Tools for Resource Efficiency and GHG Mitigation: Industrial Symbiosis and Resources Audit

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Resource efficiency and the low-carbon society

Priority objective 2 of the 7th Environment Action Programme (EU, 2013) identifies the need to ‘turn the Union into a resource-efficient, green, and competitive low-carbon economy’.

Resource efficiency and the low-carbon society have emerged as central themes in global discussions on the transition to a green economy (OECD, 2014; UNEP, 2014b).
More circularity - Transition to a sustainable society Council conclusions.

Brussels, 4 October 2019

European Council invites the Commission to present, by the beginning of 2020 at the latest, an ambitious and targeted proposal for the 8th Environmental Action Program (EAP).

In its conclusions, the Council emphasizes that further ambitious efforts are needed to stimulate a systemic transition towards a sustainable society. The circular economy is an important driving force for reducing greenhouse gas emissions, respecting the limits of our planet and achieving the United Nations sustainable development goals.

The conclusions are based on the new EU strategic agenda adopted by the European Council on 20 June 2019, which insists on the urgent need to build a green, fair, social and climate-neutral Europe.
“Today’s efforts to combat climate change have focused mainly on the critical role of renewable energy and energy-efficiency measures. However, meeting climate targets will also require tackling the remaining 45% of emissions associated with making products. A circular economy offers a systemic and cost effective approach to tackling this challenge.”

Circular Economy and GHG Emission

Global GHG emissions 2010
Billion tonnes of CO₂e per year

45% of global GHG emissions can be attributed to the production of materials, products, and food, as well as the management of land.

- Industry (material production): 17.2
- Energy systems: 10.2
- AFOLU (Agriculture, Forestry, and Other Land Use): 11.9
- Energy for transportation: 6.7
- Energy for buildings: 3
- Other (non-energy): 0.4

Note: 'Industry' and 'AFOLU' include their own energy-related emissions but not indirect emissions from electricity and heat production.

Source: IPCC, "IPCC’s Fifth Assessment Report (AR5)" and Material Economics analysis.
Resources Audit is based firstly on the analysis of input-output resources used and produced by a company and then on the investigation of possible options to optimize them, by having sensitive emission reductions.

Industrial symbiosis is a form of brokering to bring companies together in innovative collaborations, finding ways to use resources from one as raw materials for another. By preserving the energy originally used for those materials.

Source of Images: Completing The Picture How The Circular Economy Tackles Climate Change Ellen Macarthur Foundation (2019)
Circular economy represents a radical paradigm shift from the linear economy model and also supports the development of new sustainable business models, with the final aim to increase both the potential for closed-loop productive systems and the resource efficiency in a territory. Implementation tools could be:

- The audit of resources is focused on the inventory and optimisation of input and output resources used and/or produced.

- Industrial symbiosis engages traditionally separate industries in a collective approach to competitive advantage involving physical exchange of materials, energy, water and by-products (Chertow, 2000)
The essence of IS as a tool for innovative green growth: IS engages diverse organizations in a network to foster eco-innovation and long-term culture change.¹

Local or wider co-operation in industrial symbiosis can reduce the need for virgin raw material and waste disposal, thereby closing the material loop – a fundamental feature of the circular economy and it can also reduce emissions and energy use and create new revenue streams².

Industrial Symbiosis and resource efficiency tools

Pilot for the Efficiency of Resources in Umbria "PROPER Umbria“ Project developed by Enea and Sviluppumbria Regional Agency for Umbria's competitiveness and economic growth

Two tools developed by Enea to make more efficient productive processes:

- Resource Audit as an internal evaluation to make more efficient the production process
- industrial symbiosis as an external choice for valorize waste, by-product, residues;

- PROPER Umbria Project provides to exploit interesting synergies among climate change and resource management policies

- "PROPER Umbria” Project offers an opportunity to carry out a preliminary evaluation of Resource management in terms of Emission reduction
The resources audit has been developed on the basis of an analogy with the energy audit, a well-known methodology which is mandatory in Italy and which, has pushed Italian companies to become more and more energy-efficient.

The main aim of the audit is to save company’s resources by means of their optimisation and savings at internal and external level.
Industrial Symbiosis and resource efficiency tools

The resources audit is focused on the inventory, understanding and optimisation of input and output resources used and/or produced by a single entity, such as a company or a part of it.

### Resources

<table>
<thead>
<tr>
<th>Material type</th>
<th>Source (ext./int.)</th>
<th>Resources (commercial name)</th>
<th>Quantity (t)</th>
<th>Quantity (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Non-renewable materials</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Recycled materials</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL input materials used (t. m³)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL recycled input materials used (t. m³)</strong></td>
<td></td>
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</tr>
</tbody>
</table>

*all forms of materials and components that are part of the final product*

### Energy and material Flows counted by Resource Audit methodology

![ENEIA Logo]
Industrial Symbiosis and resource efficiency tools

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<table>
<thead>
<tr>
<th>Aspects</th>
<th>Materials</th>
<th>Energy</th>
<th>Water</th>
<th>Emissions</th>
<th>Effluents and Waste</th>
<th>Products and services</th>
<th>Transport</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organisation profile</td>
<td>Name</td>
<td>Energy consumption outside of the organisation</td>
<td></td>
<td>Total water withdrawal by source</td>
<td>Direct-greenhouse gas (GHG) emissions</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Primary brands, products, services</td>
<td>Energy consumption within the organisation</td>
<td></td>
<td>Water sources significantly affected by withdrawal of water</td>
<td>Energy indirect GHG emissions</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Location</td>
<td>Energy intensity</td>
<td></td>
<td>Percentage and total volume of water recycled and reused</td>
<td>GHG emissions intensity</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Headquarters</td>
<td>Reduction of energy consumption</td>
<td></td>
<td></td>
<td>Reduction of GHG emissions</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Number and names of countries where it operates or has significant operations</td>
<td>Reductions in energy requirements of products and services</td>
<td></td>
<td></td>
<td>Emissions of ozone depleting substances (ODS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Scale (employees, operations)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Markets served</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Supply chain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quantity of products or services provided</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Main indicators counted by the resource audit methodology
Industrial Symbiosis and resource efficiency tools

In the methodology, the environmental impacts and the potential advantages related to more efficient resource use and resource management is estimated by means of life-cycle based methods and tools, such as ISO LCA method (ISO 2006), based on Life Cycle Thinking (LCT) approach, which can identify the main environmental burdens of the current resource use at company level and the possible benefits obtained by the implementation of industrial symbiosis paths.

The holistic approach of LCA method can efficiently support the evaluation of the environmental performance of symbiotic systems because it includes the whole supply chain.

An accurate diagnosis of the resources that go through the production cycle useful for a monitoring plan at company level.
Industrial Symbiosis and resource efficiency case study

CASE STUDY: The production process for making the coal rings

Multinational Company from mechanical sector
Mechanical seals for Standard Duty

Industrial waste processed: industrial sludge mixed industrial dust
### INDUSTRIAL SLUDGE

- Valorization in an anaerobic digestion plant for the production of biogas
- Valorization in cement plants for energy production
- Valorization as a filler for bituminous conglomerates
- Valorization for the production of cements, bricks and bricks

### INDUSTRIAL POWDERS

- Reuse as material recovery upstream of the production process
- Valorization as secondary solid fuel in cement plants
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Industrial Symbiosis and resource efficiency case study

Specific Hoods to Capture

1. a) coal
2. b) graphite
3. c) resin

Opening bag → Mix raw material → Granulation → Printing → Oven stabilization → Lapping → Washing → Selection → Rings

Coal powder, phenolic resin, Natural graphite

Electricity

Methan

Coal powder → water

Mixed Powders

Internal depurator → internal depurator

Discarded rings

Water

Waste water

Internal depurator

Scrubber

Waste water

Internal depurator
Some economic assessments

Quantity and costs for raw materials, 2018

<table>
<thead>
<tr>
<th>Raw material</th>
<th>Quantity (t/a)</th>
<th>%</th>
<th>Unit cost (€/t)</th>
<th>Annual cost (€/a)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>45</td>
<td>61%</td>
<td>3.500</td>
<td>157.500</td>
<td>61%</td>
</tr>
<tr>
<td>Graphite</td>
<td>9</td>
<td>12%</td>
<td>4.500</td>
<td>40.500</td>
<td>16%</td>
</tr>
<tr>
<td>Resin</td>
<td>20</td>
<td>27%</td>
<td>3.000</td>
<td>60.000</td>
<td>23%</td>
</tr>
<tr>
<td>Total</td>
<td>74</td>
<td>100%</td>
<td>3.000</td>
<td>258.000</td>
<td>100%</td>
</tr>
</tbody>
</table>

Potential saving from internal reuse of powders

<table>
<thead>
<tr>
<th>Powders</th>
<th>Raw material supply saving (€/t)</th>
<th>Disposal saving (€/t)</th>
<th>Total savings (€/t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>3.500</td>
<td>526</td>
<td>4.026</td>
</tr>
<tr>
<td>Graphite</td>
<td>4.500</td>
<td>526</td>
<td>5.026</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>9.052</td>
</tr>
</tbody>
</table>
Industrial Symbiosis and resource efficiency case study

Valorization of mixed powders as secondary solid fuel in cement plants

- To verify technical feasibility (standards, specifications, etc.)
- To comply with the laws (administrative obligations, definition of “solid secondary fuel” ...) 
- To involve local institutions (stakeholders, local entities, associations of category)
- To find potentially interested companies (authorized cement plant)

Valorization scenario aims to avoid disposal of industrial dust for a comparative advantage
The objective of the study is the comparison of the environmental impacts deriving from the landfill treatment of mixed powders produced by Company (scenario 1) and those deriving from the use of mixed powders as fuel in a cement plant for heat production (scenario 2).
The use of mixed powders as a fuel leads to a reduction in environmental impacts ranging from 22% for the category of impact Acidification, to 33% for the category Climate change and to 86% for the category Exhaustion of Mineral and Fossil Resources.
Industrial Symbiosis and resource efficiency case study
Network and Tools for circular economy

- Water Supply and Sanitation Technology Platform
- EIT Climate-KIC
- PRIMA
- ECERA: The European Circular Economy Research Alliance
- European Circular Economy Stakeholder Platform
- EFFRA
- EREK
- SPRE
- EIP on Raw Materials
- RawMaterials
- EURISA
- ENEA
Thank you for attention!
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