

INDUSTRIAL SYMBIOSIS PROMOTING THE CIRCULAR ECONOMY IN ROMANIA

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Abstract

In the efforts to develop a sustainable, low carbon, resource efficient and competitive- ultimately the green economy- in the European Union, the industrial symbiosis is an important conceptual and practical approach with essential contribution. Latest developments in eco-innovation in Romania are those dedicated to implementing the circular economy, as will be analyzed and highlighted in the paper.

The main objective of the research is the analysis of the regional eco-innovation potential to play a decisive and major role in the transition to a green economy in Romania, by implementing industrial symbiosis as a high form of circular economy. Methodology is based on previous research outcomes of conceptual and empirical analysis in the areas of sustainable development, resource efficiency, green economy, sustainable forest management, eco-innovation parks as well as on a case study. The case study presents the main features, the environmental and economic drivers and benefits of the industrial symbiosis adding value by recycling wooden waste from logging within the ECOREG pilot eco-industrial park of Suceava County. The conclusions and policy recommendations are that planning, implementing and development of industrial ecosystems is needed in Romania, in view of sustainable regional economic development and a green growth.

Keywords: green economy; circular economy; industrial symbiosis; eco-industrial park; wooden waste

JEL Classification: O44, O47, Q32

1. Introduction and context of the study

As part of the research project “The role of eco-innovation for promoting a green economy in Romania”, the main objective of this paper is a deeper analysis of the eco-innovation and eco-innovation parks potential to play a decisive and major role in the the transition to a green economy in Romania, by implementing industrial symbiosis as a high form of circular economy.

Decoupling growth from resource use and unlocking new sources of sustainable growth needs therefore coherence and integration in the policies that shape our economy and our lifestyles. A revamping of the economy to become resource-efficient is a necessary, but still not sufficient condition to achieve transition towards the green economy (Frone S., Constantinescu A. 2015).

As may be followed in the paper, the green economy requires step changes in resource efficiency, investment in clean technologies, the development of alternative products, services and materials, and the ability to obtain value from the unavoidable waste (UNEP, 2012).

However, with the help of the theoretical and empirical approaches employed there is argued more on the need to acknowledge and better understand the concept and aim of the circular economy (a form of the green economy) designed to close the loop in product life cycles by keeping as many resources in the economy as possible, thereby reducing waste and promoting sustainability.

There is explained in more detail the meaning and the features of eco-innovation for the circular economy and of the industrial symbiosis, focusing on the concept of waste and resource recycling.

In this context, the paper presents a short analysis of the implementation of a pilot eco-innovation park as application of industrial ecosystems principles to regional development in

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Suceava County (ECOREG), in order to put into evidence the fact that it is an important vector promoting the green economy in Romania.

Developing on previous significant research outcomes (Frone Simona, 2015) there will be a deeper analysis emphasizing especially the synergic features of the eco-innovation parks (EInvP) in re-cycling and re-using the resources, thus closing-the-loop as desired in the circular economy.

Another important aspect of research is the link with some previous approaches on the need to acknowledge and implement an economic assessment of forest ecosystems as important for determining the efficiency of investment in biodiversity conservation, expanding national forestry fund, rational use of forestry resources, sustainable development of the forest in Romania (Platon V. et al., 2015).

In this respect, the important feature of the industrial symbiosis described in the paper is its contribution to the preservation of the Romanian virgin forests and so, of their precious forest ecosystem services. This can be done through the recycling of the wooden waste in the industrial eco-system ECOREG, through various industrial synergies closing the loop on the wood resources and adding value to wooden waste.

The methodology is based and develops on conceptual and empirical analysis in the areas of sustainable development, resource efficiency, green economy, sustainable forest management, eco-innovation parks as well as on a case study.

2. Background concepts and issues

The new paradigms of production and consumption call more and more for a higher resource-efficiency, a concept that underpins all the valuable ideal concepts of economy and development: sustainable development, the green economy and the circular economy, as well as the strategies dedicated to their objectives.

The “Green Growth”, “Green Economy” and “Green Industry” are several closely related concepts that have been developed and promoted in the last years, as a reaction to the global recession and climate change.

Technological innovation could become the cornerstone of minimizing pollution and at the same time, the key to global sustainable economic development (Constantinescu A., Frone S., 2014). Therefore, looking for a balance between aspirations towards sustainability and locally existing possibilities to implement it in practice, another concept has resulted: the eco-innovation.

As will be emphasized further in this research, eco-innovation is a strong pillar of the green economy, since having a double valence, both for ecological and economic accounting, as it will:

- improve the protection of the environment;
- increase the efficiency of resource use;
- contribute indirectly to the increase of economic competitiveness.

Hence, practically speaking, a green economy is one whose growth in income and employment is driven by public and private investments that reduce carbon emissions and pollution, enhance energy and resource efficiency, and prevent the loss of biodiversity and ecosystem services (Frone Simona, 2017a).

The main features of the green economy are:

- Ecological resilience for the ecosystem pillar;
- High resource efficiency for the Economy pillar;
- Enhanced social-equity for the Human well-being pillar.

These various terms and connected concepts (Table no.1) have in common their objective to influence and thereby alter the prevailing political discourse, to transform the financial, economic and ecological crisis into win-win situations (UNIDO, 2013).

Table no.1 Background concepts

Concept	Definition or characteristics
Green economy	In its simplest expression, a green economy can be thought of as one which is low carbon, resource efficient and socially inclusive
Circular economy	In a circular economy, the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised. It is an essential contribution to the EU's efforts to develop a sustainable, low carbon, resource efficient and competitive economy, ultimately the green economy (COM/2015/0614 final).
Eco-innovation	The introduction of any new or significantly improved product (good or service), process, organisational change or marketing solution that reduces the use of resources and decreases the release of harmful substances across the whole life-cycle (EIO website, www.eco-innovation.eu).
Eco-innovation park (EInvP)	The term eco-innovation park is used to define both eco-industrial parks and eco-innovative areas combining residential and industrial activities.
Industrial symbiosis (IS)	Industrial symbiosis traditionally engages separate industries in a collective approach to a competitive advantage involving physical exchange of materials, energy, water, and/or by-products as well as services and infrastructures shared at the industrial park scale to reduce environmental impact and overall production cost.
Industrial ecosystem	The broadest application of industrial ecology's analogical approach is to describe manufacturing complexes as "industrial ecosystems". This idea suggests a web of interaction among companies such that the residuals of one facility become feedstock for another. Industrial ecosystems aim to minimize inefficiencies and the amount of waste created by mimicking natural ecosystems in industrial systems.

Source: Own synthesis based on (Frone S., 2017a, b)

The concept and model of the circular economy is thus synergically related to a resource-efficient economy, but even more demanding. As a form of the green economy, circular economy proposes the re-use of resources used in products whose shelf life has come to an end or which have lost their usefulness to construct new objects, the same quality or even better.

The strategic approach "Towards a Circular Economy" (COM(2014) 398) promotes a fundamental transition in the EU, away from a linear economy, for resources to be not simply extracted, used and thrown away, but put back in the loop so they can stay in use for longer. This approach also sets out measures driving a more efficient use of resources and waste minimization.

As stated in (Frone D.F., Frone S., 2015) the global resource nexus model is very suggestive for a green (circular) economy model and especially for our topic, since the importance of the sustainable management of natural resources and of their increased resource-recovery and efficiency is better acknowledged.

The principles of a circular economy support ideas and mechanisms for increased competitiveness and economic growth in the European Union, by:

- creating new business and jobs opportunities;
- transforming and revamping the processes of consumption for better efficiency;
- the correct and sustainable management of resources.

Therefore, the European Commission has launched in December 2015 the ambitious **Closing the loop – An EU action plan for the circular economy** (COM/2015/0614 final) as a package of measures to develop the circular economy. It is believed that by stimulating sustainable activity in key sectors and new business opportunities, the plan will help to unlock the growth and jobs potential of the circular economy. Nevertheless, although the action plan focusses on "action at EU level with high added value", implementing the circular economy will still require "long-term involvement at all levels, from Member States, regions and cities,

to businesses and citizens”. Member States (including Romania) are invited to play their full part in EU action, integrating and complementing it with national action.

The European Commission through the Smart Specialisation Platform provides professional advice on the design and implementation of their research and innovation strategies for cooperation on issues related to innovation for the circular economy – in areas like industrial modernisation (EC Panorama, 2016).

This is very important since there are specific issues and priorities for sustainable economic development in each region of Romania, and still important hindrances that most regions have to surpass finding viable solutions to increase their innovative performance (Sandu Steliana, 2012).

Industrial symbiosis (IS), as part of the industrial ecology research field, focuses on the flow of materials and energy from local and regional economies. An “Industrial symbiosis engages diverse organisations in a network to foster eco-innovation and long-term culture change. Creating and sharing knowledge through the network yields mutually profitable transactions for novel sourcing of required inputs and value-added destinations for non-product outputs, as well as improved business and technical processes” (Lombardi, D. R. and Laybourn, P., 2012).

The methodological approach leads to the need of a deeper analysis and understanding of the eco-innovation, eco-innovation parks and industrial ecosystems, as some important concepts related to the complex changes of paradigm required by the circular and green economy.

3. Eco-innovation trends and issues in Romania

The eco-innovation for sustainable development and a green economy has many features and implications which are more and more acknowledged and proved by recent research. Although sustainable development towards the green economy is a global issue, it should be noted that developing countries do not have the technology necessary to combat mainstream environmental issues and their inherent consequences.

However, as we analyze and show in the case-study, eco-innovation is not only technological, but can be also a spatial, regional eco-innovation enabling the industrial symbiosis leading to many important benefits in resource-efficiency.

The issue of poor or inefficient resource management was signaled in the previous edition, while the latest EIO Country Profile report on Romania (EIO, 2016) raises the issues of barriers and drivers to circular economy and eco-innovation in Romania, ranking 18th in the Eco-Innovation Scoreboard (Eco-IS) (with a score of 87.1, below the overall EU-28 average score by 13%, see fig.no.1).

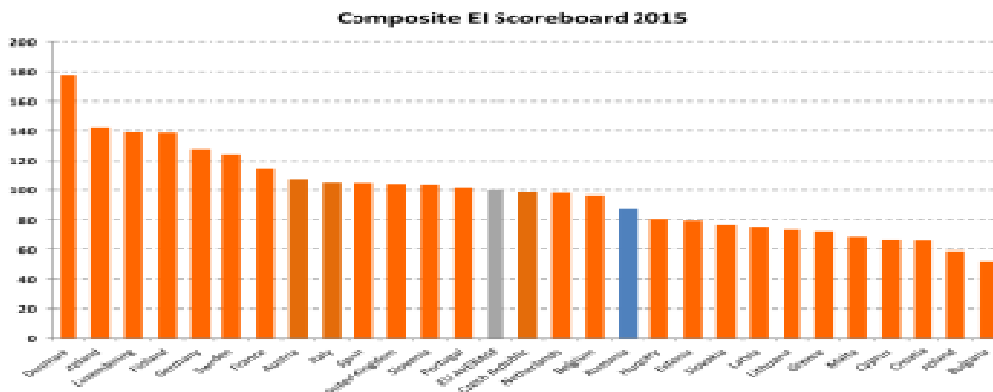


Figure no. 1 EU28 Eco-innovation scoreboard 2015, composite index

Source: www.eco-innovation.eu

The best current accomplishment is that Romania ranks above the EU average in terms of eco-innovation activities (38 points above the EU average score of 100).

Romania's eco-innovation system can be broadly characterised in terms of push and pull factors acting in opposition. It may be stated that there is still: a low level of investment in basic infrastructure and framework conditions for recycling, waste management and resource efficiency; a low input into R&D from the public and private sectors (Frone S., 2017 a, b).

As also stressed by this latest Eco-Innovation Observatory Country Profile for Romania 2014-2015, there has been limited change in the companies' environmental behaviour in Romania, since 2013.

Further negative issues but also positive findings from the Eco-Innovation Observatory Country Profile for Romania 2014-2015 report include the following (Frone S., 2017 b):

- Companies show weak environmental awareness and weak levels of transparency and communication on environmental issues.
- In terms of cost assessment, companies don't measure or do not want to declare the costs and benefits obtained through their environmental management practices.
- Most companies in the survey do not monitor their resource use systematically, which is why they are not able to take measures to improve their environmental performance.
- A notable change is the increase in companies' use of renewable energy sources. 9.3% of the surveyed companies predominantly use renewable energy sources, while for 18.5% of the companies, less than 50% of their energy use comes from renewables.
- The majority of the surveyed companies (57%) do not use recycled resources as production materials at all, while for another 16.3%, recycled resources make up less than 2.5% of their production materials. This shows there are large opportunities for development of the circular economy in Romania.

Considering these findings, it may be stated that in Romania there is still a long way towards really promoting and developing a green economy.

Already highlighted in the previous (2013) EIO Country Profile for Romania, suitable administrative capacity, availability of skilled personnel in the public and private sector, as well as the low propensity to collaborate, continue to be challenges for a systemic transformation agenda such as the circular economy, both in the public and private sector. The striking example of quite a systemic problem in Romania is particularly in sustainable waste management.

A final conclusion of the report is that, on the whole, policy approaches to environmental support in Romania have not been supportive enough and have left gaps in promoting better environmental performance in the private sector, having not engaged properly the public stakeholders at national and regional level.

However, there are islands of eco-innovation at the grass-roots level that have gradually accumulated in Romania. These have the potential to reach critical mass, and possibly have positive spillover effects on further fields of economic activities in time, but they generally need larger-scale investment and support to have a significant impact (Frone S., 2017 b).

Therefore, in the following case-study, we analyse and emphasize the necessity and opportunity for the small and medium size enterprises to group or cluster in some kind of Eco-Innovation Park, taking advantage of all the environmental and economic benefits involved, especially those of an industrial ecosystem aimed for promoting a circular economy.

The eco-innovation designed for an entire area or regional metabolism means a systemic response to the sustainable development and green economic premises. Thus, one of the most important concepts for the new paradigm of green economic growth and resource efficiency improvements is the industrial synergy (industrial ecology, industrial ecosystem) approach.

In this respect, we believe that some steps have been made towards promoting circular and green economy vectors in Romania.

4. Industrial symbiosis premises for promoting the green economy in Romania

The main conclusion of (Frone S., 2015) was based on a regression model showing that in the 16 European countries of the analyzed sample there is a positive correlation between the number of existing eco-innovation parks (EInvP) and the national level of resource productivity (as macroeconomic indicator of the resource-efficiency).

There is presented in this section, a case study of a pilot Romanian EInvP implemented as an Application of Industrial Ecosystems Principles to Regional Development (ECOREG) which may become a real model of circular economy and good practice of waste management in a region, leading to important and diverse environmental, economic and social benefits for all the involved stakeholders in the county.

The objectives of the ECOREG project correspond to the local, regional and national sustainable development requirements, since environmental, economic and social objectives. The environmental objectives were actually the most important (Frone S., 2017 b): a reduction in raw material consumption, energy, utilities, by 2-5 %for all units through implementing innovative tools and instruments; reduction of waste generation and pollutant emissions by 5-20% for all units; the conversion of wastes/by-products into resources (secondary materials); the significant reduction of environmental impact at the level of industrial units.

ECOREG is modelled on the NISP, the world's only national industrial symbiosis programme (UK) which demonstrated that industrial symbiosis has the potential to significantly reduce industrial and commercial waste and comprehensively lessen the adverse environmental impacts of business. The ECOREG project used actual business opportunity as the mechanism for encouraging resource efficiency and its holistic approach is actively dealing with all resources including water, energy, materials, logistics, assets and expertise.

This EInvP is also an example of a sustainable business model. The features of the sustainable business models have to be figured and emphasized in order to better understand the significance and potential of the industrial ecology models, featuring industrial symbiosis.

According to (Ravetz, J. 2003) the sustainable business models present precious features, since able to: reduce primary resource inputs; close material loops; apply an integrated resource management; promote regional self sufficiency and proximity; minimise the environmental impacts.

All the suppliers, producers, regulators, users and consumers of bulk minerals need to be aware of the opportunities for increased eco-efficiency and resource productivity. Business information systems for “integrated materials management” will need to match supply and demand, identify alternatives and spot business opportunities.

In Romania, the ECOREG project was implemented with financial support of the European Union, in the period 1st February 2009 – 1st October 2011, in the Suceava County, Romania. The total project budget was of 880 700 Euro. ECOREG was funded by the European Commission through the LIFE+ programme as part of its package to help businesses to improve resource efficiency and reduce waste .

The most important feature of the ECOREG is *the industrial symbiosis as eco-innovation implemented at a regional scale* (Frone S., 2017 b). It is supported by the numerous industrial synergies (200) identified in the area, out of which 114 actually implemented (nisp-ecoreg.ro).

In the paper is shortly described such an industrial synergy working around SC RITMIC SRL (a SME based in Ilisesti, 18 km E from Suceava), presenting the main features, including the environmental and economic drivers and benefits of the industrial symbiosis by adding value by recycling wooden waste.

We analyse an industrial synergy in the following case study, namely the one identified and implemented between:

- a) SC RITMIC SRL, a SME based in Ilisesti, 18 km E from Suceava, dealing, among others, with collecting wooden waste (sawdust, chops, branches, etc.), conditioning it and selling it as bio-fuel (wooden briquettes) and
- b) SC IASIMOLD SRL, another SME located near the Moldovita Commune, Suceava County, some 100 km W from Suceava, in a beautiful landscape. The company exploits wood and completes the first stages in processing timber, producing large quantities of sawdust and wooden waste, a heavily polluted material with no economic value.
- c) SC DIVIP PRODCOM SRL which is a SME located near the village of Braesti, Suceava County, some 40 km SW from Suceava, in the hills of the Sweet Bucovina Province. The organization exploits wood and completes the first stages in processing timber, producing large quantities of sawdust and wooden waste with no economic value.

The industrial synergy has economic and environmental drivers since, in June 2010 (after Romania's accession into the EU in 2007) the law enforcing agencies have issued fines (equiv. to 70000 Euros), confiscated illegally exploited timber and sawing equipment in the Suceava County. The wooden waste has no economic value, is a heavily polluted material and is available at no cost at many locations, across the county.

SC RITMIC's briquettes are, occasionally, sold to supermarkets. SC Ritmic SRL has its own transportation logistics that collects, transport wooden waste to the processing unit and delivers briquettes to customers. Its processing unit – commissioned with financing from the Romanian Environmental Fund – is a state-of-the-art installation that automatically conveys, screens, dries, separates pebbles and metallic debris, and does the briquetting of the sawdust (ECOREG Project Case Study No 5, 2010).

With these prerequisites, the industrial synergy created works like that: the sawdust and wooden debris produced by SC IASIMOLD SRL and by SC DIVIP PRODCOM SRL are collected by S.C. RITMIC SRL's trucks, transported and directed to the wooden debris processing unit of SC RITMIC SRL in Ilisesti. The sawdust and wooden debris are turned into briquettes and sold at a price of 400 RON/ton (95 Euros/ton) at the facility gate. It is worth noting that the same briquettes are sold in supermarkets at a price of 850 RON/ton (200 Euros/ton).

There are important economic, environmental and social benefits of this double (wood sector) industrial synergy identified and exploited in the ECoreg EInvP of Suceava (Frone S., 2017 a, b):

- i. The economic benefits are significant, since SC RITMIC SRL obtains the raw material it needs to sustain its business at a bargain price; SC IASIMOLD SRL and SC DIVIP PRODCOM SRL get rid of the wooden debris that occupies their production space;
- ii. The environmental benefits of this industrial symbiosis are even more interesting, considering the saved virgin forests in the area, as well as the biomass energy potential and the avoided CO₂ emissions (Table no.2):

**Table no.2 Estimated environmental benefits of the industrial synergy
SC IASIMOLD SRL - S.C. RITMIC SRL- SC DIVIP PRODCOM SRL**

Characteristics	Value	U.M.
Volume of biomass involved in synergy	1980	m ³
Virgin forest resources saved	2.27	ha
Methane gas saved by the biomass produced	185625	m ³
Total harmful CO ₂ emissions avoided	133.32	tons
Persistent Organic Pollutants (POPs) emissions avoided	522.72	micrograms

Source: Own selection and computation from (ECOREG Project Case Study No 5, 2010) and (ECOREG Project Case Study No 7, 2010)

- iii. The social benefits are also notable since the synergy keeps the actual jobs in all the three economic organizations and contributes to their social role. For customers, the synergy adds important quantities of renewable biomass fuel to the market, at a convenient price, saving households money.
- iv. Last but not least, the sustainability of this industrial synergy is high, since as the price of oil and gas will increase, biomass becomes the alternative at hand.

Moreover, forest management in Romania does not fully comply with international and EU rules for sustainability, since large quantities of wood are cut illegally, jeopardizing the virgin forest natural heritage of Romania (Platon V., Frone S., and Constantinescu A., 2016).

In the coming years, the cost of raw wood could raise, once sustainable forest management policies are implemented, adding also to the costs of processing wood.

- v. An important feature for our research is the replication potential of this industrial ecosystem synergy between these SMEs in the Suceava county, also in other regions of Romania. The project description mentions in (ECOREG Project Case Study No 5, 2010) that: “the synergy is a good and straightforward solution for improving the energy of small communities and limited geographic areas. It may be replicated in small communities across 28% area of Romania covered by forests.”

The double synergy presented and analysed above, between S.C. RITMIC SRL and the SC IASIMOLD SRL, as well as between S.C. RITMIC SRL and SC DIVIP PRODCOM SRL is only one example of the many wood sector industrial synergies working in the ECOREG project.

Therefore, ECOREG may be considered an actual eco-innovation park, since it is a spatial, regional application of eco-innovation with rich environmental, economic and social benefits for all the companies and organisations involved, as well as for the people and natural environment in that area of Suceava County.

Important for the current research is the key feature of the eco-innovation park in which material flow exchanges (or industrial symbioses) significantly increase the efficiency of energy, waste and water management, so leading to an almost exponential growth in the local resource-efficiency, for all the clustered companies.

5. Conclusions

After having previously claimed that eco-innovation and eco-innovation parks are the vectors of transition to a green economy and their importance, in this paper there are analysed and highlighted some of the objectives, features and principles of the circular economy as they are implemented through industrial synergies in these very eco-innovation parks.

For the circular economy and ultimately, for the green economy, eco-innovation is based on centralizing knowledge on material and energy flows as an efficient tool to foster a transition from a linear industrial system to a closed-loop system mimicking biological ecosystems.

The industrial symbiosis is conceptually and practically a new way to look at economic activity, so that the costly environmental preoccupations are converted into opportunities for profit and benefits (not necessarily materials).

This is achieved by setting up symbiotic partnerships between companies from various industries, through which wastes/by-products resulted from the activity of one unit become resources for another activity, thus reducing raw material consumption, the amount of waste generated and the associated impact on the environment. A new economic entity, namely the eco-innovation park (EInvP) is therefore created in a county or a region, with increased efficiency in using energy and materials.

After Romania's accession to the European Union and with the Cohesion funding support, the adoption of the environmental acquis and of the know-how and good practice of the EU member states, as well as of the Strategy 2020 has enabled the implementation of ECOREG, a pilot project of industrial symbiosis in the Suceava County.

The regional eco-innovation park of industrial symbiosis analyzed (ECOREG Project) was promoted by highlighting the potential economic benefits of joining the programme in order to boost the interest of industry. This approach was required in Suceava since the limited availability of economic operators participating in environmental projects, which most of them perceived as time demanding and costly.

The conclusions of the paper reinforce the strategic development of eco-innovation parks in Romania, as industrial ecosystems for the manufacturing and service enterprises or the local authorities seeking enhanced environmental and economic performance through closer collaboration in managing environmental and resource issues.

The official European web-site for the project description has concluded that ECOREG project „demonstrated major environmental benefits, as a result of developing a sustainable approach to waste and resource management. ECOREG recycled 530 000 t of waste, which would otherwise have gone to landfill, using less than €500 000 (€0.88/t)”.

This regional eco-innovation park will help Romania to recycle more of its waste, in line with EU policy. Still a pro-active policy, a coordinated approach and smart public management are strongly required to sustainably develop circular economy in Romania and reap its significant advantages (including preservation of the virgin forests).

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