision; in many respects it is a political decision, as de facto it requires incentives to align the behaviour of businesses and individuals to incorporate end-of-life stage circular concepts into the value chain. This also creates demand and promotes innovation in circular solutions. Without the right incentives, such as introducing green or sustainable public procurement, or adapting taxation, the important demand drivers will be missing. The EU may become a leader in CE solutions, but to do so, it has to develop a strong capacity on a scale only an EU collaborative integrated approach can offer.

Introducing innovative circular solutions into the value chain of economies is fraught with barriers, as our economies are mainly designed from the perspective of a linear chain from production to discarding. The current chain also ignores key externalities and costs: from

[1] Communication from the Commission "A new Circular Economy Action Plan For a cleaner and more competitive Europe", COM(2020) 98 final, Brussels.

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raw material extraction and transport to the production process, and carbon prices, for example. Stakeholders note that the bulk of circular economy programmes in member states focus on end-of-life solutions for waste, perhaps unsurprisingly. Other specific policies do exist in some countries, however, and focus on resource-efficiency improvements upstream (e.g. zero waste and generation of by-products from raw material sources, e.g. mineral extraction, product design) and downstream during the level of manufacturing processes, e.g. water use efficiency.

While waste reduction and management, recycling and resource efficiency during and post-manufacturing are crucial, a circular economy aims to address the overall sustainability of the economic system by interconnecting the various production processes and consumption patterns. In this respect, it is as much a technological challenge as it is a regulatory, market, financial and behavioural one. The financial value of the economic stimulus package will not do the job alone.

The 2020 Circular Economy Action Plan aims to address the above complex challenge and takes a further step towards the adoption of a more holistic perspective towards resource management at all levels. It is a plan that predates the pandemic, but it is no less topical today than it was then; on the contrary, the plan offers a blueprint for where to invest. The action plan includes several actions, many of which have a bearing on the area of research and innovation:

- Designing the enabling policy framework
    a. Designing sustainable products: measures include the need for action in R&D.
    b. Empowering consumers and public buyers and raising their awareness of circular economy and resource management: the public will need to be sensitised and a change in behaviour promoted. Second, Green Public Procurement will have to be mainstreamed and improved. The requirements for circular solutions by goods and services providers to the public sector must be reinforced.
    c. Circularity in production processes: the action plans seeks to promote circularity in industrial processes.
- Key product value chains

    The European Commission has several recommendations to reinforce circularity in the value chains for different key sectors in the economy. The sectors are electronic and ICT, batteries and vehicles, packaging, plastics, textiles, construction and buildings, food, water and nutrients.

    In those areas, innovation in the areas of eco-design, production methods, reuse repair and recycle will require research and innovation on technologies as well as legal, social and economic instruments.

- Less waste, more value

    The action plan seeks to reduce waste and to prolong the use and value of products.

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The 2020 Circular Economy Action Plan presents an approach to R&I and digitalisation, focusing on the use of several funds to support it, i.e. HORIZON, the European Regional Development Plan and LIFE. In addition to funding for the development of solutions and bringing them to the market, the action plan also emphasises the importance of ICT and intellectual property in unleashing the creation of circular solutions.

A circular economy is a key component of an environmentally sustainable future, but ***it is important to design the approach based on a solid understanding of systems, led by a science-based knowledge approach***. There is a risk of implementing a patchwork of ultimately inefficient circular economy approaches, such as closed inefficient partial loops within single industries or business sectors, missing intra-industry, cross-sectoral options. ***Mistakes can ultimately lead to adverse impacts, such as rebound effects and actual displacement of unsustainable practices, e.g. emissions, traffic or waste, rather than real positive global impacts***. Innovation programmes will be key to identifying circular economy avenues that ensure that economic and social development is sustainable in the long term.

2. An innovation and research programme fit for the Green New Deal

The European Union has the ambition to be a global leader in the areas of climate change and sustainability. Achieving this objective requires a research and innovation programme that will not only effectively support the sustainability and carbon neutrality path, but will also reinforce the leadership of the EU in technological and social solutions internationally. Circular solutions are a key part of developing a green growth approach for the EU.

To do this the European Union has to ensure the following conditions are fulfilled:

- Clarity of vision and definition of a circular economy and its key contributors
- Coordinated approach and common understanding of key indicators and policies across the EU
- Support to innovation has to be followed up with support for scaling-up, market penetration and the promotion of solutions
- Removal of barriers to innovation and deployment of innovations
- Building additional framework conditions for an innovative circular economy
- Setting up a circular economy strategic research and innovation agenda (SRIA)

The following sections will present the key actions needed to address each of them.

2.1 Clarity on the vision and definition of a circular economy

The term circular economy is often used more as a buzzword than as a clearly defined approach to value chains, production and consumption. While the basic concept of resources re-entering the production chain is understood to some extent, there is a lack of clarity on what precisely this entails.

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The CICERONE project has undertaken an extensive review of the current state of the art of circular economy innovation[2] in EU member states and beyond. One of the challenges is the lack of a clear definition of what a circular economy is. Kirchner et al.[3] list over 100 definitions of circular economy. There is a lack of coherence in the approaches in different member states and the key performance indicators (KPI) for research and innovation programmes do not necessarily correspond with circular economy objectives. The review highlights that most KPIs are qualitative rather than quantitative (only 11 out of 104 programmes have quantitative KPIs). The results of the survey indicate the need for better coordination among the responsible authorities in EU member states and the need to overcome underdeveloped performance measuring.

Figure 1 presents a framework for a circular economy starting from the design of products, their reparability, reuse, upcycling and recycling.

Figure 1. Framework for monitoring and evaluation of product eco-innovation for the circular economy

Source: Framework for monitoring and evaluation of product eco-innovation for the circular economy (O'Brien et al., 2018, p. 20).[4]

[2] B. Bahn-Walkowiak, H. Wilts, W. Reimer, L. Mengchun (2019), "Overview report on definition and concept of the Circular Economy in a European Perspective", CICERONE report, D 1.1., Wuppertal.

[3] J. Kirchherr, D. Reike, and M. Hekkert (2017), "Conceptualizing the circular economy: An analysis of 114 definitions", *Resources, Conservation & Recycling*, Vol. 127, pp. 221–232. https://doi.org/10.1016/j.resconrec.2017.09.005

[4] M. O'Brien, A. Doranova, N. Kably, A. M. Kong, O. Kern, S. Giljum, and B. Gözet (2018), Eco-Innovation Observatory - Biannual Report 2018. https://ec.europa.eu/environment/ecoap/sites/ecoap

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Figure 1 shows different aspects of circular economy frameworks. On the right the framework presents the three main areas affecting products in circularity: product design and production, product use/post-consumption, and the business model:

- Consumption and post-consumption follow and adapt the framework conditions in which the companies work, ensuring circularity.
- Product design and production: design and manufacturing which affect the circularity of the production process.
- Business model: these are the factors required in the business models to ensure full circularity, from take-back schemes to technologies used.

The external circle shows the areas that a circular approach has to cover in the design, production practices, use of products and finally the framework to ensure circularity.

All of these factors require the right regulatory framework and the right codes and standards. An example can be found in the UK, where the British Standards Institution developed standards[5] to define the characteristics, terms, definitions and metrics for a circular economy, a flexible management framework for implementing CE strategies in organisations, and economic, environmental, design, marketing and legal issues related to CE. Another example is the newly formed ISO technical committee[6] for a circular economy, which will cover public procurement, production and distribution, end-of-life and wider areas (e.g. societal behavioural change).

Material sourcing and the importance of energy demand and energy dissipation (losses) in the processes are missing in To understand circularity requirements, the specific product cycle needs to be understood. For example, Figure 2 describes the specific role of material sourcing and energy input and dissipation in zinc production and use.

Actual production cycles suffer from energy dissipation and inevitable residue loss. Circularity does not eliminate the need for mineral extraction.

_stayconnected/files/documents/eio_report_2018.pdf

[5] BSI, 2017 – "BS 8001:2017. Framework for implementing the principles of the circular economy in organizations– Guide", British Standards Institution, London.

[6] ISO/TC 323, https://www.iso.org/committee/7203984.html

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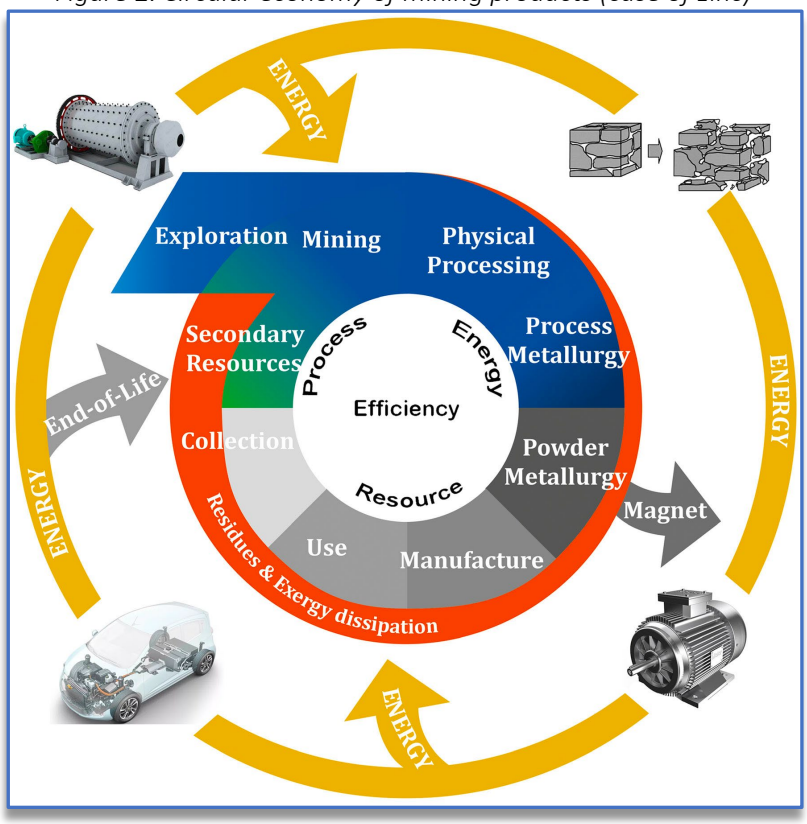
Figure 2. Circular economy of mining products (case of zinc)



Source: Example from "Simulation-Based Exergy Analysis of Large Circular Economy Systems: Zinc Production Coupled to CdTe Photovoltaic Module Life Cycle", A. Abadías Llamas, N. J. Bartie, M. Heibeck, M. Stelter, M. A. Reuter.

There is also a need for a clear definition of circular economy that responds to the objectives of such an economy. Currently, there are numerous definitions that do not fully correspond to one another. The following definition combines the most relevant definitions with the input of stakeholders:

> A circular economy is an economy that is regenerative and restorative in nature and aims for greater resource productivity by reducing and reusing waste, subsequently avoiding pollution. It entails (gradually) decoupling economic activity from the consumption of finite resources building economic, natural and social capital. The value of products and materials is maintained for as long as possible; waste and resource use are minimized, and resources are kept within the economy when a product has reached the end of its life, to be used again and again to create further value. A Circular Economy policy should also incorporate an approach to mitigate negative socioeconomic and environmental impacts of raw material sourcing.[7]

[7] This definition combines the definition of the Ellen MacArthur Foundation, the European Commission and stakeholder inputs.

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2.2 Creating a common framework of key indicators to monitor, report and verify circular economy actions across the EU

One of the key challenges to promoting a circular economy is to develop a monitoring framework to measure circular impacts. The lack of a clear definition is a problem but to some extent, the objective is to minimise resource use, reduce negative externalities and to avoid waste. Even with such an approach, there is a need for clear ways of monitoring, reporting and verifying the performance of circular solutions.

2.2.1 Challenges with measuring progress

Existing policy efforts have led to advances in achieving a circular economy, but the assessment of this progress in the EU has proved to be a challenging task. Some of the main challenges are:

- The lack of appropriate monitoring tools and CE indicators at both national and European level to accurately assess CE activities, degree of loop closing, and in- and out-flows.
- Problem shifting due to recycling activities that do not lead to real circular flows or reduce problems in one sector or geographical area, but that negatively affect other sectors or geographical areas (i.e. waste reduction achieved by exporting waste or importing raw materials without consideration to the impacts in the exporting countries).
- Lack of monitoring framework of overall material flows.

2.2.2 Innovation needs on measurement, reporting and verification

Measurement, reporting and verification (MRV) are essential tools to understand not only the performance of new technological solutions but also the performance and needs of present technologies and policy tools. In this context, *existing* standards and quality infrastructure, as well as needs for future developments, are to be considered. Based on existing and potentially new standards, MRV frameworks in member states (and globally) need to follow the same rules to ensure results are comparable.

The following list presents the expected requirements for a system-wide assessment of CE monitoring:

- Develop harmonised EU cross-country data sets and statistical reporting on CE.
- Create methods to assess the circularity of products by providing information on product design, including measurement of non-material flows and providing information on each step in the value chain (not only product design), from resource extraction until sales.
- Determine indicators that identify problem shifting.
- Identify the flows of individual substances and materials that have a high and particular environmental pressure, but low mass share (e.g. critical metals, plastics).
- Perform comprehensive material-flow analysis to provide new data that fits into CE monitoring frameworks.
- Integrate assessments between individual material in-depth analysis, environmental and socioeconomic indicators.
- Develop methods for improving statistical reporting and data availability, and resolve the ambiguity of reported quantities (e.g. of waste flows, actual recycling rates etc.).

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- Expand criteria and indicators for ecological loop-closing beyond biomass, to include, among others, soil degradation, net-carbon losses related to farming, the regional dimension of ecological loop-closing etc.
- Following the above, research on fostering a bioeconomy should be enhanced.
- Include the global scale of circularity in EU national analysis frameworks and indicators (to better account for the trade of waste and secondary raw materials).
- Implement research circularity at different levels with interlinkages, from the micro-level (company/business) to the meso-level (Eco-industrial parks/industrial symbiosis) up to the macro-level (national and beyond). One of the key questions is how to align indicators on the different levels to measure progress towards circularity.
- Shift the focus from the material flows (extraction and waste management) to the circularity of products themselves.
- Identify regulations and policies at EU and global level that promote and hinder a CE.

Improvements in measurements should be integrated into existing EU measurement frameworks (e.g. the CITYkeys performance measurement framework for smart cities) or should build upon monitoring frameworks created at national-level (e.g. the Oto-GOZ project[8] in Poland).

The European Commission has already set up a monitoring framework with a list of ten indicators with several sub-indicators in the area of circular economy.[9] This is an important first step that needs to be further expanded and developed.

The indicators presented in the framework include:

Table 1. Ten indicators for a CE monitoring framework

Production and consumption
EU self-sufficiency for raw materials *(percentage)*
Green public procurement
Waste generation
Generation of municipal waste per capita *(kg/capita)*
Generation of waste excluding major mineral wasters per GDP unit *(kg per €1000, chain-linked volumes)*
Generation of waste excluding major mineral wasters per domestic material consumption *(percentage)*
Food Waste *(million tonne)*
Waste management
Recycling rates
Recycling rate of municipal waste *(percentage)*
Recycling rate of all waste excluding major mineral waste *(percentage)*

[8] See http://circularhotspot.pl/pl/oto-goz
[9] See https://ec.europa.eu/eurostat/web/circular-economy/indicators/monitoring-framework

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Recycling /recovery for specific waste streams
Recycling rate of overall packaging *(percentage)*
Recycling rate of plastic packaging *(percentage)*
Recycling rate of wooden packaging *(percentage)*
Recycling rate of e-waste *(percentage)*
Recycling of biowaste *(kg per capita)*
Recovery rate of construction and demolition waste *(percentage)*
Secondary raw materials
Contribution of recycled materials to raw materials demand
End-of-life recycling input rates (EOL-RIR) *(percentage)*
Circular material use rate *(percentage)*
Trade in recyclable raw materials *(tonne)*
Imports from non-EU countries
Exports to non-EU countries
Intra-EU trade
Competitiveness and innovation
Private investment, jobs and gross value added related to circular economy sectors
Gross investment in tangible goods *(percentage of gross domestic product (GDP) at current prices)*
Persons employed *(percentage of total employment)*
Value added at factor cost *(percentage of gross domestic product (GDP) at current prices)*
Number of patents related to recycling and secondary raw materials

Source: https://ec.europa.eu/eurostat/web/circular-economy/indicators/monitoring-framework

Further research is also needed to better understand how quality infrastructures and standards can be best used to promote the diffusion of CE innovation.[10] Voluntary schemes (e.g. ISO 14034:2016[11] for Environmental Technology Verification) and EU programmes (e.g. the EU Environmental Technology Verification ETV[12]) dedicated to innovation and market uptake would be a good starting point. The development of the infrastructures requires public policies and investments, while the standards may be developed by standards organisations, which can be fostered by the appropriate public policies setting up minimum standards and policies such as adopting MRV and standards for key indicators.

[10] As an example of such research, see: X. Cirera, J. Frías, J. Hill, and Y. Li (2020), "A Practitioner's Guide to Innovation Policy: Instruments to Build Firm Capabilities and Accelerate Technological Catch-Up in Developing Countries", World Bank Group, Washington.

[11] ISO 14034:2016 helps cutting-edge green technologies to reach markets www.iso.org/obp/ui/#iso:std:iso:14034:ed-1:v1:en

[12] EU Environmental Technology Verification ETV https://ec.europa.eu/environment/ecoap/etv_en

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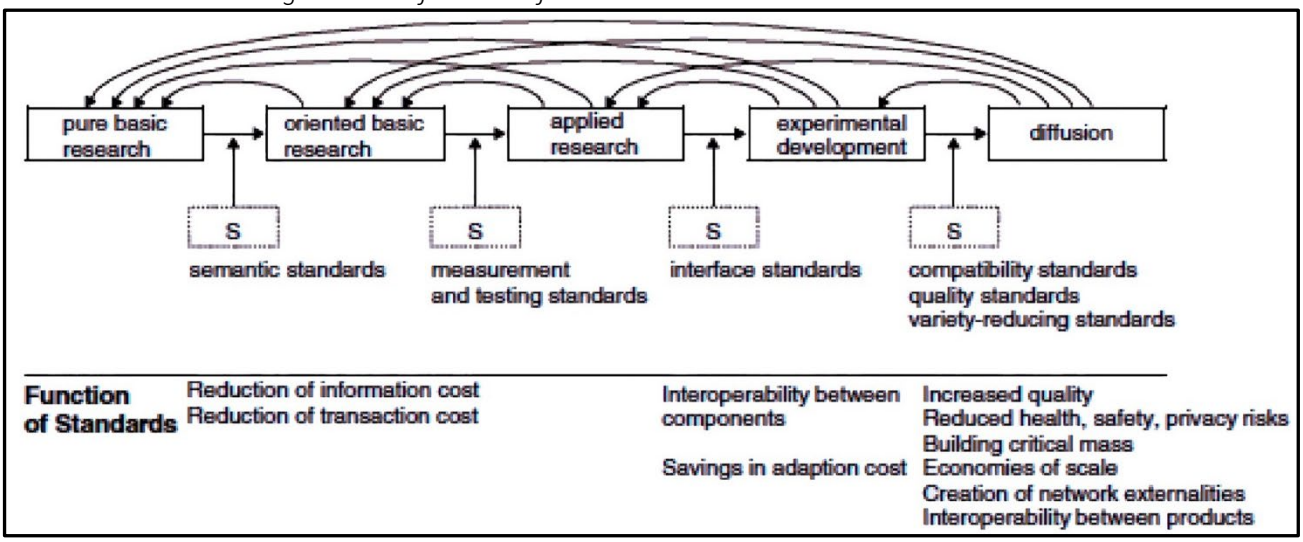
Future circular economy RDI programmes must be developed in collaboration with CEN/CENELEC.

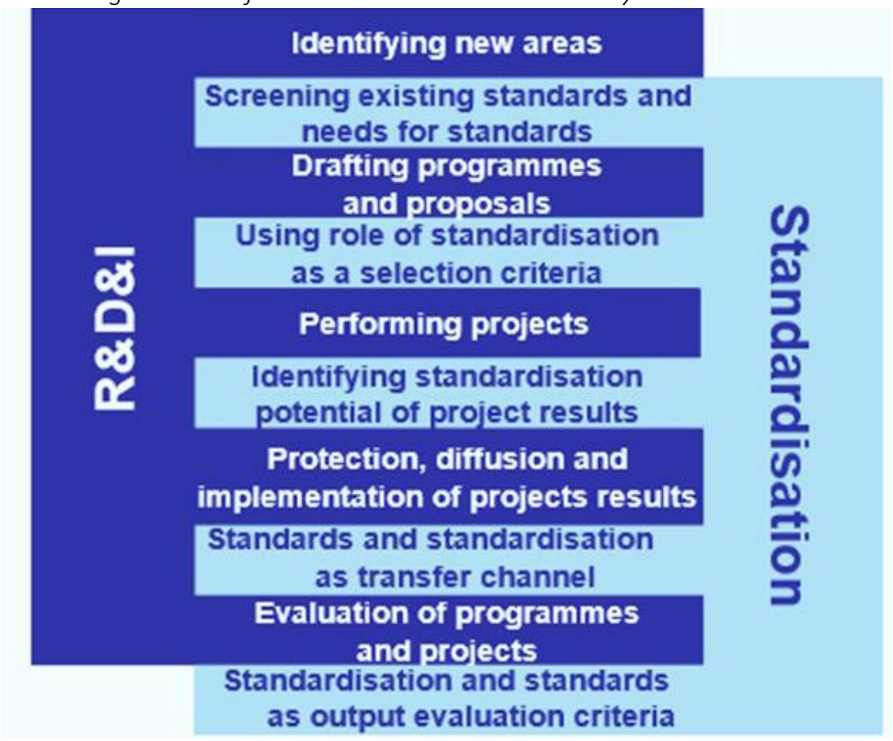
Figures 3 and 4 below illustrate the contribution of standards as selected quality infrastructure instruments.

Figure 3. The function of standards in research and innovation



Source: K. Blind, S. Gauch (2009), "Research and Standardisation in Nanotechnology: Evidence from Germany", *Journal of Technology Transfer,* Vol. 34, no. 3, pp. 320-342.

Figure 4. The fit between RDI and standards by CEN-CENELEC



Source: CEN-CENELEC STAIR (2011), "The Operationalisation of the Integrated Approach: Submission of STAIR to the Consultation of the Green Paper 'From Challenges to Opportunities: Towards a Common Strategic Framework for EU Research and Innovation funding'".

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2.3 Support for innovation requires also support for scaling up, market penetration and the promotion of solutions

2.3.1 Challenges for research to scale up and access to the market

The European Union is a global leader in research and development, but it is frequently reported that there is a weakness in the ability to transform innovations into businesses. Start-ups and SMEs with innovative solutions are often unable to grow and there has been a history of companies even moving to the US for capital. While many barriers exist (e.g. underdeveloped equity finance in the EU; inability to scale start-ups into major companies; slow digital adoption in the public sector; reduced investment in intangibles (such as software and databases); fragmentation of the single market etc.), the EU could leverage its strengths and find its ingredients for innovation adoption (e.g. industrial ecosystems, public sector digitisation, data governance etc.).[13]

2.3.2 Support instruments needed for post R&D business models

The European Union has for a long time been concerned by the lack of venture capital and angel investors in the EU, which has resulted in the weak performance of companies moving from successful research results to scale in the market. There is a need to further research new business models and systems that would allow companies the potential to grow and compete while using a circular economy approach to their products. The business innovation needs are the following:

- Development of new financing and business models to promote innovation, expand the risk capital and growth capital. Work has been carried out on this for several years, in particular, the European Commission's ESCALAR concept,[14] which has been under development since its formulation in 2015 and has been launched on 8 August 2020. An additional example is the use of Environmental Technology Verifications (ETV)[15] as a tool to help innovative environmental technologies from SMEs reach the market and build the trust of technology users.
- Support for business accelerators, networks and clusters, which can enable start-ups to grow and find a market.
- New methods of engagement for the private and public sector in research, innovation and deployment are needed. Incentives need to be reviewed and must make sense for the private sector companies that are approached to participate. Models of depoliticised public-private partnerships (PPPs or PPPPs – public-private-people partnerships) should be researched. Other options such as crowdsourcing models should be explored.
- There needs to be a stronger dialogue between business communities and policymakers to determine the research needed to remove technological, regulatory and financial barriers to a CE.

[13] McKinsey Global Institute, 2019, *Reviving innovation in Europe*, www.mckinsey.com/featured-insights/innovation-and-growth/reviving-innovation-in-europe#

[14] See https://ec.europa.eu/newsroom/growth/item-detail.cfm?item_id=673899

[15] See https://ec.europa.eu/environment/ecoap/etv_en

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- Public procurement for innovative solutions needs to be expanded, and green or sustainable public procurement should be mandatory and implementable in practice, as is the case in some countries.[16] The requirements should also be reviewed so that they align with the circular economy objectives. Extensive training programmes for procurement officials should be launched.
- Review the rules of incentives, such as the seal of excellence in HORIZON 2020[17] to ensure that the needs for a CE approach are incorporated into the products developed.
- Create 'circular hubs', i.e. multi-stakeholder initiatives in public-private partnerships to accelerate the transition to a circular economy by providing support to SMEs and companies for the implementation of circular models at the local, regional and national level, as a key step in making the transition to a CE.

2.4 Build additional framework conditions for an innovative circular economy

2.4.1 Challenges caused by a lack of understanding in society

A circular economy is as much an industrial approach as it is a social choice. There is a need to bring circular concepts into the education system; this means that in general education, the implications of human activities on ecosystems should be explained, and in higher education a fact-based understanding of the scientific preconditions on CE should be assured. Aligning technological change and sustainability needs to become evident. Lack of education, awareness and understanding of the benefits of a circular economy also hinder the uptake of circular solutions.

2.4.2 Need for intervention and research in education

Circular economy concepts should be communicated to the stakeholders that need to be involved in circular economy solutions and to the general population

- Launch new approaches to develop awareness and capacity-building programmes, develop co-creation programmes.
- Develop data-gathering and dissemination systems to increase the transparency and understanding of a circular economy.
- Develop information tools to facilitate the emergence of collaborative structures and new circular business models.
- Explain the given technical and scientific framework conditions and limitations of closing the loop, also as a justification for further research to overcome barriers.
- Study the effectiveness costs and feasibility of introducing policies obliging transparency on issues such as companies' production chain traceability.

[16] For information on the current state of public procurement: J. Núñez Ferrer (2020), "The EU's Public Procurement Framework - How is the EU's Public Procurement Framework contributing to the achievement of the objectives of the Paris Agreement and the Circular Economy Strategy", Briefing for the European Parliament IMCO Committee.

[17] The seal of excellence is given to projects that were judged to deserve funding by the EU HORIZON 2020 but missed out due to budgetary restrictions. This seal is offered to facilitate the application for other funding sources.

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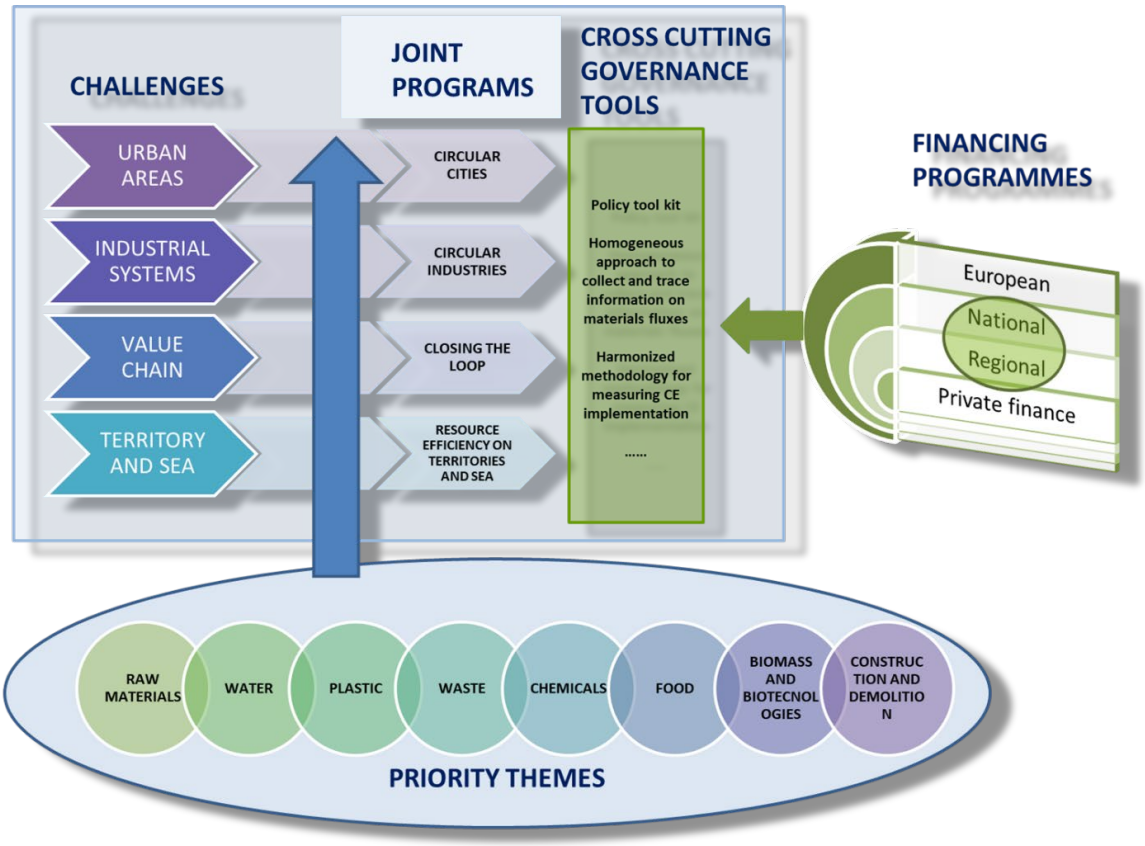
3. Set up a circular economy strategic research and innovation agenda (SRIA)

Developing the framework conditions for bringing research and innovation solutions to the wider market and creating incentives for their adoption is essential. The EU has been quite successful in the areas of basic research and development of new solutions, but due to particularities of its fragmented markets and barriers, as well as member state policymaking, it has not been very successful in deploying them or in creating successful new businesses.

In the area of circular economy, the European Union can and should be a global leader, and for this it needs a solid research and innovation (R&I) activity with a dedicated agenda. One of the key objectives of the CICERONE project is to develop a strategic research and innovation agenda (SRIA) for a circular economy. This SRIA focuses on systemic change and adopts a cross-cutting interdisciplinary approach that will allow future users (mainly composed of EU programme owners)[18] of the upcoming joint programming platform (in development within CICERONE) to co-create, co-fund and work together towards a systemic circular economy in the EU. The SRIA being produced by this project identifies priority areas for circular economy research and has organised them as follows.

Figure 5. The Strategic Research and Innovation Agenda



Source: CICEORNE – The SRIA.

[18] Programme owners are the public officials working in government and funding agencies coordinating research and innovation programmes.

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The SRIA has identified eight **priority themes** for research: **biomass, chemicals, construction and demolition, food, plastic, raw materials, waste and water.** Each theme incorporates a set of circular economy **challenges**, namely **urban areas, industrials systems, value chain, territory and sea.** For example, reducing the use of a chemical will fall under the chemicals theme and may be relevant for industrial systems. Under each challenge, there will be a corresponding **joint programme** that should include all necessary research areas. In this case, the circular industries' joint programme will address the problem of the chemical in question.

For each challenge there is a corresponding joint programme (circular cities, circular industries, closing the loop, resource efficiency on land and on sea respectively) based **on which national and regional programme owners will collaborate to provide strategic guidance for systemic innovation, creating integrated and cross-cutting programs to achieve greater impact**.

The SRIA is designed to enable systemic change towards the transition to a circular economy in the EU. A vital element in this effort is eco-innovation, which can play a role in transforming the economy, businesses, citizen interaction with products and services and create value in different ways:[19]

Process eco-innovation

- Material use, emissions and hazardous substances are reduced, risks are lower, and costs are saved in production processes
- Advanced remanufacturing, such as:
    - Refurbishment by replacing or repairing defective components, including updating products
    - Disassembly and recovery at the component, material and substance level
        - Upcycling, functional recycling, downcycling
        - Zero waste production, zero emissions, cleaner production

Product design eco-innovation

- The overall impact on the environment and material input is minimised over the whole product life cycle
    - Product integrity (aimed at preventing and reversing obsolescence at a product and component level) and design for recycling (aimed at preventing and reversing obsolescence at a material level)
    - Allowing for recovery options such as repairing, maintenance, remanufacturing, recycling and cascading use of components and materials
    - Developing eco-design to substitute for hazardous substances

[19] Adaptation based on: EIO, 2016, "Policies and Practices for Eco-Innovation Up-take and Circular Economy Transition" [https://ec.europa.eu/environment/ecoap/sites/ecoap_stayconnected/files/eio_2016_report.pdf]; X. Vence, A. Pereira (2018), "Eco-innovation and Circular Business Models as drivers for a circular economy", *Accounting and Administration,*Vol.64, No. 1, DOI: http://dx.doi.org/10.22201/fca.24488410e.2019.1806

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Services eco-innovation design

- Add ecological and social value to the value proposal and change producer and consumer practices
    - Change business models from new product and service design to reconfigured value chains, new/short supply chains
    - Transform the way citizens interact with products and services
    - Develop improved systems for delivering value (green mobility smart energy systems, short supply chains etc.)
- Product as service: offer product access and retain ownership to internalise benefits of circular resource productivity

Organisational eco-innovation

- Methods and management systems reorganisation pushing for closing the loops and increasing resource efficiency
- New business models e.g. industrial symbiosis, new collection and recovery schemes for valuable resources (incl. extended producer responsibility/individual producer responsibility)
    - From products to functional services (product-service systems)

Marketing eco-innovation

- Product and service design, placement, promotion, pricing
- Promotion of the reuse for the same purpose (e.g. bottles, appliances),
- Promotion of the reuse for different purposes (e.g. tyres as boat fenders, for playgrounds)
    - Eco-labelling, green branding

Social eco-innovation

- Behavioural and lifestyle changes, user-led innovation
- Sharing (e.g. domestic appliances, books, textiles), collaborative consumption (e.g. flats, garden tools) sufficiency (e.g. plastic bag bans)
    - Smart consumption, responsible shopping, use rather than own schemes
    - At all levels of education from a young age to lifelong learning
- Incentives through taxation changes, e.g. differential VAT rates

System eco-innovation

- Entirely new systems are created with completely new functions reducing the overall environmental impact
    - Leading to a substantial dematerialisation of the industrial society
        - New urban governance, smart cities, permaculture
        - A new model for the financial sector
        - New governance systems research
        - Ecosystem services research

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4. A coordinated public innovation approach at EU level driven by key actors

The approaches to circular economy under the present multitude of definitions and interpretations fragment efforts to develop circular solutions. While research and innovation must be open to different ways of approaching the challenges, basic concepts and objectives must be shared by all. These include methodologies for measuring circularity or common definitions for different approaches which allow comparability. It is also important that developments in different member states do not excessively fragment the approaches and lead to diseconomies of scale in a circular economy, such as different waste classification categories and incompatible legal frameworks that can in turn limit collaboration between member states. This could lead to, for example, circular systems in border regions not developing due to bureaucratic barriers and incompatible approaches.

Collaboration between member states to develop new competencies and solutions to improve circularity also needs better tools. In addition, member states would need systemic thinking to tackle the circular economy, collaborating across sectors and regions with systems innovation and joint programming (multi-level, cross-regional).

These are the main reasons that led to CICERONE to come into being, i.e. to create the space for collaboration across EU borders and to link the responsible administrators (programme owners). CICERONE is about to develop into a novel platform with practical objectives to support the authorities. While there may be several formats it can take, the most appropriate would be one driven by the beneficiaries (programme owners), i.e. an actor-driven platform. It would offer services and involve external stakeholders but will also allow members to have a real influence on the programme of the platform, and a real influence on the innovation policy of the EU in this area. Private sector and academic stakeholders will also have a role to make their concerns and views known to the participant programme owners and the European Commission, but the platform's main function is to support and direct the R&I action of the public authorities and to develop their programmes.

Innovation in the circular economy area could become one of the central tools for the development of future business and industrial structure ecosystems in Europe, and requires the support of national authorities. The importance, direction and influence of the platform will be directly proportional to the support it receives from its members.

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Main stakeholders officially consulted for this report[20]

European Chemical Industry Council CEFIC

ICLEI – Local Governments for Sustainability

Ministry of Infrastructure and Environment of the Netherlands

Ministry of Economic Affairs and Employment, Finland

National Academy of Science and Engineering, Germany

Institute for Technology and Management, Technische Universität Berlin

Italian National Agency for the New Technologies, Energy and Sustainable Economic Development ENEA

Sofia Development Association SDA

Netherlands Enterprise Agency RVO

Bio-Based Industries Consortium

VDI/VDE Innovation + Technik GmbH, Berlin

Ragn-Sells Recycling

Climate-KIC Brussels

Technical Research Centre of Finland VTT

Swedish Environmental Research Institute IVL

Forschungszentrum Jülich, Germany

EIT Raw Materials

Geokompetenzzentrum Freiberg GKZ, Germany

Institute for Ecology of Industrial Areas IETU, Poland

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CICERONE partners

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