



EU'S FUTURE R&I NEEDS IN THE FIELDS OF 'CLIMATE ACTION, ENVIRONMENT, RESOURCE EFFICIENCY AND RAW MATERIALS'

Recommendations from the RECREATE project

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Key messages and executive summary

This report presents key recommendations gathered in the RECREATE project ('REsearch network for forward-looking activities and assessment of research and innovation prospects in the fields of Climate, Resource Efficiency and raw mATERials') regarding future research and innovation needs in 'Societal Challenge 5': 'Climate Action, Environment, Resource Efficiency and Raw Materials'. The recommendations presented in this report have been derived from project research work, which relied on three main methodologies and approaches – evidence-based narratives, scenario building and stakeholder participation – to allow for the co-creation of evidence between scientists and societal stakeholders. Recommendations cover concrete priority areas for fostering innovation, overarching research needs and methodological suggestions.

Recommendations on priority areas for fostering innovation encompass

- **Fostering new, especially service-oriented business models and creating a market environment that allows sustainable businesses to thrive.**

Sustainable business models will have to play a bigger role in the EU if it is to be successful in addressing SC5. Yet from unfavourable market conditions and a lack of financing

options to very concrete support needs on new standards for leasing and service schemes, a lot remains to be done to support new business models. We provide insights and recommendations on the following innovation areas: 'Enable social and business innovations to scale up the circular economy by creating conducive financial and regulatory framework conditions' (Recommendation 1); 'Selling solar services as a contribution to a circular economy' (Recommendation 2), 'Fostering free-floating electric car-sharing' (Recommendation 3); and 'Improving service based remanufacturing for the circular economy' (Recommendation 4).

- **Pushing for a circular economy by turning waste into a resource.** The circular economy concept is widely accepted to be the EU's key to 'close the loop' of product lifecycles, keeping the value of materials high and designing waste out of the circle to generate economic and environmental benefits. Despite broad political support, a number of barriers remain to the successful implementation of the circular economy concept. National waste programmes are one area with scope for action. See Recommendation 5, 'Stepping up waste prevention – Opportunities for

national programmes'. A multitude of concrete action areas to revalue waste also exist and require further policy support and research. See e.g. 'Mitigating climate change by using bio-ethanol from residues and waste' (Recommendation 6). In this context, efforts to connect different sectors promise the most effective results. See Recommendations 7 and 8: 'Improving waste management via the Internet of Things' and 'Fostering urban waste water symbiosis for a green economy'.

- **Increasing funding for the implementation of as well as for R&I and knowledge diffusion about 'nature-based solutions'** as promising options to increase resilience and the adaptive capacities of local communities in the face of climate change and associated emerging risks. See Recommendation 9, 'Use nature-based solutions to adapt to climate change, while simultaneously enhancing the environment and saving raw materials', and Recommendation 10, 'Promote climate information services for urban resilience'.

Overarching research recommendations include suggestions to better integrate the Societal Challenge 5 research fields of 'Climate Action, Environment, Resource Efficiency and Raw Materials' as well as to **acknowledge interlinkages**, such as the resource-climate nexus, and the **complex nature** of the research fields. This will involve

- **Refining and strengthening the definition of 'circular economy'** to serve as a conceptual umbrella term for the topics 'Climate Action, Environment, Resource Efficiency and Raw Materials'. It is important to **combine the concept with facilitators**, such as 'Internet of Things' and to enhance our knowledge on finance, successful business models and the role of social innovation for the circular economy (see Recommendation 11).
- **Moving from isolated measures to a system transition.** Systemic approaches require inter- and trans-disciplinary research and benefit greatly from a conceptual umbrella. In addition, R&I policy needs to take the synergies and feedback loops between the different fields of Societal Challenge 5 into account. This necessitates setting visions and targets, which can also help mobilise stakeholders to participate in local research projects toward pathways to systemic change (see Recommendation 12).
- **Aligning R&I policies with policies in other domains.** Systemic change requires coherence between different policy fields. Incompatible policies, such as subsidies for environmentally harmful technologies or fiscal barriers to the market uptake of new technologies, hamper a sustainability transition. Actions in policy fields outside the R&I policy domain, for example setting market incentives for sustainable

businesses, may sometimes be more effective in fostering innovations in e.g. the circular economy (see Recommendation 13).

- **Supporting cross-analyses of ongoing/finalised research projects funded under European R&I funding** to take advantage of and synthesise the wealth of knowledge already gathered (see Recommendation 14).

Finally, we present the **methodologies used to derive these recommendations** and give advice as to when and how these methodologies and approaches lead to fruitful outcomes (see Chapter 4 of this summary pocket book). These are

- Using evidence-based narratives (EBNs) to develop easy-to-use narratives, plausible chains of arguments and heuristics that provide orientation in a situation characterized by complexity and uncertainty. In doing so, policy recommendations can be based on evidence from micro- and local-level innovation cases.
- Applying scenario-building processes to enhance joint vision building for mission-oriented R&I policies. Using participatory scenario building that supports dialogue along various stages of the process.
- Fostering the use of a variety of methods and of co-creation to harvest knowledge from different societal groups to find new solutions to societal challenges.

- Strengthening the conceptual clarity of the term co-creation and embedding a binding and clear definition in H2020, Cohesion and Territorial funding call texts. Based on this definition, co-creation should be stipulated in mission-oriented R&I calls for topics where societal impact and hence meaningful stakeholder participation are essential. Existing funding instruments should be adapted and new ones developed to provide more flexible and open-ended forms of science funding to foster co-creation.

- Fostering the provision of policy-relevant data on R&I system performance, e.g. through scoreboards, to support better-informed policy making in the face of abundant but scattered data. It is also necessary to ensure that the tools providing policy-relevant data are up-to-date and remain so by providing means to maintain and update them.

RECREATE had a wide research scope. However, we neither claim nor aim to give conclusive recommendations regarding concrete innovation priority areas, overarching issues or methodologies. In order to cover the wide scope of potential recommendations relevant for future R&I funding in the areas of SC5, the results of in fact all related research projects should be analysed, updated and checked to fill any remaining gaps. This was beyond the scope of RECREATE.

What will I find in this summary pocket booklet?

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1

Introduction

Research and innovation (R&I) shape the way we will live in the future. The key aim of the framework programmes of the European Union is to foster knowledge and innovation, support the competitiveness of the European economy and enable sustainable development. Innovations in products, services and processes are to contribute to creating jobs and sustainable growth. But what areas should R&I policy target to future-proof European society and the well-being of its citizens? It is an important and delicate task to identify future research needs, especially because major societal challenges are interlinked. Interdependencies between the persistent problems of our time require going beyond filling isolated research gaps to developing innovations and interventions to foster systemic changes. This requires new technological research and applications, but also innovative management, new business models and services as well as behavioural and institutional changes. All of these represent drivers for transitioning and future-proofing the EU in a sustainable fashion.

Therefore, identifying future research needs is only one part of setting the European research and innovation

About the project

RECREATE – “**RE**search network for forward looking activities and assessment of research and innovation prospects in the fields of Climate, **Re**-source **Efficiency** and raw **mATE**rials” was an European research project, funded under the FP7 framework of the European Commission.

Its **objective** was to support the development of the EU’s future research and innovation policies in the fields of ‘Climate Action, Environment Resource Efficiency and Raw Materials’. It included 16 partners from research and industry as well as a stakeholder network including several hundreds of organisations of all types.

Duration:

July 2013–June 2018

More information:

www.recreate-net.eu

agenda on its most fruitful path. Equally important are efforts to address the fragmentation between topics and actors as well as overcoming the knowledge loss that too often occurs after projects end.

In this report, we aim to do justice to these relevant dimensions:

Firstly, we present very concrete research gaps that the RECREATE project identified by tapping into the wealth of concrete findings acquired. From these concrete recommendations the reader may pick those that interest him or her most. While the topics are naturally related to each other, they are also understandable as stand-alone texts. The recommendations differ in length due to the different scopes of the topics underlying the recommendations. At the end of each chapter, we provide the source documents for readers who wish to dive into the topic in more detail.

Secondly, we present overarching research needs and recommendations on how to better integrate various research fields.

Thirdly, we present scientific methodologies and approaches that we deem to have a high potential to (i) tackle the aforementioned challenges and (ii) increase the impact of future research and innovation projects. We present their application and merits as assessed from testing the methodologies and approaches in the RECREATE project.

Even research projects with a wide scope, such as RECREATE, have to select some topics to the exclusion of others. Hence, the recommendations presented in this booklet neither claim nor intend to be representative of the broad and diverse set of topics, issues and methodologies that R&I under SC5 covers.

The RECREATE summary pocket booklet is, in a way, an unusual document in that it provides a potpourri of recommendations on both concrete and overarching research needs as well as on methodologies and approaches. The aim of the booklet is to present the wealth of RECREATE results in a concise manner. Therefore, we build on the source documentation and mention its authors as co-authors of each chapter. We, the main authors, were responsible for selecting, condensing, summarising and synthesising all the recommendations. We invite you to do the same: Pick your subjects and jump through the document as you please. References are given under each chapter in case you need more details.

We hope you find your journey enjoyable and informative.



2

Concrete R&I funding priorities in the fields of ‘Climate Action, Environment, Resource Efficiency and Raw Materials’

While we strongly believe in the need to better integrate various research fields and apply inter- and transdisciplinary research to more research topics, we also acknowledge that many scientific recommendations for policy makers remain on a meta-level and fail to capture the wealth of concrete findings acquired in projects. Here we attempt to synthesise the key findings on European research and innovation policy, which the RECREATE project summarised as follows:

- Supporting new business models by creating the market environment for a thriving circular economy;
- Pushing for a circular economy by turning waste into a resource and harvesting synergies between different sectors; and
- Fostering new approaches such as nature-based solutions and supporting information dissemination on these and other climate services, especially in the local context.

2.1

Supporting new business models and developing the market environment for a thriving circular economy

RECOMMENDATION 1

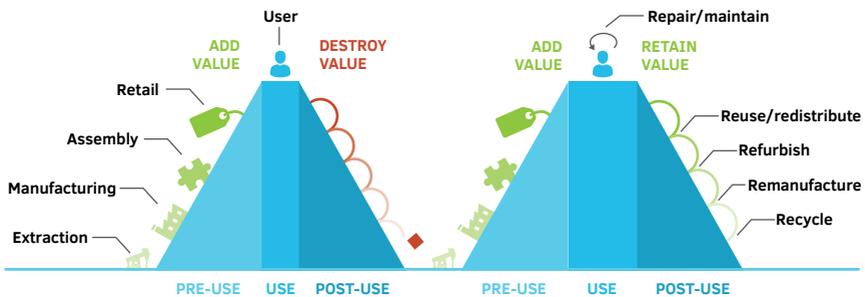
Enable social and business innovations to scale up the circular economy by creating conducive financial and regulatory framework conditions

Short background

The circular economy necessitates new business models. These new business models require different regulations and financing options as well as integration with socio-economic innovations. Entrepreneurs require incentives and regulations to give innovative business models a chance on the

market. Traditional risk assessment methods do not take the benefits of the circular economy into account, so funding is not widely available for smaller innovative businesses and the tax system discourages sustainable business practices.

Figure 1: The Value Hill model and the circular economy



Source: Achterberg, E., van Tilburg, R. (2016). 6 Guidelines to Empower Financial Decision-Making in the Circular Economy (White paper). Circle Economy & Sustainable Finance Lab.

We recommend

Better fitting financial support to the needs of small and medium innovators by

- Developing differentiated risk assessment methods for use by financiers, especially for product-service systems whose future earnings are often underestimated by traditional methods;
- Learning from the emerging variety in new financial instruments (e.g. 'social impact bonds', 'equity in people') and asking financiers for guidance on how to better incorporate them in larger-scale finance; and
- Increasing access to funding from public financiers for start-ups and small- and medium-sized enterprises (SMEs).

Reforming regulation and incentives by

- Measuring environmental performance and circularity in a stand-

ardised way to provide detailed information to customers and include circularity as a category for green public procurement;

- Applying stricter circular economy requirements in public procurement; and
- Pricing environmental externalities by way of cap-and trade systems and/or by tax reforms.

Providing guidance for innovation by

- Focusing research and innovations more on major socio-economic changes and trends necessary for a circular economy scale-up; including experimentation with market models that favour 'co-opetition' between stakeholders; and
- Enabling and implementing more social experiments with local circular economies.

Sector Finance and regulation

How this recommendation was developed

Stakeholder interviews and discussions (Joint K4I/RECREATE Dinner Debate on 'Circular Economy and Nature-based Solutions', 28 June 2016, European Parliament, Brussels; Parallel workshops on 'Financing the Circular Economy' and on 'Startups in the Circular Economy', 25 October 2016, DG RTD, Brussels; Workshop on 'Finance and Entrepreneurship in the Circular Economy' (as a direct follow-up on the workshops on 25 October 2016), 23 May 2017, Amsterdam.

Co-author(s) of this chapter Stephan Slingerland, Tycho Smit

Further information; RECREATE source

Stephan Slingerland, Tycho Smit. 2017. Scaling-up the circular economy. Recommendations for finance, regulation and required innovations. RECREATE Policy Brief No. 6.

RECOMMENDATION 2

Selling solar services as a contribution to a circular and low-carbon economy

Short background

Solar services are a business model in which the service covers the use of solar electricity produced on the customer's roof, including the installation, monitoring, maintenance, repair and replacement. The ownership remains with the solar service company. As such, it can contribute to the transition to a circular economy, as businesses based on selling services instead of products have a strong incentive to invest in the high quality and professional maintenance of their

products. Increasing the longevity of the products increases the revenues of the businesses while reducing the demand for partly scarce resources, such as rare earth elements. Furthermore, the replacement of solar PV panels is professionalised through the companies, which can improve recycling rates and help save materials. Such a change from 'using' to 'owning' can reduce barriers to adopting an environmentally friendly innovation.



We recommend

- Fostering 'information diffusion and capacity building' options. 'Buying a service' as a business model is something new and innovative as the customer is still used to the traditional 'ownership' business model. Knowledge generation and diffusion towards new customers and investors of this alternative business model is important.
- Providing 'financing' options. The lack of sufficient public and private financing can be addressed via several routes and perhaps even accompanied by special arrangements for pilot regions or first-mover customers. Existing financing options include fiscal instruments (innovation/renewables subsidies or tax advantages), debt financing (soft loans, specific credit lines), equity (buying in, etc.) and others.
- Revising 'regulatory' options. Investors perceive unforeseen changes in the political and economic environment of the energy market as a risk. Clear political will to support framework conditions in which innovative business models can flourish would help the market uptake of solar services. For instance, standard setting for leasing companies could be helpful here.

Sector Renewable energy

How this recommendation was developed

Based on the methodology of evidence-based narratives developed in the project.

Co-author(s) of this chapter

Katarina Svatikova, Irati Artola, Stephan Slingerland, Susanne Fischer

Further information; RECREATE source

Susanne Fischer, Jorrit Gosens, Ina Krüger, McKenna Davis, Martin Drews, Holger Gerdes, Sandra Naumann, Linda Krummenauer. 2015. D4.7.a Evidence-Based Narratives – part 2; Katarina Svatikova, Irati Artola, Stephan Slingerland, Susanne Fischer. 2015. Selling Solar Services as a Contribution to a Circular Economy. RECREATE Policy Brief No. 1.

RECOMMENDATION 3

Fostering free-floating electric car-sharing

Short background

Several car-sharing schemes representing different business models are operating in a number of European cities. In Copenhagen, a free-floating electric car-sharing scheme was established by DriveNow, a joint venture between a car manufacturing company, BMW, and a car rental company, SIXT. Registered users can access the car-sharing service through a smartphone app as well as through a website and a hotline, and the availability and location of the vehicles can be detected through a GPS system. An innovative feature implemented in Copenhagen also allows users to access the DriveNow vehicles through the public transportation card (Rejsekort), which is a step forward in the city's multi-modality integration.

The positive impacts of car-sharing systems on car ownership and traffic volumes have been highlighted in a number of studies. Other studies, meanwhile, suggest that overall traffic may increase due to people using car-sharing merely in addition to their privately-owned cars. Due to

the relative novelty of the schemes, the context-specific nature of the findings and the potential for complex rebound effects, more empirical evidence is needed.

Nevertheless, like other service-based businesses, car-sharing companies have a strong incentive to rent out durable products and invest in maintenance, which is likely to have positive effects on resource efficiency. Furthermore, a definite advantage of **electric** car-sharing schemes is the densification of charging points. Expanding electric mobility infrastructures would allow for a greater uptake of electric vehicles in the future. Public charging infrastructure providers and car-sharing operators can complement each other.

Automakers started to actively participate in the fast-growing sector of mobility-as-a-service by establishing car-sharing services mainly in partnership with car rental companies in a growing number of cities around Eu-

rope and the US. Having big players in the market of service mobility is an essential driver for the broad diffusion of such schemes. However, the number of electric vehicles in car-sharing fleets

is still fairly limited, and the positive impacts on greenhouse gas (GHG) emissions and local pollution reduction are therefore limited as well.

We recommend

- Supporting research activities to monitor, evaluate and confirm the impacts of broadly diffused electric and shared mobility, especially on car ownership/congestion and local air and noise pollution, and car traffic growth in the city to create a solid evidence basis for decision making.
- Supporting R&I in technology development for charging infrastructures and network development. Moreover, new forms of collaboration and partnership between electric charging providers, car-sharing operators and municipalities could support the coordination of investments in both infrastructure and end-user services.
- Implementing awareness campaigns and supporting behavioural changes that shift mobility preferences towards decarbonised options in urban transport systems.
- Introducing more stringent vehicle emission targets at the European and national levels. Establishing stable, long-term policy goals at the European, national as well as local level for the decarbonisation of the transport system would provide more fertile ground for businesses engaged in e-mobility and shared mobility market development.

Sector Transport, e-mobility

How was this recommendation developed

Based on the methodology of evidence-based narratives developed in the project.

Co-author(s) of this chapter

Simone La Greca, Martin Drews, Maria Åkermann, Morten Andreas Dahl Larsen, Kirsten Halsnæs

Further information; RECREATE source

Simone La Greca, Martin Drews, Maria Åkermann, Morten Andreas Dahl Larsen, Kirsten Halsnæs. 2017. D4.5 Evidence-Based Narratives Infrastructure Systems in a Sustainable City.

RECOMMENDATION 4

Improving service based remanufacturing for the circular economy

Short background

Remanufacturing is understood as a process of disassembly and recovery at the subassembly or component level. Functioning, reusable parts are taken out of a used product and rebuilt into a new one. This process includes quality assurance and potential enhancements or changes to the components. Remanufacturing holds significant untapped environmental and economic potential for Europe, including the prevention of waste generation, saving resources, reducing greenhouse gas (GHG) emissions, reducing costs and prices and creating jobs.

Remanufacturing may be promoted by innovative business models based on retaining manufacturer ownership of

goods, thus leading to service-based remanufacturing. Here, we can distinguish between remanufacturing as a service within the value chain and remanufacturing as a service to consumers. Several barriers hinder the wider application of the concept of remanufacturing, such as a rather negative consumer perception, difficulties in accessing information and technologies for SME remanufacturers or knowledge gaps in the area of remanufacturing and circular business model design. On the other hand, there are already several existing good examples, suggesting a promising growth perspective in the remanufacturing sector.

We recommend

- Designing appropriate financing mechanisms, in particular to support smaller companies entering the market. These mechanisms are essential in the initial market phase.
- Supporting research to develop metric systems that would enable measurements of values generated by service-based remanufacturing business models. This should include metrics for quantifying the impacts of product-service systems (PSS) from, e.g., a life-cycle assessment perspective. Such instruments would greatly support and facilitate decision making by entrepreneurs.
- Supporting R&I activities in process and product development, with a special focus on design for remanufacturing. In parallel, R&I activities for knowledge development in circular business model development should be supported.
- Promoting behavioural changes in the form of more sustainable consumer patterns and boosting product-service business models through educational programmes and awareness raising on the benefits of circular economy among manufacturers and consumers.
- Integrating remanufacturing as a key concept in EU 'end of life' legislation frameworks. This should also consider the clarification of the legal status of cores and remanufactured goods and thus help to overcome trade barriers.
- Promote the creation of quality standards for remanufactured goods and promote the public procurement of remanufactured goods and product-service offerings.

Sector Remanufacturing

How this recommendation was developed

Based on the methodology of evidence-based narratives developed in the project.

Co-author(s) of this chapter Pierre Menger

Further information; RECREATE source

Susanne Fischer, Pierre Menger, Ton Bastein, Henning Wilts. 2017. D4.4 Evidence-Based Narratives. Material and Waste Management in a Circular City.



2.2 Pushing for the circular economy by turning waste into a resource and harvesting synergies between different sectors

RECOMMENDATION 5

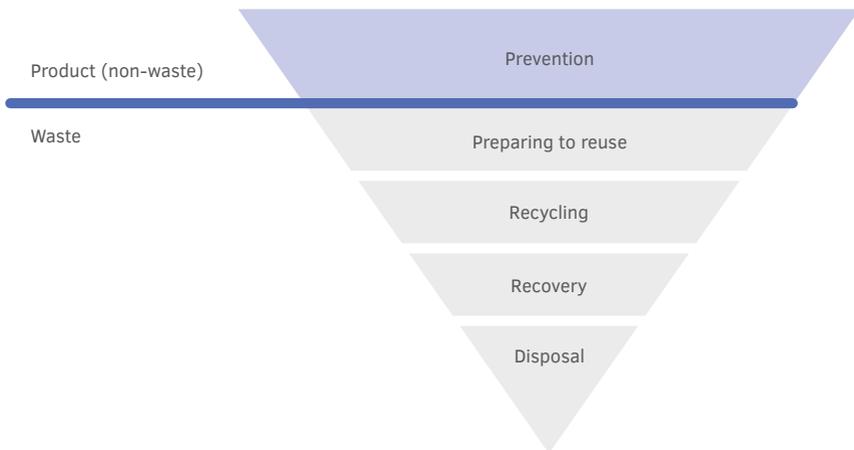
Stepping up waste prevention – realising opportunities in national programmes

Short background

Despite long-standing waste policies and 'prevention' standing at the top of the EU waste hierarchy (see Fig. 2), municipal waste generation has been increasing in the EU over the last two decades. Municipal waste accounts for only about 10% of total waste generated, but it is of political concern due to its complex composition, littering and consumption patterns. Government expenditure for waste management amounts to roughly 0.4 % of GDP/year (2009–2015) in the EU-28.

Waste prevention theoretically has the highest environmental value and lowest public cost of all waste management activities. Manifold leverage points for successful prevention activities exist. On the production side, the quantity of materials can be reduced. On the consumption side, the mass of consumption as such can be reduced or the efficiency with which products are used can be increased. At the product's end-of-life, re-use or refurbishment can prevent actual

Figure 2: Waste hierarchy



Source: EEA (2015). Waste Prevention in Europe: The Status in 2014. Luxembourg: Publications Office

waste generation. Nevertheless, waste prevention programmes face a number of challenges. The costs and benefits of prevention activities are difficult to measure as data is sparse, and causal effects are difficult to demonstrate and monitor. Furthermore, waste prevention requires behavioural changes by individuals and groups, which are difficult to promote.

We recommend

- Introducing quantitative waste prevention targets at the EU level and supporting Member States in setting national targets. These targets should be based on a sound knowledge of the impacts of measures and targets. Therefore, research on methods to calculate the costs and benefits of waste prevention measures as well as the measurement of the potential impacts of waste prevention targets should be funded.
- Establishing a European waste prevention agency – or increasing the EEA's funds and capacities for waste prevention – to support Member States.
- Setting up, implementing and evaluating municipal waste prevention programmes and/or initiatives, including funding for new organisational structures or specific staff employment. This could be done, for

The Waste Framework Directive (2008/98/EC) required Member States to set up National Waste Prevention Programmes by the end of 2013. Measures in these programmes could encompass information campaigns, promotion and regulation. The analysis of existing National Waste Prevention Programmes points to successful prevention measures.

instance, by listing these among the waste management priorities within Operational Programmes (OP) or allowing such funding under Article 3 (1) of the ERDF Regulation.

- Reflecting on and further developing policy interventions aimed at fostering behaviour change. A behaviour change unit could be set up at the European Commission level. In order to increase knowledge in this field, research based on behavioural economics (e.g. nudging) and social psychology should be stepped up. Special attention needs to be given to
 - rebound effects;
 - the role of household behaviour in the design and success of waste prevention measures; strengthening the research focus on collective behaviour change; and

- establishing and testing methods for measuring behaviour change effects.
- Building on knowledge gained in on-going and recent research projects, such as REFRESH (Resource Efficient Food and dRink for the Entire Supply cHain), UrbanWINS (Urban metabolism accounts for building Waste management Innovative Networks and Strategies) or WASP Tool (Development and demonstration of a waste prevention support tool for local authorities).
- Coordinating all research and innovation (R&I) on waste prevention closely with EU regional policy in order to match societal needs with opportunities arising from socio-technical innovation on a local and regional level.

Sector Waste

How this recommendation was developed

Based on the methodology of evidence-based narratives developed in the project.

Co-author(s) of this chapter Susanne Fischer, Mandy Hinzmann

Further information; RECREATE source

Susanne Fischer, Pierre Menger, Ton Bastein, Henning Wilts. 2017. D4.4 Evidence-Based Narratives. Material and Waste Management in a Circular City; Susanne Fischer, Mandy Hinzmann, Martin Hirschnitz-Garbers. 2017. Stepping up waste prevention – Challenges and opportunities for national waste prevention programmes. RECREATE Policy Brief No. 7.

RECOMMENDATION 6

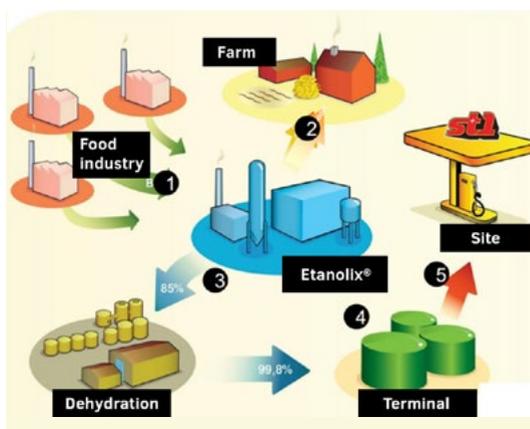
Mitigating climate change by using bio-ethanol from residues and waste

Short background

Waste-based bio-ethanol can mitigate climate change without leading to land competition with food production. The economic potential is high, but barriers such as immature technologies or waste sorting logistics hinder greater investment and market uptake. While different plant types exist, a good practice example is the St1 Biofuels Oy's bio-ethanol production plant in Sweden (see Fig. 3). The plant produces ethanol utilising

ligno-cellulosic biomass from three different waste streams, collected at smaller scale sites for conversion to ethanol. St1 utilises a special processing concept for sugar and starch-rich waste streams, e.g. from the beverage industry or bakeries. In addition, St1 has processing technologies for the biological fractions of municipal solid waste and for forestry industry wastes and straw. The plant is highly adapted to the resources available locally.

Figure 3: Etanolix—dispersed ethanol production concept



- I Process residue and/or wastes are sources from nearby industries
- II Residues from ethanol production are used as animal feed, fertilizer or solid biomass fuel
- III 85 % pure ethanol is centrally collected for dehydration in Hamina
- IV Storage and blending with gasoline
- V Distribution to over 1.200 fuel stations in Scandinavia

Source: St1, captions edited by Gosens, J.

We recommend

- Increasing research and innovation funding for waste-based bio-fuel production (for instance with regard to utilising cellulosic ethanol).
- Increasing funding for training to build the capacities of researchers, entrepreneurs, process operators, service providers and policy makers to foster innovation in the bio-based economy.
- Allowing Member States more flexibility in utilising mandates or tax exemptions for waste-based bio-fuels on a national level.
- Changing the scoring of research proposals in favour of proposals that link existing projects from different regional contexts, feedstocks and policy frameworks as well as proposals that combine H2020 funding with other funding mechanisms that encourage the spread of project impacts.
- Developing H2020 calls that
 - compare different technologies and demonstration plants regarding the sustainability of biofuels production from different waste-based feedstocks;
 - compare supply and demand side policy frameworks for favourability for waste-based biofuels; and
 - analyse societal support for waste-based fuels.

Sector Waste, energy

How this recommendation was developed

Based on the methodology of evidence-based narratives developed in the project.

Co-author(s) of this chapter Jorrit Gosens

Further information; RECREATE source

Susanne Fischer, Jorrit Gosens, Ina Krüger, McKenna Davis, Martin Drews, Holger Gerdes, Sandra Naumann, Linda Krummenauer. 2015. D4.7.a Evidence-Based Narratives – part 2; Martin Hirschnitz-Garbers, Jorrit Gosens. 2017. Producing bio-ethanol from residues and wastes. A technology with enormous potential in need of further research and development. RECREATE Policy Brief No. 2.

RECOMMENDATION 7

Improving waste management via the ‘Internet of Things’

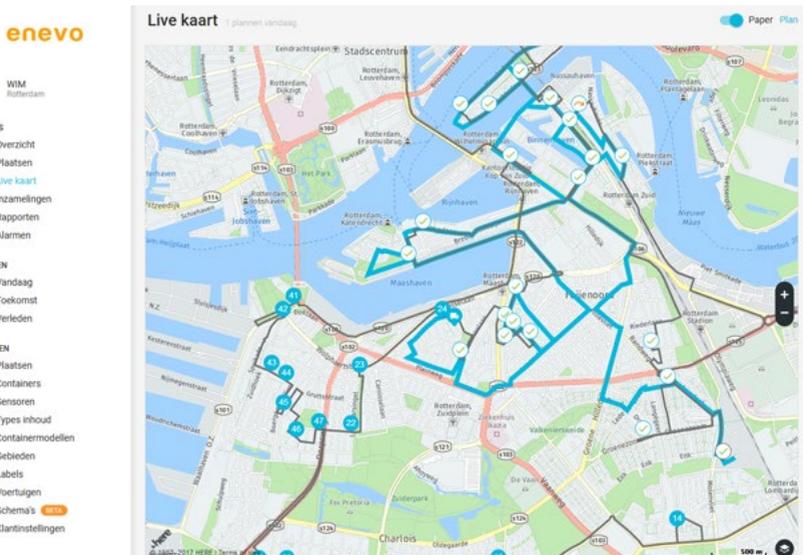
Short background

The ‘Internet of Things’ (IoT) connects sensor-equipped objects to the internet. Thus, it increases our location-specific knowledge about the condition of an asset and its availability. It can contribute to achieving sustainability goals, for example when waste containers send information on their fullness levels and thus enable

tailor-made, more efficient waste collection routes. A case study on paper containers showed that the use of IoT improved resource efficiency and helped optimise waste collection planning and execution (see Fig. 4).

The European Commission has three main policy goals regarding IoT: 1) a single market for the IoT; 2) a thriving

Figure 4: Dynamic waste collection routing in the south of Rotterdam



Source: See Bastien, T. (2017). ICT-based waste and resource management, RECREATE, D4.4 Evidence-based narratives.

IoT ecosystem, which encompasses the cooperation of cross-sectoral players as well as the development of new products, services and markets; and 3)

We recommend

Advancing a single market for the IoT by

- Investing in the further development of IoT technologies and their adaptation to sectoral needs, as well as the needs of end-users and the circular economy; and
- Exchanging best practices and disseminating knowledge.

Creating a thriving IoT ecosystem by

- Examining the need to further develop IoT standards, while being mindful of specific local circumstances;
- Examining the role of public procurement for scaling up environmental IoT pilots, considering service rather than product procurement; and

a human-centred IoT, which complies with European values and legislation (e.g. data privacy).

- Setting dynamic environmental targets that reflect the latest environmental technology to stimulate continuous innovation.

Ensuring a human-centred IoT by

- Assuring the privacy, security as well as transparency of data use. The European Commission should investigate if a harmonisation of standards and practices across the EU could be beneficial to reach these goals; and
- Considering the indirect effects of IoT, such as potential employment losses, communicating them and taking actions to mitigate negative effects.

Sector Waste, digitalisation

How this recommendation was developed

Based on the methodology of evidence-based narratives developed in the project.

Co-author(s) of this chapter Stephan Slingerland, Irati Artola, Ton Bastein

Further information; RECREATE source

Susanne Fischer, Pierre Menger, Ton Bastein, Henning Wilts. 2017. D4.4 Evidence-Based Narratives. Material and Waste Management in a Circular City; Stephan Slingerland, Irati Artola, Ton Bastein. 2017. Improving waste management via the Internet of Things. Lessons learnt from the case of sensor-equipped paper containers in Rotterdam. RECREATE Policy Brief No. 8.

RECOMMENDATION 8

Fostering urban waste water symbiosis for a green economy

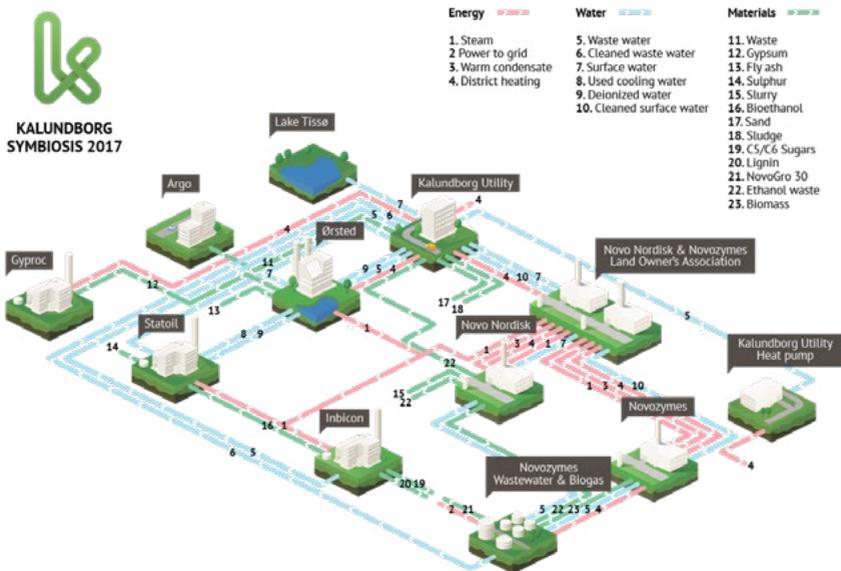
Short background

Water is an essential but limited resource, and solutions for optimising, recycling and reusing (waste) water will be important in the emerging context of a circular and more resource-efficient economy. Therefore, water utilities in Europe and worldwide have to start taking steps towards a new 'sanitation paradigm' that is fo-

cused on increasing the local resource recovery and reutilization of energy and nutrient contents of urban solid waste and wastewater.

A seminal example of this innovative practice can be found in Kalundborg, Denmark, where an urban wastewater symbiosis was established. The symbiosis brought together the local

Figure 5: The urban (industrial) symbiosis in Kalundborg



Source: Kalundborg Symbiosis 2017, <https://symbiosecenter.dk/wp-content/uploads/2017/11/Diagram-2017-EN.png>.

wastewater treatment plant, municipality and local companies (see Fig. 5). In such a symbiosis, the emphasis is not on technological novelty or a ground-breaking business innovation, but rather on a rearrangement of actors in a specific local context to allow novel value creation opportunities for partners and to enhance the efficient exchange of information, facilities and material and energy flows. This kind of symbiosis is about systemic change creating mutual dependencies and benefits and as such represents a rather radical innovation. Benefits from a wastewater symbiosis can include nutrient recovery, electricity and/or biogas production and the production of fertilisers.

Urban water symbioses offer a number of benefits, but certain barriers can hinder their wider implementation. One of the most critical barriers is organisational, including the need to establish deep and committed partnerships between actors from different business fields and the public vs. private sectors. This involves breaking down and reorganizing the existing siloed divisions between the solid waste treatment system, water services, energy services and agricultural systems to jointly develop a coherent agenda. Another principal barrier towards investment in innovative urban wastewater symbiosis are the high upfront costs of new water treatment installations. Changing and/or optimizing the existing urban planning culture and conventional urban planning and building solutions can be a significant challenge.



We recommend

- Building and supporting networks and platforms for knowledge exchange that provide data on available resource and side streams in different localities. The development of these requires particular attention to the issues of data ownership and privacy.
- Supporting pilot projects, e.g. to underpin and document realistic investment cases, as well as diverse funding mechanisms for experiments, prototypes and living labs, e.g. through instruments such as Horizon 2020, Water KIC and Climate KIC. This includes experimentation with new business models.
- Undertaking comprehensive economic assessments and life cycle analyses of the wastewater symbiosis in order to build the credibility of the innovation and to help unlock investment and engagement from the private sector while ensuring general public acceptance.

Sector Waste, water, energy, raw materials

How this recommendation was developed

Based on the methodology of evidence-based narratives developed in the project.

Co-author(s) of this chapter

Maria Åkermann, Martin Drews, Morten Andreas Dahl Larsen

Further information; RECREATE source

Simone La Greca, Martin Drews, Maria Åkermann, Morten Andreas Dahl Larsen, Kirsten Halsnæs. 2017. D4.5 Evidence-Based Narratives. Infrastructure Systems in a Sustainable City.



2.3 Fostering new approaches such as nature-based solutions and supporting information dissemination on these and other climate services, especially in the local context

RECOMMENDATION 9

Use nature-based solutions to adapt to climate change while simultaneously enhancing the environment and saving raw materials

Short background

Nature-based solutions (NBS) have the potential to sustainably protect cities from flooding while generating additional benefits for the environment and society. In order to unlock their

potential, however, an enabling governance framework and research on long-term performance and critical factors is needed.

We recommend

- Setting up a supportive national policy framework for NBS in the area of flood protection. Such a framework should:
 - rely on decision-making criteria that are holistic in nature, reflecting the goals of other policy sectors, such as nature protection, recreation, public health, climate change mitigation, spatial planning and the development of the housing sector;
 - encourage the involvement of a wide range of stakeholders and funding sources, combining multiple interests, such as the pursuit of biodiversity conservation, human well-being, water management, economic development and job creation and climate change adaptation; and
 - promote the integration of NBS into current planning processes as a complement to conventional grey infrastructure solutions.
- Supporting the development and uptake of NBS for coastal flood protection and urban drainage. We suggest that European research and innovation policy:
 - encourage cities to engage in living labs or pilot studies that involve the implementation of NBS in order to contribute to the evidence base;
 - support the identification of critical factors that inhibit cities from

reaching their full NBS potential and develop a toolbox to assist planners in overcoming these obstacles;

- promote the development and application of standardised monitoring and reporting protocols with which to evaluate long-term NBS (cost) effectiveness, including the integration of ecosystem

services into environmental assessments, multi-criteria analyses and cost benefit assessments; and

- encourage peer-to-peer learning processes between (non-) EU cities, which can offer good practice experience in the implementation, monitoring and maintenance of NBS.

Sector

Cities, water, climate adaptation, flood protection, nature-based solutions

How this recommendation was developed

Based on the methodology of evidence-based narratives developed in the project.

Co-author(s) of this chapter McKenna Davis, Ina Krüger and Mandy Hinzmann

Further information; RECREATE source

Susanne Fischer, Jorrit Gosens, Ina Krüger, McKenna Davis, Martin Drews, Holger Gerdes, Sandra Naumann, Linda Krummenauer. 2015. D4.7.a Evidence-Based Narratives – part 2 (see EBNs ‘Use of Natural Solutions for Protecting Cities from Flooding’ and ‘Sustainable Urban Drainage Systems’); McKenna Davis, Ina Krüger, Mandy Hinzmann. 2015. Coastal protection and Sustainable Urban Drainage Systems - Nature-based solutions. RECREATE Policy Brief No. 4.

RECOMMENDATION 10

Promote climate information services for urban resilience

Short background

Climate information services (CIS) are understood as the transformation of climate-related data into customized products (such as smartphone apps), which allow different user groups to adapt to climate-related events (e.g. farmers to upcoming droughts, city official to cloudbursts and potential

flooding). In the urban sector, climate-related data can facilitate improved decision-making, as shown by several research projects and best practise examples. However, the general uptake of CIS appears to be very limited.

We recommend

- Promoting international standards for CIS to ensure that services are delivered to scientifically sound and engineering practices standards.
- Using funding schemes to link cities and city networks for the exchange of experiences and transfer of good CIS practices.
- Embedding a requirement for city-scale demonstrators to generate business cases, narratives and best practise examples in future funding schemes to help the market for urban CIS mature.
- Acknowledging research proposals that outline mechanisms for attracting co-funding from different funding schemes in order to support the use of different financing models to stimulate adaptation action by positive evaluation scoring.
- Providing (more), revising and aligning incentives to stimulate co-production and co-development between commercial actors, academia and end-users.

Sector Cities

How this recommendation was developed

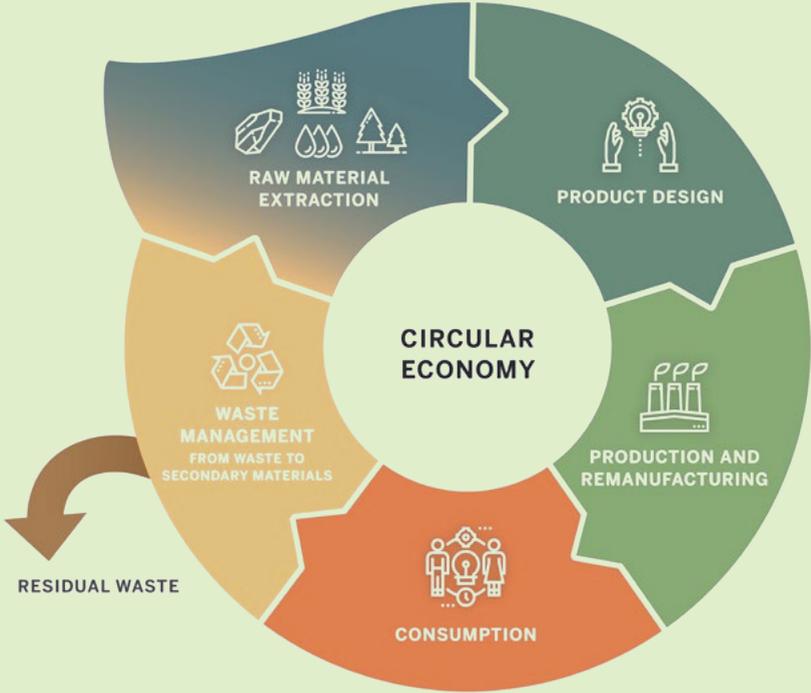
Based on the methodology of evidence-based narratives developed in the project.

Co-author(s) of this chapter Martin Drews

Further information; RECREATE source

Susanne Fischer, Jorrit Gosens, Ina Krüger, McKenna Davis, Martin Drews, Holger Gerdes, Sandra Naumann, Linda Krummenauer. 2015. D4.7.a Evidence-Based Narratives – part 2; Martin Hirschnitz-Garbers & Martin Drews: 2016. Climate Information Services for urban resilience. Learning from the Danish experience with cloudburst management. RECREATE Policy Brief No. 3.





3

Overarching research needs and recommendations on how to integrate research fields

RECOMMENDATION 11

Use ‘circular economy’ as a conceptual frame for integrating raw materials and resource efficiency in the successor to ‘Societal Challenge 5’

Short background

‘Societal Challenge 5’ in Horizon 2020 covers the fields environment, raw materials, resource efficiency and climate action. While disciplinary research

has strong merits, the interlinkages between different research fields can benefit from a bridging concept.

We recommend

- Using the concept of ‘circular economy’ as a conceptual umbrella for the fields ‘raw materials, resource efficiency and circular economy’ and framing the successor to the Societal Challenge 5 under this umbrella. While ‘circular economy’ cannot and should not contain all aspects of SC5, it does help to frame the nexus of resource efficiency and secondary raw materials via circular approaches. The terms climate action and environment – despite clear interlinkages and synergetic effects with raw materials, resource efficiency and circular economy – appear too separate from the latter three terms to be subsumed under circular economy as a new umbrella term.
- Sharpening the term ‘circular economy’ to become an ambitious concept that sets as a requirement specific results from projects and that can be clearly distinguished from related concepts such as industrial symbiosis or material recycling.
- Encouraging initiatives that combine different approaches (see above) in order to learn more about successful circular strategies.
- Combining the circular economy concept with facilitators such as ‘lean and frugal design’, the ‘Internet of Things’ and ‘a sustainable environment for investors, based on public-private partnerships’.

- Fostering research and innovation on:
 - Determining which circular economy business models have the most potential;
 - Finding finance for the circular economy;
 - Possible benefits of social innovation (e.g. local economies) for the circular economy;
 - Promises and limitations of the 'Internet of Things' for the circular economy; and
 - How industries can contribute to making products more circular along their whole value chains.

Sector Circular economy

How this recommendation was developed

Internal discussions drawing on all project results.

Co-author(s) of this chapter RECREATE Project Team

Further information; RECREATE source

RECREATE Project Team. 2018 Position Paper: Recommendations for the European Union's 9th Framework Programme for Research and Innovation.

RECOMMENDATION 12

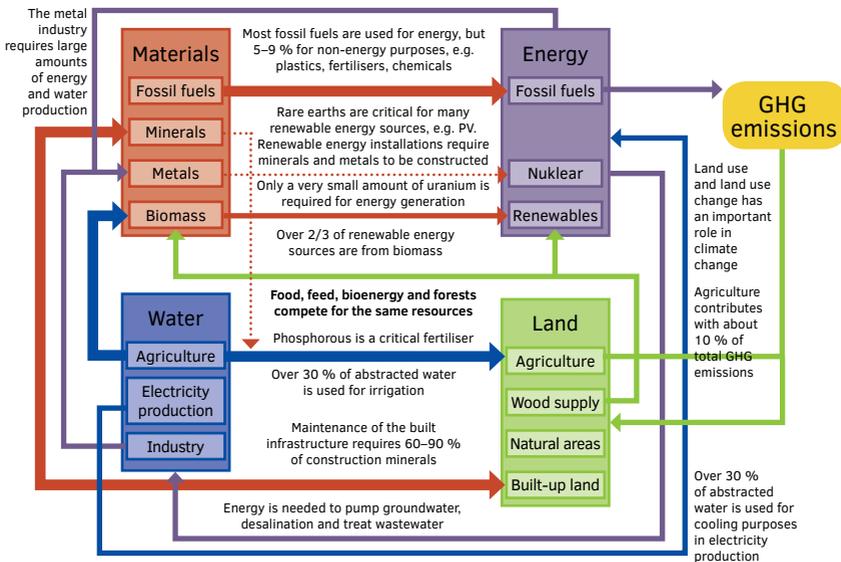
Foster systemic research and innovation

Short background

The fields of climate change, environment, resource efficiency and raw materials are highly interlinked. This suggests the need for integrated research and innovation on a systemic level to make use of synergies and consider feedback loops between the areas (see Fig. 6). This furthermore includes be-

ing mindful of societal developments and trends. Systemic innovation can be initiated at various policy levels. Systemic innovation does not necessarily cover different policy fields but may also mean to better integrate actions within a single policy field.

Figure 6: Interactions between resources use and climate change



Source: BIO Intelligence Service, Institute for Social Ecology and Sustainable Europe Research Institute (2012). Assessment of resource efficiency indicators and targets. Final report prepared for the European Commission, DG Environment.

We recommend

- Increasing cooperation between scientists, citizens and business representatives for systemic R&I approaches. Bringing together diverse stakeholders leads to mutual learning and an increased awareness of wider societal consequences. Special effort must be made to 'translate' sector- or stakeholder group-specific concepts for a fruitful conversation.
- Setting visions and targets that can mobilise local or regional stakeholders for systemic change. Jobs, economic growth and development – but also fossil-free or self-sufficiency – targets can unite stakeholders.
- Bringing a variety of actors from different policy fields together in order to reduce bureaucratic overlap and remove inconsistent policies, subsidies and taxes.
- Integrating tools that show the wider societal benefits of proposed sector-based solutions (e.g. life cycle management) to help motivate systemic change.
- Ensuring sufficient monitoring and adequate governance for systemic R&I needs.

Sector Overarching system, linking of various sectors

How this recommendation was developed

Stocktaking exercise. Forty cases of integrated and systemic research and innovation policies and programmes that link the fields of climate action, environment, resource efficiency and/or raw materials were analysed.

Co-author(s) of this chapter

Irati Artola, Katarina Svatikova, Stephan Slingerland, Johanna Kohl

Further information; RECREATE source

Irati Artola, Katarina Svatikova, Stephan Slingerland, Johanna Kohl. 2017. Systemic research and innovation in the fields of climate action, environment, resource efficiency and raw materials. Lessons from practical experience. RECREATE Policy Brief No. 5.

RECOMMENDATION 13

Align R&I policies with policies in other domains

Short background

Rules or incentives set by other policies (e.g. banning environmentally harmful technologies or providing fiscal incentives for new technologies) often trigger more innovation than R&I funding programmes. Furthermore, large-scale market uptake of advanced technologies is often hindered by regu-

latory framework conditions, systemic interdependencies, fiscal rules and/or human habits. Therefore, supporting systemic change requires coherence between different policy fields to remove obstacles to and foster synergies for a sustainability transition.

We recommend

- Increasing coherence between R&I policies and actions in other policy domains.
- Developing R&I policies in closer cooperation with other policy fields and considering if actions in other policy fields might make a certain policy goal more efficient or effective.

Sector

Overarching; other policy domains

How this recommendation was developed

Internal discussions drawing on all project results.

Co-author(s) of this chapter

RECREATE Project Team

Further information; RECREATE source

RECREATE Project Team. 2018 Position Paper: Recommendations for the European Union's 9th Framework Programme for Research and Innovation.

RECOMMENDATION 14

Foster action to integrate, cross-analyse and update the results of related policy support projects

Short background

The EU has funded a number of projects that have had the objective of providing support to policy-making and programming in the fields covered by 'Societal Challenge 5' (e.g. RECREATE, CASI, Green.eu, OPERAs). The output of these projects will remain accessible for a certain number of

years, but it is quite dispersed, has few cross-links and no cross-analysis is being undertaken. Furthermore, no updates are scheduled, which means that the outputs will lose their value and the investments made will bring a suboptimal return.

We recommend

- Defining a call for a support project that will build upon the strengths of these projects by selecting their most valuable assets, organising and cross-analysing them, as well as updating the key outputs.

Sector

Overarching; other policy domains

How this recommendation was developed

Internal discussions drawing on all project results.

Co-author(s) of this chapter

RECREATE Project Team

Further information; RECREATE source

RECREATE Project Team. 2018 Position Paper: Recommendations for the European Union's 9th Framework Programme for Research and Innovation.



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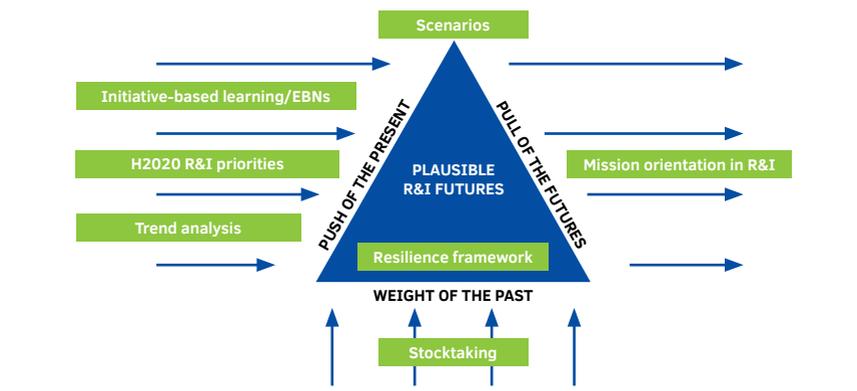
Key recommendations for approaches, methods and methodological diversity

In order to identify research needs and potential priorities for future European R&I policy, the RECREATE team applied a diversity of research approaches and methodologies. The goal was to apply a research design that would allow for a comprehensive analysis of past, present and future developments as well as for an integration of stakeholder perspectives in climate action, environment, raw materials and resource efficiency (see Fig. 7). RECREATE collected and analysed information and stakeholder views with the aim to identify path dependencies, current trajectories, commitments, intentions and plausible future opportunities and trends to guide present action. Complementing this was

initiative-based learning, namely the evidence-based narrative approach, which helped to identify the need for mission orientation in European R&I policy. The following figure shows the various methodologies and approaches that RECREATE used.

These approaches and methodologies allow us to not only provide recommendations on concrete research needs identified in the project, but also on approaches and methodologies as such. In the following, we present the approaches and methodologies used, discuss their advantages and limitations and give advice as to when which approach is most appropriate. We will furthermore address the implications for (future) R&I policy.

Figure 7: Logic of the RECREATE structure



Evidence-based narratives

Short background

One of the core activities of RECREATE has been co-design between policy making and science. Through co-design we aimed at providing the Directorate General for Research and Innovation of the European Commission (DG RTD) with robust information for evidence-based policy making under conditions of high uncertainty and fragmented evidence. The approach of evidenced-based narratives (EBNs) combines insights from cognitive science and from social science by providing evidence in the form of narratives and heuristics that en-

able the use of what feels like “simpler rules of thumb”. Their main advantage is reducing complexity by providing a storyline rather than compiling a large amount of data presented in quantitative models or other non-narrative ways. EBNs match the logic of mission-oriented policies, which are currently being debated as one of the potential cornerstones of FP9. Both EBNs and mission-oriented policies are based on a holistic approach, integrating visions for the future across various policy domains.

Methodology

The EBN method is based on the technological innovation systems (TIS) framework,* which allows for qualitative judgments, looks at innovation system dynamics beyond simple cause-and-effect and aims at systematically mapping the activities that usually take place in innovation systems and finally contribute to innovation diffusion. The development of narratives is based on desk research, interviews and workshops with relevant experts and stakeholders. Thus, all EBNs provide evidence about the underlying inno-

vation system and offer policy recommendations based on them.

Continuous exchange and intense discussion with the European Commission during the project yielded

- The following definition of EBNs: *“Evidence-based narratives are a systematic approach following the Technological Innovation System (TIS) Analysis that helps to develop stories on emerging innovations each of which are following the same blueprint structure and*

* Hekkert, M.P., Suurs, R.A.A., Negro, S.O., Kuhlmann, S., and Smits, R.E.H.M. (2007). Functions of innovation systems: A new approach for analysing technological change. *Technological Forecasting and Social Change* 74, 413–432.

proven heuristics; EBNs are underpinned by triangulated findings and data, and are as such able to serve as a communication tool for research and innovation policy makers assisting them in giving the best possible policy decisions in the context of uncertainty and limited resources."

- A clear set of criteria for an EBN to be considered valuable by its users. These include:
 - A clear area that is micro-scaled and concrete enough to achieve tangible results but not too small to preclude conclusions at the macro scale.
 - Evidence, especially from direct interaction and interviews with stakeholders, since it is this kind

We recommend

- Using EBNs to develop easy-to-use narratives, plausible chains of arguments and heuristics that can provide orientation in a situation characterized by complexity and uncertainty. In doing so, policy recommendations should be based on

- of bottom-up micro-evidence that the Commission often lacks.
- Both economic and environmental evidence, making the EBN interesting for internal EC stakeholders from different DGs.
- Conscientiousness about not duplicating what is known and covered in existing R&I programmes or neighbouring consultancy services.

Within RECREATE, the consortium has developed 20 evidence-based narratives addressing programming for research and innovation in the area of SC5, of which 11 were further analysed and 10 were translated into RECREATE Policy Briefs. The EBNs underlie Recommendations 1–10.

evidence from micro- and local-level innovation cases. Evidence should be gathered by applying a triangulation of methods, i.e. by integrating findings from a literature review with stakeholder interviews and stakeholder workshops.

- Being careful and transparent in selecting potential innovations for EBNs to cover. If the purpose of EBNs is to support sound research policies, the collection of EBNs should properly represent the programming area activities; therefore, the selection of potential innovations to be analysed via an EBN becomes a critical issue.
- Fostering the use of EBNs as 'boundary objects' that support the process of translation and knowledge integration between scientists and policy makers. The approach could be relevant for governmental and non-governmental decision makers by providing a knowledge-based framework for potentially transformative policy advice.
- Considering EBNs a complement to impact assessments. EBNs and IAs fulfil different roles as they focus on different development stages in the cycle of innovations and policies. While IAs assess the expected ex-ante impacts of a certain policy assumed to lead to certain innovations, EBNs assess ex-ante policy pathways to a certain innovation that may lead to certain impacts.
- Further developing the EBN method by combining it with foresight approaches. When EBNs focus too narrowly on existing/known innovation systems and quantifiable market potentials, R&I programming may lack a longer-term perspective. By combining the EBN method with prospective TIS analysis, an innovation system analysis is performed for innovation systems that do not exist today but can be envisioned through participatory foresight processes. Such analyses could be of considerable help in shaping future R&I programming.

Co-author(s) of this chapter

Susanne Fischer, Jesse Fahnestock, Philipp Schepelmann, Martin Drews, Ton Bastein, Jürgen Kropp, Linda Kruppenauer

Further information; RECREATE source

RECREATE Project Team. 2018 Position Paper: Recommendations for the European Union's 9th Framework Programme for Research and Innovation; Susanne Fischer (et al.). 2015. D4.7.a Evidence-Based Narratives – part 2 – Triangulation of Selected Narratives; Susanne Fischer (et al.). 2017. D4.4 Evidence-Based Narratives. Material and Waste Management in a Circular City; Simone La Greca (et al.). 2017. D4.5 Evidence-Based Narratives. Infrastructure Systems in a Sustainable City; Linda Kruppenauer, Jürgen Kropp. 2018. D4.6 Evidence-Based Narratives: Sustainable Urban Adaptation and Resilience.

Scenario building and analysis

Short background

EU research is often fragmented between topics and actors. One of the goals of the RECREATE project was to offer ideas and solutions for integrated R&I. One of the methods chosen to achieve this goal was scenario building and analysis. Scenario building is a foresight method that provides al-

ternative views of the future. Scenario building is based on the analysis of interactions between interconnected factors of change. Three integrated scenarios were developed as part of the forward-looking activities in the RECREATE project.

Methodology

Foresight can be built on a variety of methods that can be creativity-based, evidence-based, expertise driven and interactive. All these four dimensions were applied in building the RECREATE scenarios. The foundation was a strong knowledge base, which was built by a literature study, key indicator data (see the RECREATE Scoreboard for more information) and a stocktaking analysis, which consisted of a policy analysis of European and non-European countries. A trend analysis identified relevant trends having an impact on RECREATE focus areas. An expert analysis included expert reviews from different disciplines and stakeholder communities (research, industry, administrations, NGOs) and interviews with policy makers.

Steps undertaken in the RECREATE scenario building process encompass:

1 Stocktaking. This included defining the scope of the exercise; selecting case studies that would help identify

the linkages and synergies between climate action, environment, raw materials and resource efficiency policies; and developing a template to ensure comparable descriptions. The template was filled using desk research.

- 2 Review of existing policy statements.** A set of policy documents were scanned to identify policy targets that would link R&I on climate action, environment, resource efficiency and raw materials. These were used as discussion initiators and as validating points for the scenario creation.
- 3 Stakeholder workshops and interviews.** Identification of scenario factors and R&I priorities.
- 4 Drafting the three scenarios.** The scenarios were drafted using the information gathered in the previous steps. They were refined in an iterative process based on stakeholder and partner feedback, and knowledge was accumulated during

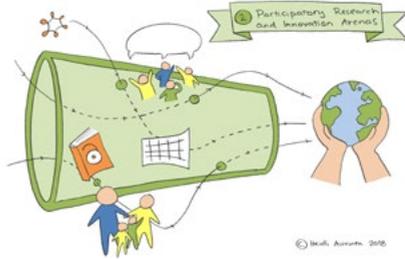
the RECREATE process, including through EBNs, analysis of existing H2020 R&I priorities and scenario factor deep dives, meaning a further integration of RECREATE context-related thematic factors (as a form of narratives) into scenarios .

5 Scenario analysis. The implications of scenarios for future European R&I in climate action, environment, raw materials and resource efficiency were analysed.

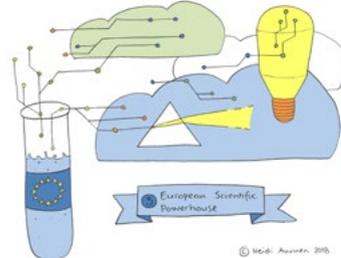
The RECREATE scenarios aim at showing ways how the European Union could revise and develop its R&I system to tackle the challenges of systemic transition. The scenario building produced narrative storylines for plausible R&I futures. The three scenarios are:



Scenario 1: *Global Innovation Communities for Growth* depicts a Europe in which resilience is achieved by technological and business innovations. This approach emphasizes sustaining economic growth. This approach assumes that decoupling growth from resource use and environmental degradation is plausible. There are, however, several external factors, such as global population growth, that challenge this approach.



Scenario 2: *Participatory Research and Innovation Arenas* assumes that the engagement of citizens in solving sustainability challenges will increase the capacity to adapt to environmental changes. The adaptation is manifested in changing lifestyles and new sustainable consumption patterns. Yet structural factors, such as production systems and urban infrastructure, are out of the control of grassroots communities.



Scenario 3: *European Scientific Powerhouse* has potential in producing impartial scientific findings and evidence to support sustainability transitions and resilience. The challenge in this scenario is in turning evidence into actions.

The RECREATE scenarios focus on innovation ecosystems and present alternative R&I platforms (i.e. innovation communities, participatory research arenas and centres of excellence) as

instruments to foster collaboration for systemic transition. The scenarios assume that rapid, constant change is the new status quo of the future and that new types of R&I approaches sensitive to this changing context are needed.

The RECREATE scenario analysis indicates that,

- to achieve the broader socio-technical changes called for in R&I missions, there is an urgent need to combine natural scientific and technological knowledge with the understanding of societal change dynamics offered by social sciences and humanities. This puts increasing emphasis on interdisciplinary collaboration and research structures that support long-term interdisciplinary communication and joint action.
- to reach sustainability goals in climate action, environment, resource

We recommend

- Applying scenario-building processes for supporting the creation of mission-oriented R&I policies, as it enhances joint vision-building and the identification of R&I priorities. To succeed in this, there is a need to keep the overall target of scenario building clear.
- Using multi-method approaches for participatory scenario building,

efficiency and raw materials, fundamental changes in economic and consumption patterns are required. These changes are likely to also impact societal well-being and social stability. Therefore, it is imperative to make the process of designing and agreeing on future R&I missions transparent and, when possible, inclusive.

- to create impactful R&I missions, which drive genuine sustainability transitions, there is also a need for mitigation tools to negotiate the societal re-distribution of costs and benefits. As the correlation between employment, productivity and economic growth is weakening due to digitalization, there is need to look at other welfare factors beyond growth of GDP to ensure public support of R&I spending.

as different foresight and knowledge production methods (e.g. creative-based, evidence-based, expertise driven and interactive) have different advantages and disadvantages in engaging participants.

- Designing scenario building in such a way that supports process dialogue between different stages of the process.

Co-author(s) of this chapter

Henna Sundqvist-Andberg, Maria Åkerman, Jesse Fahnestock

Further information; RECREATE source

Henna Sundqvist-Andberg, Maria Åkerman, Jesse Fahnestock. 2018. D5.3. Three integrated scenarios until year 2050 -no. 3. RECREATE project report.

Co-creation and stakeholder participation

Short background

Co-creation aims to improve and foster the participation of end-users (customers in the private sector; citizens in the public sector) by actively involving them in technological and social innovation processes. With public trust in governments waning and citizens perceiving a decline in the quality of public

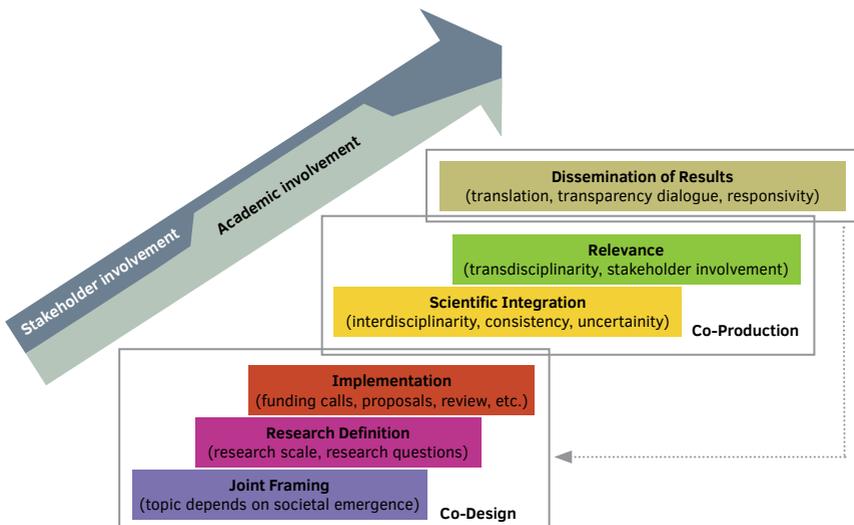
services, co-creation appears essential to re-establish trust and improve the quality of governance. In the context of product innovation, involving end-users allows companies to better match customers' needs, minimise market failure and provide companies with a competitive advantage.

Methodology

The process of co-creation is multi-stage and includes (see Fig. 8 below)

- 1 Co-designing and co-producing knowledge, products and services; and

Figure 8: Co-creation of societally relevant knowledge for solving real-world problems in sustainability science



Source: Mauser, W., G. Klepper, M. Rice, B.S. Schmalzbauer, H. Hackmann, R. Leemans, H. Moore (2013). Transdisciplinary global change research: the co-creation of knowledge for sustainability. *Current Opinion in Environmental Sustainability* 5 (3–4): 420–431.

2 Co-implementing innovations.

Co-creation is believed to yield a number of benefits, including

- Tapping into additional knowledge, creativity and new insights;
 - Allowing the establishment of long-term relationships, partnerships and trust; thus
 - Increasing end-user satisfaction; and also
- Fostering legitimacy through ensuring citizen acceptance and consent.

However, achieving such partnerships and mutual learning is challenging, *inter alia*, because (i) of existing power relations and power asymmetries; and (ii) it requires skills in integrating different kinds of knowledge and a readiness among different stakeholders to engage into open-ended and mutually respectful joint research processes.

In order to foster co-creation in European R&I, we recommend

- Fostering the conceptual clarity of the term co-creation and embedding a binding and clear definition in H2020, Cohesion and Territorial funding call texts.
- Stipulating co-creation in mission-oriented R&I calls covering topics where societal impact and hence meaningful stakeholder participation is essential.
- Adapting existing and developing new funding instruments to provide more flexible and open-ended forms of science funding that
 - provide room for experimentation and flexibility in project execution and allow the use of project funding for adapting research processes to emerging co-creation needs and opportunities, e.g. via unforeseen subcontracting of professionals in PR and knowledge brokerage;
 - require setting up meaningful stakeholder participation processes;
 - fund or provide other incentives for stakeholder participation in co-creation (travel costs and time spent); and
 - foster mutual learning among different stakeholder groups.

- Supporting researchers in organising and achieving co-creation, e.g. by
 - providing guidance on how to engage stakeholders; and
 - facilitating stakeholder identification and contacting for researchers, for instance by setting up exchange platforms or match-making events.
- Funding research projects that
 - assess the added value of co-creation from a political and cultural perspective to identify, evaluate and possibly quantify the democratic, governance and socio-political value of co-creation; and
 - highlight the relevance of co-creation as a process and strategy to address potential democratic deficits or performance gaps in public services.
- Improving the capacities of funding agencies to assess and handle transdisciplinary project applications, which may be accompanied by a higher risk-return ratio as they are open-ended and bring in changes/stakeholders that could lead to disruptions in the project.
- Fostering the development of standards of “excellence” for transdisciplinary research and promoting their use among evaluation systems, inter-alia, for project funding, assessing scholarly performance and peer reviewing.
- Fostering skilling for knowledge integration and boundary management in science education.

Further information; RECREATE source

RECREATE Project Team. 2018 Position Paper: RECREATE Project Team. 2018 Position Paper: Recommendations for the European Union’s 9th Framework Programme for Research and Innovation; Martin Hirschnitz-Garbers (2018). Co-creation in Sustainability Science – Challenges and potential ways forward to implementing co-creation in European Research and Innovation Funding. RECREATE Policy Brief No. 9.

RECREATE Green Horizons Scoreboard

Short background

In a functioning circular economy, resource outputs would be turned back into inputs, creating a sustainable flow of energy and materials available to produce goods and provide services. Understanding innovation systems that influence material flows is important

for evidence-based policy making. Innovation systems allow for capturing innovation processes in markets and within societies in a holistic perspective that points to opportunities for transforming currently unsustainable mass markets.

The tool

The RECREATE Green Horizons Scoreboard is an online tool that provides time series indicators on 11 technological innovation systems that are relevant to societal challenges in the areas of climate action, environment, resource efficiency and raw materials. These encompass agriculture and soil sciences, the bio-economy, climate adaptation, critical raw materials, energy efficiency, environmental governance, fossil fuel efficiency, material efficiency, renewable energy, waste and recycling and water and waste water. All indicators are presented as parts of various technological innovation systems in order to show them in a problem-solving context and to point to potential causal links between them. Furthermore, the RECREATE Green Horizons Scoreboard adopts six functions of innovation systems that all need to be 'performed' or 'stimulated' for successful innovation. These are:

- 1 Knowledge development and diffusion;
- 2 Influence on the direction of search;

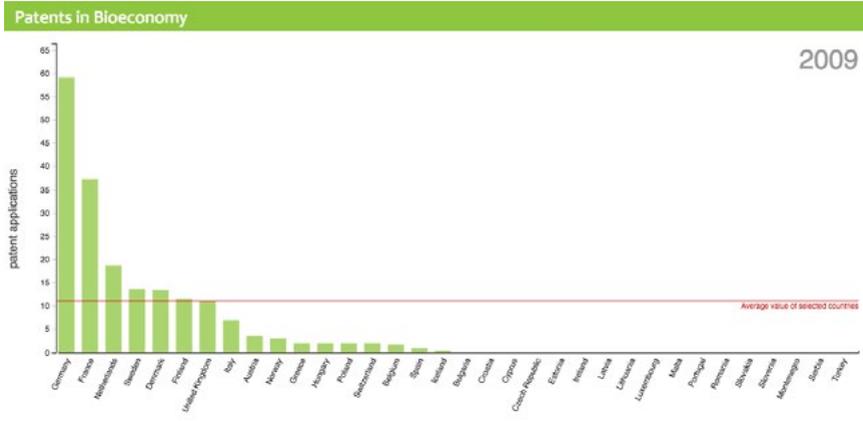
- 3 Entrepreneurial experimentation;
- 4 Market formation;
- 5 Legitimation of technologies; and
- 6 Resource mobilisation.

The Scoreboard enables policy-makers, researchers and the general public to quickly find sets of relevant indicators, compare performance over time and across space and analyse the relationship between different indicators for 34 European countries.

What policy answers can the scoreboard provide?

- 1 Information on 11 environmental innovation systems and indicators for each of their functions;
- 2 Link to raw data behind the indicators;
- 3 Comparison of countries for one to three indicators;
- 4 Evolution of indicators over time for one or more countries;
- 5 Analysis of indicators for a single country; and
- 6 A display of indicator data on a map of Europe.

Figure 9: Example of the Scoreboard use: Patents in bioeconomy across EU Member States



For example, the scoreboard allows the comparison of indicators from a specific innovation system across countries (see Fig. 9). The ‘get a country overview’ tab gives information on indicators in each information system

in a chart, including which country has the minimum and maximum value for the indicator as well as the average value.

Find the scoreboard at:
<http://green-horizons.eu>

We recommend

- Fostering the provision of policy relevant data on R&D system performance, e.g. through the development of scoreboards to allow for better informed policy making in the face of abundant but scattered data.
- Ensuring that the tools providing policy relevant data are up-to-date and remain so for the long(er) term

by providing sufficient funding and follow-up projects or other ways to maintain and update the tools.

- Funding research or coordination activities that bundle data from existing scoreboards, which do not have future funding, and investigate options for institutionalising such overarching data platforms.

Co-author(s) of this chapter

Katarina Svatikova, Stephan Slingerland

Further information; RECREATE source

Katarina Svatikova, Stephan Slingerland. 2018. The Green Horizons Scoreboard. Providing data for integrated climate action, resource efficiency and raw materials policies. RECREATE Policy Brief No. 10.

5 Closing remarks

Great efforts have been made in the H2020 programme to foster research and innovation in the fields of climate action, environment, resource efficiency and raw materials and to link research more strongly to innovation and tangible results in order to increase European economic competitiveness and improve the wellbeing of European citizens (EC 2018).

The EC names the main challenges to tackle under this ‘Societal Challenge’ as:

- Achieving a resource- and water-efficient as well as climate change resilient economy and society;
- The protection and sustainable management of natural resources and ecosystems; and
- A sustainable supply and use of raw materials to meet the needs of a growing global population within the sustainable limits of the planet’s natural resources and eco-systems.

In RECREATE, we searched for research gaps and future R&I priorities that need to be tackled in order to reach those goals. There are many concrete research projects waiting to be set up to increase our knowledge of the new business models and technological and social innovations that can help turn waste into a resource and foster nature-based solutions.

More complex and also far-reaching are the overarching research needs ahead of the EU: Truly tackling social-ecological challenges requires moving from isolated measures to a systemic transition and the alignment of R&I policies for climate action, environment, raw materials and resource efficiency with other domains. The goals of Societal Challenge 5 can only be reached if environmental policy is mainstreamed in policies from all other policy areas, most prominently agriculture, digitisation, economy/industry, energy, finance and mobility. The links between different research and policy fields must be accounted for. More inter- and transdisciplinary research is needed to bridge the remaining gaps.

These research opportunities seem to emerge at a time when politics and society are catching up with, and sometimes even overtaking, previously frontrunning research. The EU Circular Economy Package is a great step towards breaking silos and better connecting the environmental and economic agendas in the EU. On the societal side, countless signs of transition could be mentioned. For example, younger generations are challenging workplace values and traditional reward systems and instead demand more flexibility, leisure time and high ethical standards in their working environments. Sharing systems for all

types of belongings are on the rise, and there seems to be a societal trend towards more cooperation rather than increased individualism. We do not argue that all of these developments are positive: sometimes a new sharing system may simply fill a void that the state used to fill in the past. But we do argue that a systemic transition is needed and that a societal transition is already in progress. The changes required may sometimes challenge traditional solutions in a radical way.

Therefore, it is all the more important to learn as much as possible about these changes so as to provide policy with a knowledge base to act on behalf of European citizens, rather than react to pressing environmental concerns.

We believe that the most important goal of future EU research and innovation activities must be to understand, develop, test and implement pathways for system transition.



Imprint

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Note about this report: This report is based on the RECREATE project. Its aim is to condense and synthesise the main recommendations of the project as well as to lead the way to the source documents of each chapter. The authors of the source document are therefore understood and presented as co-authors of their respective chapter.

Naturally, a single project cannot cover all potential research and innovation needs for SC5. The priorities of RECREATE were chosen in intense dialogue with the European Commission's DG Research and Innovation and relate to the EC goals of:

- 1 Positioning Europe at the forefront of realising a circular economy through systemic approaches to eco-innovation.
- 2 Making Europe a world leader in nature-based solutions that use renewable natural resources and /

or ecosystems to address societal challenges, yielding economic social and environmental benefits.

- 3 Creating a market for climate information services that enables economic actors to seize opportunities arising from climate action, governments to take climate-smart mitigation and adaptation decisions and citizens to optimise their quality of life in the face of climate change.

We mainly used the method of evidence-based narratives (EBNs; see Chapter 4.1) to derive concrete recommendations for future R&I orientation in these topics. By assessing potential environmental and socio-economic benefits, the EBNs provide robust insights about the potential (future) relevance of certain innovation areas. Hence, the concrete recommendations focus on innovations whose scaling-up has socio-economic and environmental potential across Europe.

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