

## The approach of ENEA (*National Agency for new technologies, energy and economic development sustainable*) to the Circular Economy Transition: an overview

### *Abstract*

*As part of its mission as the Italian Agency for new technologies, energy and economic development sustainable, ENEA is pre-eminently focused on 'applied' research, that is, on making available innovative technologies and advanced services in the various sectors of expertise, to the business world, to the public sector administrations and citizens themselves. From this point of view, the circular economy is one of the strategic priorities and takes shape through numerous operational projects with the aim of going 'beyond slogans' and translating them into reality is the founding principle of closing cycles, as a driving force for growth and competitiveness and, at the same time, an essential tool for a society model focused on sustainability.*

### Main Text

The circular economy is a topic that is talked about very often, ignoring its true scope and great potential. The circular economy, in fact, is not an elegant way to solve the waste problem but is a new economic model whose complete adoption is increasingly necessary.

The first of these reasons is that our Planet has limited resources and that we are consuming them at a much faster rate than the Planet itself can regenerate them. Therefore a condition of absolute unsustainability.

If we then talk about non-renewable resources, the so-called raw materials, in particular critical raw materials, indispensable to hi-tech industrial supply chains, it should be underlined that very often the supply of these resources comes from countries with very strong social and political instability and, in some cases, the scene of wars. Not infrequently these are 'forgotten' conflicts, such as the so-called 'COLTAN war'.

On the other hand there is the great challenge of climate change, decarbonisation and carbon neutrality by 2050. If we look at the breakdown of greenhouse gas emissions we see that 45% comes from the use of products and management of the territory in all its facets, agriculture, forests etc.

To be able to contain this increase below 2 degrees, it is essential to implement circularity interventions in all production sectors, from industry to transport, from energy systems to agro-industrial ones, from construction to forest and land management.

In this scenario we can affirm that if the circular transition is absolutely necessary, for all countries globally, promote circular transitions everywhere within production cycles, recycling everything possible, trying to drastically reduce the use of virgin raw materials and emissions in whatever form they may be, not only within the individual plant, but in the industrial areas between the different production cycles, also taking advantage of new business models.

Among the most powerful tools we have in this context, there is the industrial symbiosis that can be applied between production cycles and the territory and within the territory itself, starting from our cities.

There is a need to make efficiency the main driving force of this transition by developing eco innovation at all levels: eco innovation of process, product but also system, with the development of new business models and new cultural approaches.

This report illustrates the approaches and models that ENEA is putting in place to support the transformation towards the economy circular, with a focus also on training and information, aspects of great importance for bringing about change culture and necessary behaviors. In these projects the Department “Sustainability of Production Systems e Territoriali” (SSPT) has a leading role, as coordinator or referent of activities in collaboration with others Agency departments, national and international partners, local central companies and institutions, and other entities at a territorial and urban level. These activities involve over one hundred researchers and technologists from the SSPT Department and a network of infrastructures, technological halls, pilot plants and advanced analytical laboratories specialized in process, product and system eco-innovation. The projects allow the circular economy to be applied in different ways application areas such as:

- Urban areas: ENEA designs and develops integrated and circular operating management models and systems urban for more sustainable, circular and inclusive cities, to promote sustainable lifestyles and consumption, for carry out correct management of water and urban waste also in terms of valorisation and protection health and safety, stimulating cultural industries, tourism and best practices in urban and peri-urban contexts.

Cities are the most common human habitat and primary economic drivers, so they represent the most powerful physical and political leverage points for transition to circular economy models. Circular cities is the challenge dealing with the complexity of urban territories, that can be considered like complex systems of other many complex sub-systems: wastes, water, buildings, food cycle, energy, mobility, etc. Due to this complexity, in cities the CE link to geographical scales is still under-tapped and cities struggle in their transition to implement a full CE model.

An integrated and systemic approach is therefore the only possible approach aiming to define strategies, methodologies, instruments and technologies to improve cities’ environmental performances, to maximize positive social and economic impacts and to stimulate the necessary changes in terms of culture and mindsets. In line with the 2030 Agenda on Sustainable Development, the Pact of Amsterdam for an Urban Agenda for the EU, and the Draft Action Plan for Urban Agenda for the EU Circular Economy, stressing cities role as powerful drivers of innovation and economic sustainable development, how is it possible to manage and to deal with this complex transition?

The main constraints are lacks of intersectorial collaboration and of collaboration among cities, lack of new consumption models (sharing economy, pay for use, reuse), lack of plants and sharing platforms, low citizens participation, and much others are the needs, e.g. implementation of stakeholders platforms, sharing economy platforms, development of technologies and plants and more citizens’ involvement.

An integrated action plan at different levels and integrated projects are then mandatory to achieve the transition towards circular cities .

- Territory and sea: ENEA plans and develops processes and methodologies for the sustainable management of land and sea sea from a circular economy perspective through the

management of ports and coastal areas, sustainable tourism and development of the fish supply chain.

Territory & Sea is the challenge dealing with the complex relationships between mainland human activities and the open water, chiefly represented by the technosphere environment of harbours. The goal is to set up a line of actions aimed to a suitable transition to the Circular Economy in the small and big ports management. How to do it? Fostering sustainable and circular innovations in the main productive sectors occurring in the ports and in the main activities and businesses linked to its economic life. In line with the emerging Blue Economy principles and the Blue Growth perspective, the main addressed topics to be tackled will be among others marine litter, sustainable tourism, integrated waste and water management, but also the sea level increasing due to the climate change effects and the solutions for its mitigation. Innovation could lead, for example, to the fishing traceability and valorization of the fish supply chain residues in new products, to the integrated waste and water management, to an industrial symbiosis platform implementation, to sustainable logistics in tourists and goods management and to new jobs opportunity and businesses. Managing this complex transition to a circular and sustainable anthropic connection between territory and sea should be driven by an integrated approach and a holistic view in order to create a feasible model for economic capital creation and natural capital safeguard.

- Industrial system: ENEA develops and implements technologies and methodologies for multiple production and consumption models sustainable and regenerative to support industry with innovative technologies and new business models (industrial symbiosis, Circular design models, Sharing economy, ..), tools for businesses, redevelopment of industrial sites with a circular perspective.

The challenge is to promote innovative technologies and tools for the efficient use of resources in industry and for sustainable production.

The approach is based on innovative integrated solutions to be implemented in factories, industrial areas and production sectors (agro-industry, metallurgy, textiles, etc.).

The actions should concern innovation in product design, production processes, efficient use and management of resources, reduction of emissions and waste, valorisation of process waste, collaborative exchanges between different industries and cross-sector collaboration (for example through industrial symbiosis), the sustainable and circular management of industrial areas, the redevelopment of industrial areas and the conversion of existing factories to the circular economy.

- Value chain: ENEA develops system approaches to promote and facilitate the closing of cycles in production chains and along the life cycle of products and materials through activities to promote collaboration between different actors and sectors, approach integrated and multidisciplinary (life cycle thinking and circularity measurement), new business models and market analysis. The challenge 'Value chain' covers the main topics for closing the loop of specific materials (i.e. Critical Raw Materials or others), products (i.e. plastic packaging, WEEE, tyres, etc.) and in specific supply chains (such as buildings, agro-industry, textile, etc.). Within this challenge all value chain phases need to be taken into consideration: design, material supply and production, consumption and distribution, end of life as new production of materials. This type of challenge has itself a wide territorial extension that typically is from national to global scale (depending on the geographical area of supply for primary resources).

It aims the implementation of synergic actions involving all the actors of the value chain (designer, producer, distributor, user, end of life manager, recycler) in order to identify barriers and remove bottlenecks and broken rings hindering the closure of loop and implement a sustainable system for all the actors involved.

As scientific coordinator of the EU Cicerone project (Circular economy platform for European priorities strategic agenda), ENEA was able to evaluate the importance of the role of policy for eco-innovation in the circular economy transition especially for European countries.

The goal of a sustainable resource and waste management must be to ultimately achieve a transition to a fully-fledged circular economy within this century (WBGU 2016, p. 85), i.e. to preserve the value of the resources and materials as long as possible, to reuse them as often as possible and, ideally, to generate no or as little as possible waste. The concept includes all sectors of the economy, from resource extraction over the production, storage and consumption, as well as the disposal or recycling. Through the closing of loops waste shall become a resource again (so-called "second-sourcing"). But to implement this idea as extensively as possible, the consideration of reuse, repair, remanufacturing, sharing and recycling is necessary as well as eco-innovation and circular economy aspects in the product design (Wilts 2016). Stronger eco-innovation efforts are needed for each option.

Eco-innovation is a vital element of all circular economy efforts and has been defined as any innovation that reduces the use of natural resources and decreases the release of harmful substances across the whole lifecycle (EIO 2010). Eco-innovations with the potential to enable the transition to a resource-efficient circular economy model span efforts to change dominant business models (from novel product and service design to reconfigured value chains), transform the way citizens interact with products and services (ownership, leasing, sharing, etc.) and develop improved systems for delivering value (sustainable cities, green mobility, smart energy systems, etc.) (EIO 2014, p.8).

As mentioned above, circular economy activities at the Member State level are still overwhelmingly regarded as waste management measures (EEA 2016), which indicates a lack of knowledge and general uncertainty in the transformation to a circular resource management and neglects the eco-innovation efforts in the stage of product design.

However, eco-innovation and circular economy concepts and activities need to be more closely linked – especially when it comes to R&D programmes. The Waste Framework Directive provides for technical requirements and regulations (e.g. mandatory recycling quota for several waste streams) but, as yet, the institutional settings and the country-specific planning for circular economy issues vary significantly from country to country with regard to contents, ambitions, targets and choice of policy instruments and it mainly focuses on waste management (Bahn-Walkowiak et al. 2014). The following figure shows where the current policy framework has direct and indirect impacts on the different options and phases of a circular economy.

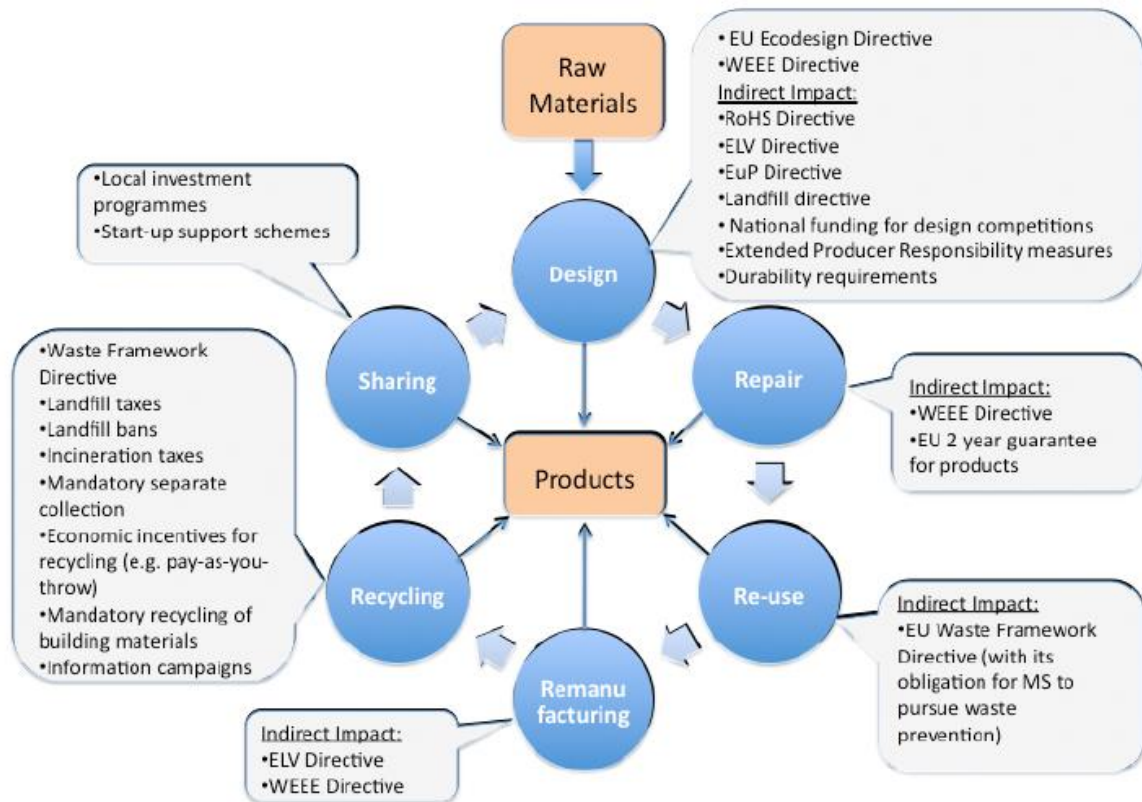


Figure 1 Overview of existing instruments and approaches for a circular economy in EU (Doranova and Gigli 2014).

The EU MS also often lack an integrated infrastructure planning for waste infrastructures, with corresponding counter and side effects on resource efficiency and circular economy. For example, regional waste incineration over-capacities act as an incentive to use those usually capital-intensive incineration plants at full capacity but they do not drive a circular economy. The current diverging country performances concerning waste recycling rates, infrastructures and waste prevention measures in place indicate that—as long as waste is still looked at as a cost factor instead of as a “resource”—regulatory instruments are often more effective than economic instruments (Bahn-Walkowiak et al. 2014).

Policy approaches are frequently not sufficiently considering the waste hierarchy and circular necessities and thus lead to unwanted effects. A policy for diverting waste from landfill without considering an alternative and eco-innovative treatment for a pathway further up the waste hierarchy, which might be environmentally and economically appropriate in the specific context, can lead to results, which:

- are ineffective (e.g. recycling focus on less resource-intensive waste fractions instead of the resource-intensive ones),
- induce unwanted pathways (e.g. investment in capital-intensive incineration capacities without taking account of future shifts such as recycling) or
- have a completely counterproductive effect (e.g. illegal dumping).

Implementing policies towards building a circular economy model requires the participation of many different types of stakeholders. This is particularly true for implementing a coherent strategy, when a wide range of actors should be involved, including national/regional/local governments, local businesses, NGOs, social enterprises, consumers/citizens, academic and

research centres. Diverse roles and potential inputs by diverse stakeholders are summarized below.

- National, regional, local authorities and agencies dealing with industrial development and waste
  - Ensuring policy, regulatory support, introduction of support measures, as well as technical and financial support
  - Facilitating the dialogue with, and between, research organisations, businesses and civil society organisations
  - Leading, or involvement in, project development, implementation, monitoring of project activities and the financial allocation
  - Supporting awareness raising and education amongst the population and promoting more sustainable lifestyle, sharing, re-use, recycling
- Businesses and industries
  - Developing and investing in new sustainable businesses, business models, products and services based on circularity principles, symbiosis
  - Cooperating with authorities in implementing initiatives and helping to scope visions for the greening and circularity in regions, cities and communities
  - Cooperating with research organisations in developing new eco-innovative and circular solutions
- National, regional or local innovation agencies and intermediaries
  - Advising SMEs and organisations on innovation measures
  - Advising or playing an active role in the development and implementation of projects and monitoring project activities, outcomes and impacts
  - Cooperating with authorities in implementing eco-innovation initiatives and scoping visions for the greening of regions, cities and communities
  - Promoting or lobbying for specific regulations or policy decisions
- Research organisations, cluster organisations and universities
  - Cooperating with authorities in implementing sustainable initiatives and helping to scope visions for the greening and circularity of regions, cities and communities
  - Cooperating with SMEs and industries in developing new solutions
  - Facilitating or taking an active role in project development and implementation, and the monitoring of project activities, outcomes and impacts
- NGOs, citizens, user groups
  - Participating in priority setting for eco-innovation initiative planning

- Educating and raising awareness amongst the population and promoting social innovations in areas such as lifestyle and mobility
- Supporting project planning, implementation and monitoring
- Creating networks and mobilising local efforts
- Lobbying for specific regulations or policy decisions
- Co-creating and co-testing of new eco-innovations by users, NGOs, citizens, user groups
- Supporting the dissemination of eco-innovations towards a circular economy
- Supporting eco-innovative or sustainable systems such as recycling, eco-mobility and sustainable lifestyle

For all those stakeholders, eco-innovation for a circular economy will have different meanings and involve different approaches and responsibilities. This requires a systemic approach that “makes use of a wide toolkit of policies and measures, across different points of value changes and affecting the full set of private and public stakeholders. Given the multi-level governance approach needed, options can be structured across different actors (e.g. EU, Member State, regional and local authorities, private sector, civil society, citizens), levels and timeframes, keeping in mind that in some areas circular economy benefits will materialise as a result of own initiatives by the private sector, while in other areas support (including public intervention) will be needed to encourage transitions” (European Union 2014, p. 54).

The circular economy aims to boost the EU's competitiveness by protecting businesses against scarcity of resources and volatile prices by helping to create new business opportunities and innovative more efficient ways of producing and consuming (European Commission 2015, p.2). Policy frameworks like the European Commission's Circular Economy Action Plan or similar national initiatives aim to initiate eco-innovations that would enable fulfilling these ambitious objectives. For the circular economy to go from an attractive concept towards business reality, pioneers along the whole value chain are challenged to develop alternatives to the traditional “make-use-dispose” approach. Already today new technologies, design concepts, services, and innovative forms of co-operation are contributing to the circular economy across the EU.

Becoming a circular economy will require radical eco-innovations that enable completely transforming the linear patterns of production and consumption that developed over the last two centuries and became an obviously wasteful but stable regime of over-consuming natural resources. The circular economy will thus require eco-innovations in two very different fields that could be labelled as circular economy “hardware” and “software”: The technologies and technical infrastructures that would allow to turn waste (like glass, see the following good practice example) into resources (hardware) and at the same time the skills, expertise and business models that would turn this transformation into a business case (software).

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