Waste to Resource value chain optimisation by applying the Life Cycle Thinking approach to the regional management system of construction and demolition waste (CDW)

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Context

Construction and demolition waste (CDW)

- 30-35% of the total waste yearly generated in Europe
- 70% recycling target set by the directive 98/2008/EC
- recent programs/initiatives aiming at fostering the transition towards circular economy (e.g. Communication “Resource efficiency opportunities in the building sector” (2014), Circular Economy Action Plan (2015))

The government of Regione Lombardia chose the Life Cycle Thinking approach to assess and optimize its own CDW management system.
Description of the project

Environmental sustainability of the CDW management system in Lombardy by applying the Life Cycle Assessment (LCA) methodology

*Research project (Apr 2016 – Sept 2017) in collaboration with:

Sara Pantini, Eng. Ph.D.
Lucia Rigamonti, Eng. Ph.D.

Economic sustainability of the CDW management system in Lombardy by applying the Life Cycle Costing (LCC) methodology

*Part of a Ph.D. project (Nov 2019 – Ongoing) in collaboration with:

Federica Carollo, Eng.
Lucia Rigamonti, Eng. Ph.D.

Francesca Ceruti, Ph.D.
Methodology framework and scope

The environmental (LCA) and economic (LCC) analyses encompass all the processes from the waste entering the regional management system until it leaves the system as a “secondary resource” or final emission to environment (disposal).

**OBJECTIVES**

- To highlight both good aspects and critical issues along the entire value chain
- To identify possible improvements, based on environmental and economic considerations
- To give recommendations to the regional government to maximize its resource-efficiency
Methodology: LCA

1. Goal and scope definition

Year of reference: 2014
Type of waste analyzed: non-hazardous CDW, excluded categories 1705 and 1706
System boundaries: regional plant system, import / export excluded

2. Inventory analysis

Quantification of waste flows: official MUD (i.e. yearly waste declaration) database

Material/energy consumption and emissions associated with the CDW recycling: primary data collected through technical visits at major CDW plants and questionnaires

Quality and actual end-uses of recycled aggregates: primary plant data + questionnaires + interviews with some construction companies

3. Impact assessment

Software: SimaPro, ecoinvent database

Impact assessment method: ILCD 2011
Methodology: LCC

The LCC investigates the costs (in euros) of the whole CDW recycling chain and evaluates the most effective solutions from an economic perspective.

### Data collection: Survey

<table>
<thead>
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<th>Demolition companies</th>
<th>CDW recycling plants</th>
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<td><strong>Year of reference:</strong> 2019</td>
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- The survey requests data about **preliminary costs** (e.g. preparation of the demolition site), **machinery acquisition costs**, **management costs** (labor costs, diesel and water consumption costs, etc.), and **transportation** and **delivery costs/profits**.

- The result of the survey is the sum of the total cost of demolition including the end-of-life of the output flows, thus getting the total cost per m³ demolished.

- The survey requests data about **preliminary costs** (e.g. land purchase), **machinery acquisition costs**, **management costs** (labor costs, diesel and water consumption costs etc.), and **transportation** and **delivery costs/profits** (both input and output flows).

- The survey aims to separate the costs from the profit of the plant to verify the consistency with the gate fees declared by the demolition companies.
Issues addressed

Life Cycle Assessment (LCA)

- 13 environmental impact categories
  - Climate change
  - Ozone depletion
  - Human toxicity
  - Acidification
  - Cancer and non cancer effects
  - Particulate matter
  - Photochemical ozone formation
  - Terrestrial eutrophication
  - Freshwater eutrophication
  - Marine eutrophication
  - Freshwater ecotoxicity
  - Water resource depletion
  - Mineral and fossil resource depletion

- Energetic indicator (i.e. Cumulative Energy Demand)

- “Ad-hoc built” indicator (for natural resource consumption/saving)

Life Cycle Costing (LCC)

- Costs
  - Preliminary costs
  - Machinery acquisition costs
  - Management costs
  - Transportation and delivery costs/profits
Evidence of success

The LCA allowed to identify **hotspots** of the CDW value chain in Lombardy Region:

- Deficiencies in the treatment of some specific waste streams (e.g. gypsum-based waste)
- Unstable market of recycled aggregates (on average, 70% RAs sold)
- Poor competitiveness of RAs due to large availability and low prices of natural aggregates
- Low-grade applications of RAs due to quality issues (presence of unwanted materials as soil or gypsum)
- Absence of EoW criteria, low-knowledge and diffidence on RAs technical properties among the main reasons preventing widespread RAs uses

How to improve the sustainability of the system

How to measure its effectiveness
Evidence of success

Quantification of the environmental benefits potentially achievable with the proposed solutions by comparing current vs future scenarios

**Climate Change**

**Ozone Depletion**

**Human Toxicity, no canc.**

**Acidification**

**Energetic Indicator - CED**

**Sand & Gravel consumption**

Recommendations/ Suggestions provided to the Regional Government

Total CDW managed in Lombardy in 2014: 7.38 Mt (EER 1701,170302,170802,170904)
Evidence of success

High-priority objectives and suggested actions:

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<th>TO FOSTER THE MARKET OF RECYCLED AGGREGATES - RAs</th>
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| Effective implementation of existing regulatory tools aimed at favouring the use of RAs | • Make the DM 203/2003 and CAM for construction fully operational  
• Introduce incentives on construction works that use RAs |
| A more sustainable planning of the mining activities of natural resources (NA) | • Increase taxes on mineral extraction  
• Authorisation of excavated volumes should take into consideration for the local availability of recycled aggregates |
| Avoid unfair competition between RAs and NA | Update the sector’s technical instruments to the European standards (e.g. Call for Tenders, price lists of construction works) |

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<th>TO PROMOTE THE PRODUCTION OF HIGH-QUALITY RAs</th>
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| Widespread application of selective demolition, so that highly homogeneous CDW streams are generated | • On—site multi-streams waste separation should be awarded  
• Creation of new chains/ Enforcement of existing chains for those materials currently mixed in CDW e.g. gypsum |
| Upgrading existing CDW recycling plants | • Favour the operation of recycling plants powered with electricity (in the authorisation process)  
• And, more advanced technology for separation of light-impurities  
• Avoid the mixing of different waste streams in the CDW plants (e.g. reclaimed asphalt, gypsum) |

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<th>TO OPTIMIZE THE WASTE MANAGEMENT SYSTEM</th>
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| Minimization of waste transportation and limitation of intermediate waste management steps | • Platforms facilitating the match between RAs demand and supply  
• Definition of location criteria for new CDW plants taking into account for local «deficiency of treatment» |
Potential for learning

Implementation of concrete actions for optimizing CDW management by involving multiple stakeholders

- Definition of a procedure for MUD database processing
- Identification of critical waste streams, e.g. gypsum waste

CURRENT CDW MANAGEMENT SYSTEM

A PERFORMANCE ASSESSMENT FRAMEWORK (LCA + LCC) FOR THE SUSTAINABILITY OF THE CDW SYSTEM

- Measuring the effectiveness of the identified actions
  Regione Lombardia has recently established two incentives aiming at promoting selective demolition and RAs utilization to boost RAs local markets

MAKING AVAILABLE DISAGGREGATED DATA ON CDW

- Identification of current bottlenecks and adopting appropriate solutions
  e.g. Regione Lombardia, in collaboration with ANCE, promoted training courses for institutions and operators → knowledge dissemination about the technical properties and applications of RAs

EXPLORING THE CURRENT STATE OF THE CDW VALUE CHAIN

IDENTIFYING HOTSPOTS IN THE REGIONAL CDW SYSTEM

FUTURE SUSTAINABLE CDW MANAGEMENT SYSTEM

- Definition of actions with highest priority
  e.g. Regione Lombardia, in collaboration with ARPA, re-structured its informative waste system O.R.So. to allow declaration on the type and amount of RAs annually produced → facilitate the match between RAs supply and demand
Potential for transfer

The Good Practice implementing the combined *Life Cycle Assessment* and *Life Cycle Costing* approach:

- can be extended to other regional contexts
- can be used to evaluate other waste management systems e.g. steel slags or bottom ash from municipal waste incineration
- provides guidance for other regional governments interested in improving the sustainability of their own waste management system
- assists policy makers in monitoring and refining waste management plans in relation to sustainability goals
- improves regional competitiveness in successful economic and policy development
Challenges

- Processing official MUD database (ARPA) requires a complex procedure to extract disaggregated data at waste code level, with long processing time (punctual mass balances were applied to find out data discrepancies) (e.g. 7 waste codes, >300 plants in Lombardy → 2-3 months)

- Data collection is a challenging step, but fundamental for generating an accurate inventory (collecting data about the amount, types and sold volumes of recycled aggregates can be difficult and time-consuming; economic data are rarely provided, due to confidentiality)

- The proposed combined approach LCA + LCC requires time, resources (to obtain data and information) as well as expert knowledge on the life cycle methodologies (for a fair modelling)
Publications


Thank you!

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