Life cycle assessment of a ceramic tiles manufacturing: strategies for circular economy

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2. Project Overview

LIFE: Force of the Future (Forture)
New circular business concepts for the predictive and dynamic environmental and social design of the economic activities

Coordinating Beneficiary: GRESMALT
Associated Beneficiaries:
Consultants Partners:

With the contribution of the LIFE financial instrument of the European Community.
Project Duration: October 2017 – September 2020
3. Life Project

OBJECTIVES

To integrate the three pillars of sustainability (environment, economy and society) into the company business model.

To transform impact assessment from static actions carried out on final results (looking back) into an analysis performed moment by moment (looking ahead) in a dynamic way.

To add the parameters of sustainability to the company quality system in order to manufacture products with lower environmental, social and economic impacts.

To validate the model through the design and production of a new collection of ceramic tiles with a high level of sustainability.

To transfer the results of technological innovation to the European ceramic industry and more generally to the building industry.
4. The Italian ceramic district

- About 80% of Italian production of ceramic tiles
  (Indagini Statistiche sull’Industria Italiana, 2016)

Non-renewable resources

Emissions (local)

Waste (1077265 ton for 729000 ton of ceramic products)

EMAS Case Studies – Tiles industry district of Modena and Reggio Emilia, Italy

EPD Italian Ceramic Tiles - ECO EPD Ref. No. ECO-00000444
5. The Life Cycle Sustainability Assessment

\[ \text{LCSA} = \text{LCA} + \text{LCC} + \text{S-LCA} \]

**ENVIRONMENTAL DIMENSION**: Life Cycle Assessment (LCA)

**ECONOMIC DIMENSION**: Life Cycle Costing (LCC)

**SOCIAL DIMENSION**: Social Life Cycle Assessment (S-LCA)

ISO 14040-14044  ISO 15686  Guidelines

Glazed porcelain stoneware tiles

Ceramic district (2015)
6. LCA - Goal and scope definition

→ **Goal and scope:** assessment of the environmental impact related to the life cycle of glazed porcelain stoneware tiles in the district of Sassuolo, in 2015.

→ **System function:** covering of floors and walls.

→ **Analised system:** the production of glazed porcelain stoneware tiles in the district of Sassuolo, in 2015.

→ **Functional unit:** total amount of glazed porcelain stoneware tiles in the district of Sassuolo, in 2015.

→ **System boundaries:** the system boundaries cover the entire life cycle of the tiles, starting from the extraction of raw materials for the slurry up to the end-of-life processes.
7. LCA - Inventory

- DATA QUALITY: primary, from literature, from database (Ecoinvent)
- CALCULATION CODE: SimaPro 8.3
- METHOD: IMPACT 2002+ modified
- EMISSIONS: approximate calculation method for local and indoor emissions
8. LCA - Impact Assessment of glazed porcelain stoneware tiles

Total damage: 545kPt

<table>
<thead>
<tr>
<th>DAMAGE CATEGORY</th>
<th>%</th>
<th>SUBSTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human health</td>
<td>33.23</td>
<td>Particulates &lt;2.5μm</td>
</tr>
<tr>
<td>Ecosystem quality</td>
<td>8.06</td>
<td>Zinc</td>
</tr>
<tr>
<td>Climate change</td>
<td>23.16</td>
<td>Carbon dioxide, fossil</td>
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<tr>
<td>Resources</td>
<td>18.60</td>
<td>Oil, crude</td>
</tr>
<tr>
<td>Human health, indoor</td>
<td>3.52</td>
<td>Hydrocarbons, aromatic, indoor</td>
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<tr>
<td>Human health, local</td>
<td>16.95</td>
<td>Hydrocarbons, aromatic, local</td>
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</tbody>
</table>

PROJECT LIFE16 ENV/IT/000307 - LIFE: Force of the Future
fortune-life.eu
9. LCA - Impact Assessment of the manufacturing process

Total damage: 195kPt

- 72.18% Emissions
- 65.8% Local emissions

Bar chart showing the distribution of impacts across different categories.
CONCLUSIONS

- The process responsible for the main environmental impacts is the manufacturing of the tiles, followed by the distribution to the customer.
- Within the manufacturing process, the main impacts are caused by the emissions, mainly during the atomization and firing phases.
- The Human Health, local category linked to local emissions, is responsible for 16.95% of the total damage.

IMPROVEMENTS

- EMISSIONS: closely related to the standardised production processes
- DISTRIBUTION: promotion of a more sustainable transportation (railway)
- ENERGY: co-generation plants
11. Life Cycle Costing

The LCC methodology allows to evaluate the **internal costs along the entire life cycle** of a product, from the manufacturing to the disposal phase; in addition, the costs of the environmental impacts associated with it (**externalities**), can be assessed.
12. Life Cycle Costing

INTERNAL COSTS - REVENUE

13. Assessment of the external costs

METHOD: EPS 2015
- monetarisation of the environmental impacts
- willingness to pay to restore impacts
- ELU (Environmental Load Unit) = €

14. Social Life Cycle Assessment

Goal and scope

Life cycle inventory

Life cycle impact

Interpretation

<table>
<thead>
<tr>
<th>STAKEHOLDER CATEGORIES</th>
<th>STAKEHOLDER SUBCATEGORIES</th>
<th>STAKEHOLDER DETAILS</th>
<th>SPECIFIC STAKEHOLDERS</th>
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<tbody>
<tr>
<td>1. Human Resources</td>
<td>1.1 Staff Personnel</td>
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<td>1.1.1 Blue-collar Workers</td>
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<td>Gresmalt’s Workmen</td>
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<td>1.1.2 Employees</td>
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<td>Gresmalt’s Employees</td>
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<td>1.1.3 Managers</td>
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<td>Unimore’s Researchers</td>
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<td>1.1.4 Top Management</td>
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<td>Unimore’s Professors</td>
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<td>Urjc’s Professors</td>
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<td>Urjc’s Researchers</td>
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<td>1.2 Trade Unions</td>
<td>1.2.1 Confederate Trade Unions</td>
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<td>Italian General Confederation of Labour (CGIL)</td>
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<td>Italian Confederation of Workers’ Trade Unions (CGIL)</td>
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<td>Italian Labour Union (UIL)</td>
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<td>Spanish Trade Union Confederation of Workers’ Commissions (CCOO)</td>
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<td>1.2.2 Independent Trade Unions</td>
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<td>Italian Confederation of the Base Committees (COBAS)</td>
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<td>2. Local Community</td>
<td>2.1 Local Public Institutions</td>
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<td>Autonomous Community and Province of Madrid (Spain)</td>
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<td>2.1.2 Provincial Governments</td>
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<td>2.1.3 Municipalities</td>
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<td>Municipality of Sassuolo (Modena - Italy)</td>
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<td>Municipality of Nules (Castellón - Spain)</td>
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|                        |                          |                     | Municipality of Villafamés (Castellón - Spain) Villafamé

16. S-LCA - Stakeholders identification and mapping

3.1 Private Business

3.1.1 Company's Shareholders
- Gresmalt’s Shareholders

3.1.2 Association of Manufacturing and Service Companies
- AIAC (Italian Association of Ceramic Glaze, Inorganic Pigments and Metal Oxides)
- ANM (Italian Association of Mines and Mining Industry Associations)
- AIF (Italian Federation of the Ceramics Industry)
- FIMAC (National Italian Federation of Clay, Ceramic and Building Material Industries)
- ANFADE (National Association of the Italian Market for Building Materials and Sanitary Ware)
- ACIMAC (Association of Italian Manufacturers of Machinery and Equipment for the Ceramic Industry)
- ASSOCER (Spanish Association of Ceramic Industry)
- ANFFECC (National Spanish Association of Ceramic Frits, Glazes and Pigments)

3.1.3 Chambers of Commerce
- Modena Chamber of Commerce (Italy)
- Reggio Emilia Chamber of Commerce (Italy)
- Treviso Chamber of Commerce (Italy)
- Castellón Chamber of Commerce (Spain)
- Madrid Chamber of Commerce (Spain)

3.2 Public and Private Organization

3.2.1 Regulatory Authorities
- Arpae (Regional Agency for Prevention, Environment and Energy of Emilia-Romagna, Italy)
- Spanish Environment Authorities
- Ministry of the Environment and Protection of Land and Sea (MATTM, Italy)
- Ministry of Environment and Rural and Marine Affairs (MAPAMA, Spain)

3.2.2 Research Community
- University of Modena and Reggio Emilia (Unimore, Italy)
- University of Bologna (Unibo, Italy)
- Jaume I University (UJI, Spain)
- University of Bologna (Unibo, Italy)
- Institute for Ceramic Technology (ITC, Castellón, Spain)
- Institute of Ceramics and Glass (ICV, CSIC, Madrid, Spain)
- Institute of Science and Technology for Ceramics (ISTEC, CNR, Faenza, Italy)
- Ceramic Center Bologna (CCB, Italy)
- European Ceramic Society (ECerS, Mons, Belgium)
- Italian Ceramic Society (I.Cer.S., Bologna, Italy)
- Spanish Society of Ceramics and Glass (SECV, Madrid, Spain)
- Society of Environmental Toxicology and Chemistry (SETAC, Brussels, Belgium)

3.2.3 National and International Public Institutions
- Directorate General for Environment (European Commission, Brussels, Belgium)
- Ministry of the Environment (Ministerio del Medio Ambiente, Medio Rural y Marino, España)
- Ministry of Environment and Rural and Marine Affairs (MINAM, Spain)

3.2.4 Civil Society Organizations
- WWF (World Wide Fund for Nature, Switzerland)
- Friends of the Earth (Amsterdam, Netherlands)
- Italia Nostra (Rome, Italy)
- Legambiente (Rome, Italy)
- Fondo Ambiente Italiano (FAI, Rome, Italy)
- Ecologistas en Acción (Madrid, Spain)

3.3 Environment

3.3.1 Natural Environment
- Natural Environment

3.3.2 Future Generations
- Future Generations

3.4 Media

3.4.1 Newspapers
- Il Resto del Carlino (Modena, Italy)
- Gazzetta di Modena (Modena, Italy)
- El Periódico Mediterráneo (Castellón, Spain)

3.4.2 Professional Magazines
- Cer Magazine (Sassuolo, Italy)
- Ceramic World Review (Modena, Italy)
- Técnica Cerámica (Barcelona, Spain)
- Boletín de la Sociedad Española de Cerámica y Vidrio (Madrid, Spain)

3.4.3 TV and Radio
- Rai - Radio Televisione Italiana - Regional Centre of Emilia Romagna (Bologna, Italy)
- Tele Radio Città (Modena, Italy)
- Telemadrid (Madrid, Spain)
- Radio Bruno (Carpi, Italy)

3.4.4 Internet
- Ceramic World Web (Modena, Italy)
- Ceramica.info (Sassuolo, Italy)
- Tile of Spain (Castellón, Spain)
## 4. Consumers

### 4.1 Trade Channel Operators

<table>
<thead>
<tr>
<th>Category</th>
<th>Stakeholders</th>
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</thead>
<tbody>
<tr>
<td><strong>4.1.1 Resellers</strong></td>
<td>Gresmalt's Italian Resellers</td>
</tr>
<tr>
<td><strong>4.1.2 Trading Partners</strong></td>
<td>Gresmalt's Italian Agents</td>
</tr>
<tr>
<td><strong>4.1.3 Business Customers</strong></td>
<td>Large Scale Retail Organisations</td>
</tr>
</tbody>
</table>

### 4.2 Final Consumer

<table>
<thead>
<tr>
<th>Category</th>
<th>Stakeholders</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4.2.1 Private Customers</strong></td>
<td>Household Customers</td>
</tr>
<tr>
<td><strong>4.2.2 Consumers Associations</strong></td>
<td>European Consumer Organisation (Brussels - Belgium)</td>
</tr>
</tbody>
</table>

## 5. Value Chain Actors

### 5.1 Suppliers

<table>
<thead>
<tr>
<th>Category</th>
<th>Stakeholders</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>5.1.1 Large-Scale Suppliers</strong></td>
<td>Manufacturers of Ceramic Machinery and Equipment</td>
</tr>
<tr>
<td><strong>5.1.2 Small-Scale Suppliers</strong></td>
<td>Producers of Ceramic Glazes, Inorganic Pigments and Inks</td>
</tr>
<tr>
<td><strong>5.2 Partners</strong></td>
<td>Process Consultants</td>
</tr>
<tr>
<td><strong>5.3 Competitors</strong></td>
<td>Oders Ceramic Tile Manufacturers</td>
</tr>
</tbody>
</table>

### 5.2 Partners and Professionals

<table>
<thead>
<tr>
<th>Stakeholders</th>
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<tbody>
<tr>
<td>Practitioners and Professionals</td>
</tr>
<tr>
<td>Process Consultants</td>
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<td>Project Consultants</td>
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### 5.3 Competitors

<table>
<thead>
<tr>
<th>Stakeholders</th>
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<tbody>
<tr>
<td>Direct Competitors</td>
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<tr>
<td>Indirect Competitors</td>
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<tr>
<td>Consumers Associations</td>
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</tbody>
</table>
18. The dynamic assessment - The spreadsheet

- Tool that allows to calculate the damage associated with a process, with the variation of appropriately chosen **variables**, **without** resorting to the **calculation code**.

1. Impact assessment of the original process using the calculation code
2. Selection of appropriate variables
3. Rewriting of the entire process in the spreadsheet, with the identification of the variables
4. Elaboration of the formula that dynamically calculates the damage as the variables vary

\[ \text{Damage}_{\text{tot, var}} = \sum_i \frac{\text{Damages}_{i, \text{input}}}{\text{Data}_{i, \text{input}}} \cdot \text{Data}_{i, \text{var}} \]
19. LCSA implementation

LCSA = LCA + LCC + S-LCA
20. Conclusions

- LCSA is a methodological framework that provides quantitative information for a global assessment of the sustainability of a system.

- LCSA could be used together with circular economy indicators in order to obtain a comprehensive overview of a system and make effective sustainable choices.

- With the spreadsheet, continuous monitoring and evaluation of the environmental performances are carried out, especially when some parameters of the system are changed.

- The integration of the LCSA with the Enterprise Resource Planning (ERP) could add sustainability issues to the company business model and concretely guide it through more responsible choices.

- The focus on the local context could be an opportunity for a more sustainable development of the ceramic district from an environmental, economic and social perspective.
Thank you for your attention.
Any questions?

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