



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

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UNIVERSITÀ DEGLI STUDI DI
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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:



Associated Beneficiaries:



Consultants Partners:







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

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



-  **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*

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

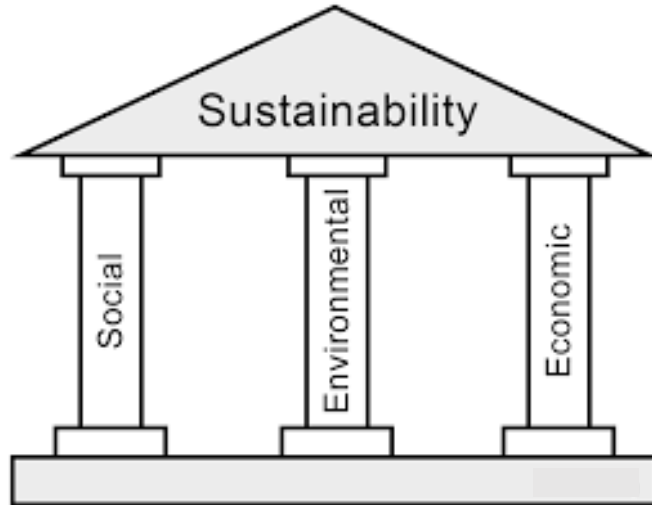
5. The Life Cycle Sustainability Assessment

$$\text{LCSA} = \text{LCA} + \text{LCC} + \text{S-LCA}$$

ISO 14040-14044

ISO 15686

Guidelines



ENVIRONMENTAL DIMENSION: Life Cycle Assessment (LCA)

ECONOMIC DIMENSION: Life Cycle Costing (LCC)

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



*Glazed porcelain
stoneware tiles*

*Ceramic district
(2015)*

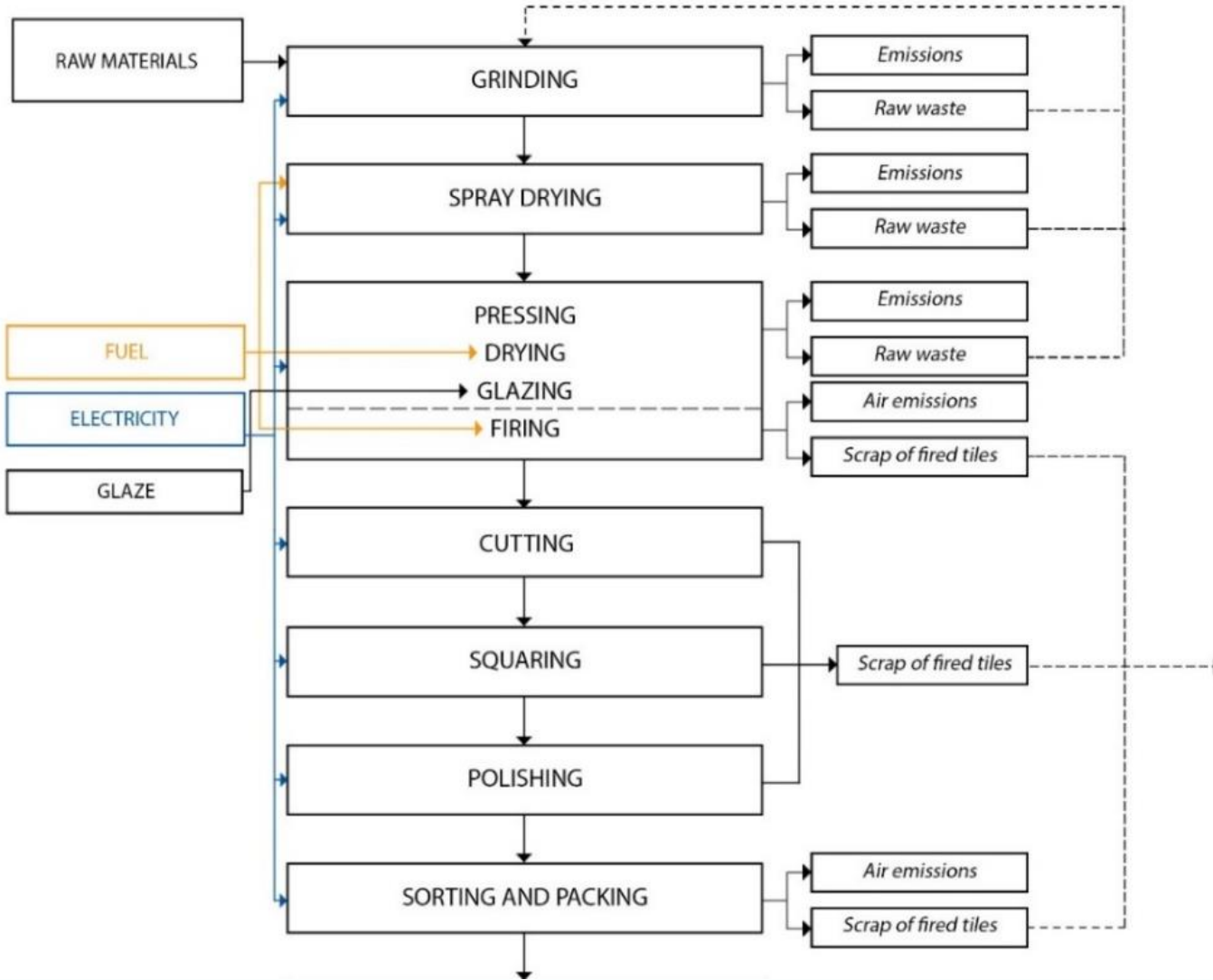
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6. LCA - Goal and scope definition

- **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



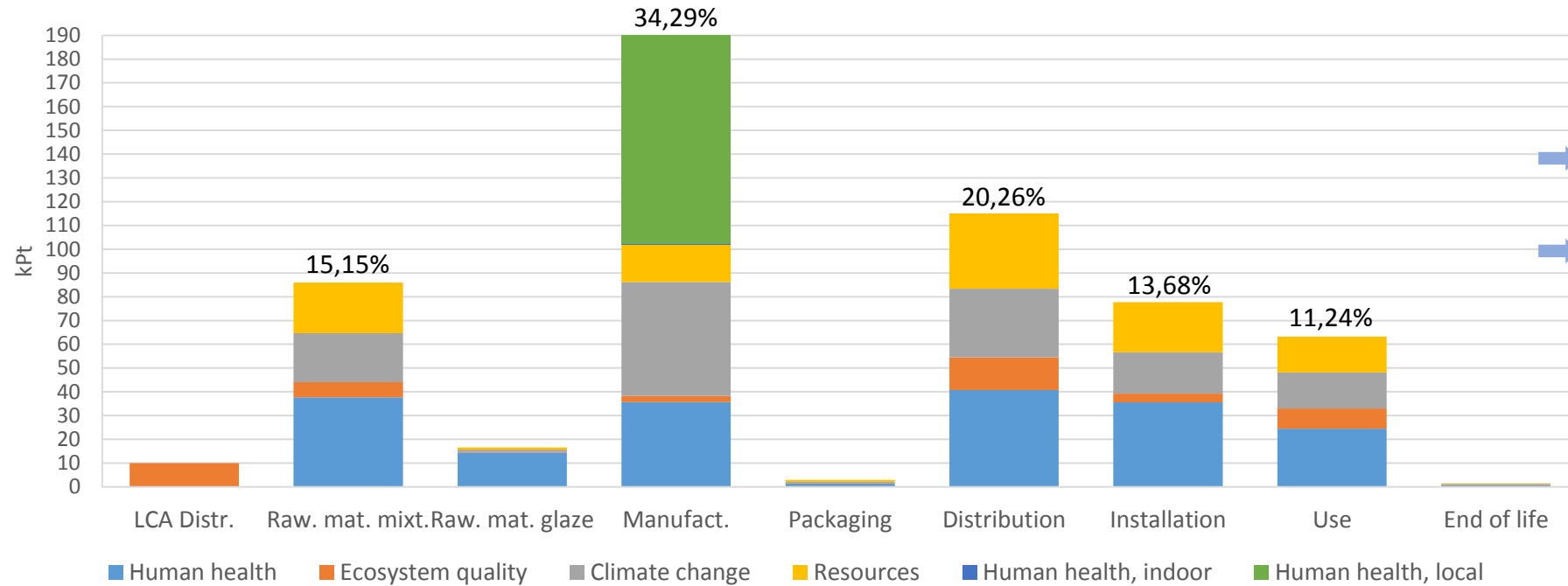
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- **DATA QUALITY:** primary, from literature, from database (Ecoinvent)
- **CALCULATION CODE:** **SimaPro 8.3**
- **METHOD:** **IMPACT 2002+ modified**
- **EMISSIONS:** approximate calculation method for local and indoor emissions

8. LCA - Impact Assessment of glazed porcelain stoneware tiles

Total damage: 545kPt

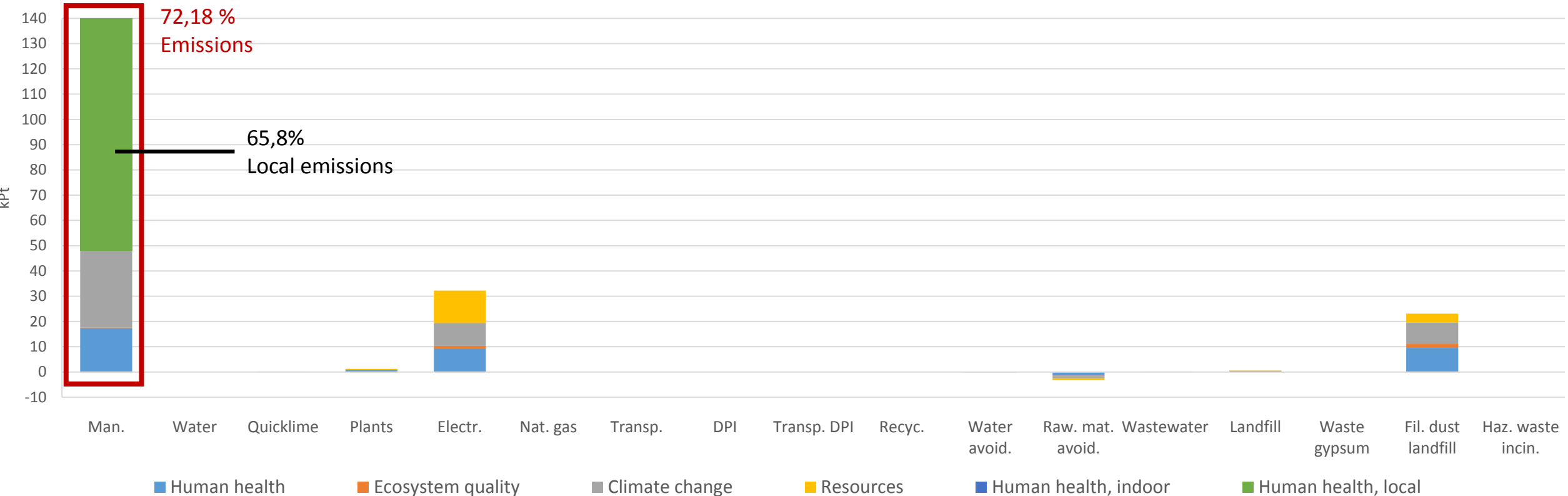


DAMAGE CATEGORY	%	SUBSTANCE
Human health	33,23	Particulates <2,5µm
Ecosystem quality	8,06	Zinc
Climate change	23,16	Carbon dioxide, fossil
Resources	18,60	Oil, crude
Human health, indoor	3,52	Hydrocarbons, aromatic, indoor
Human health, local	16,95	Hydrocarbons, aromatic, local



9. LCA - Impact Assessment of the manufacturing process

Total damage: 195kPt



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

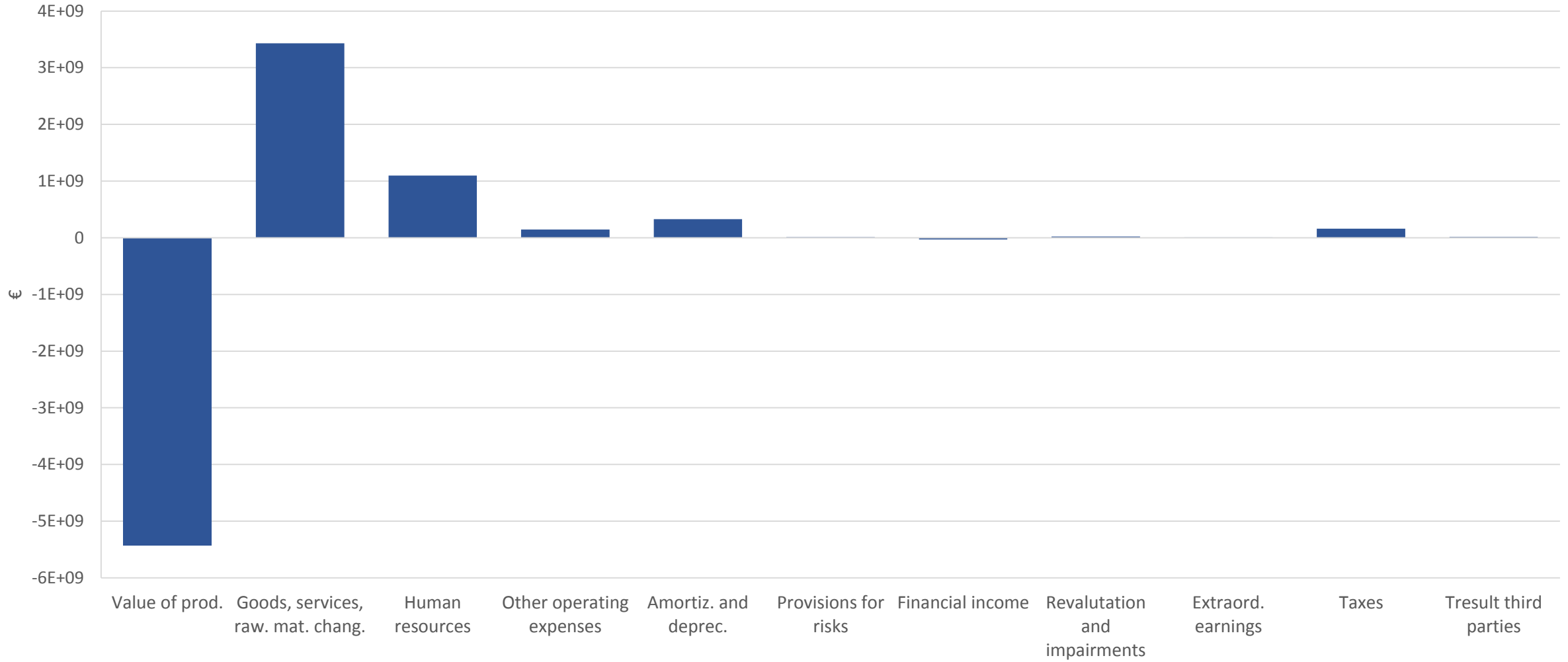


The LCC methodology allows to evaluate the **internal costs along the entire life cycle** of a product, from the manufacturing to the disposal phase; in addition, the costs of the environmental impacts associated with it (**externalities**), can be assessed.



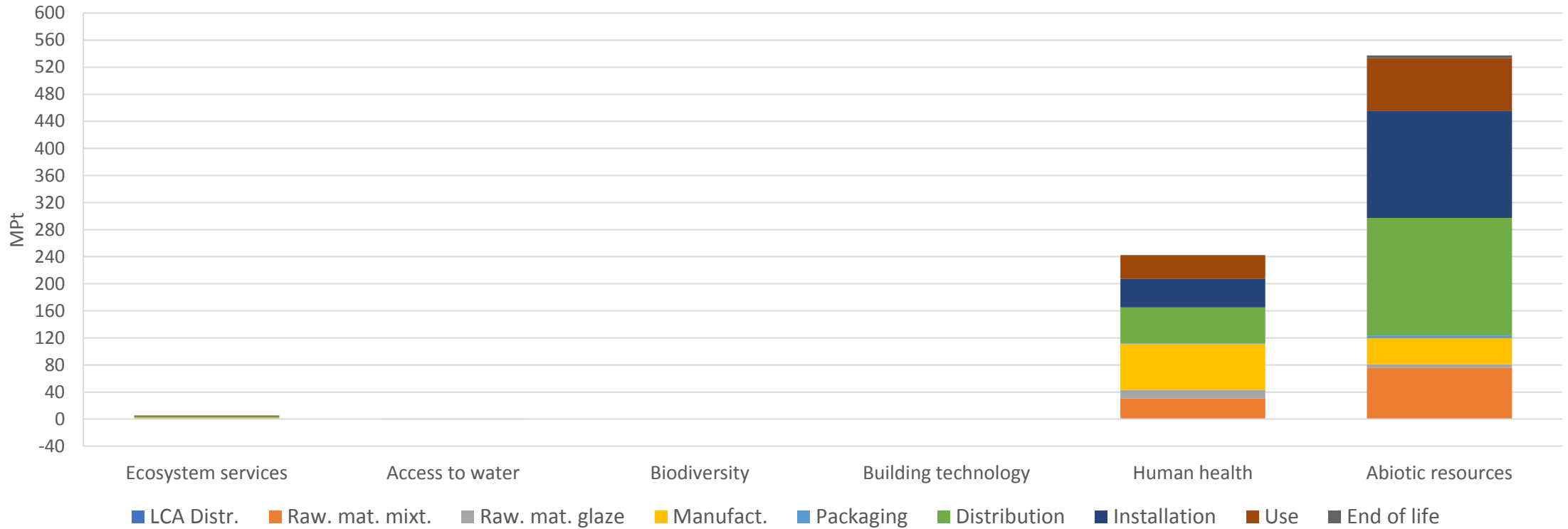
12. Life Cycle Costing

INTERNAL COSTS - REVENUE



13. Assessment of the external costs

EXTERNAL COSTS

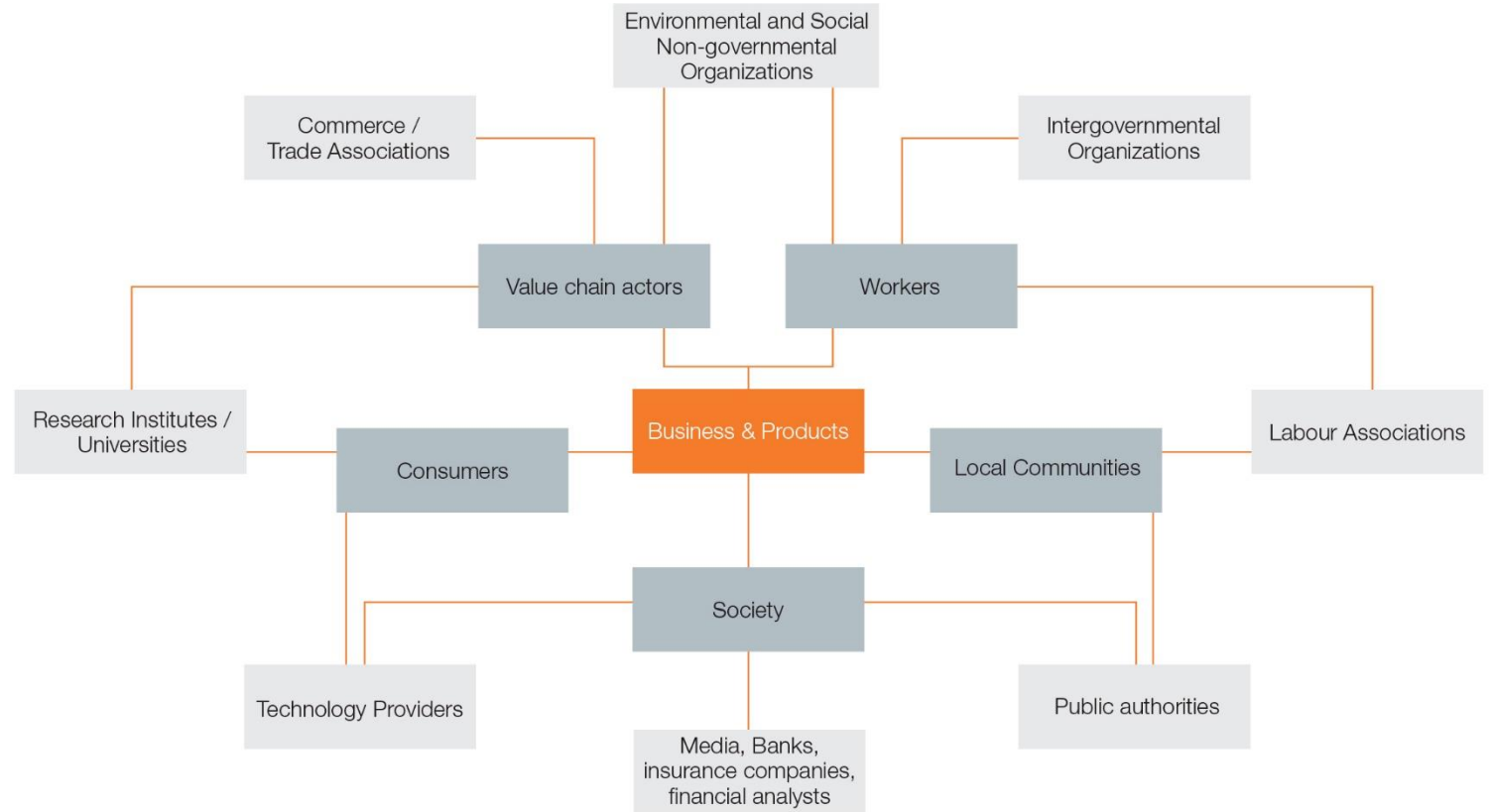
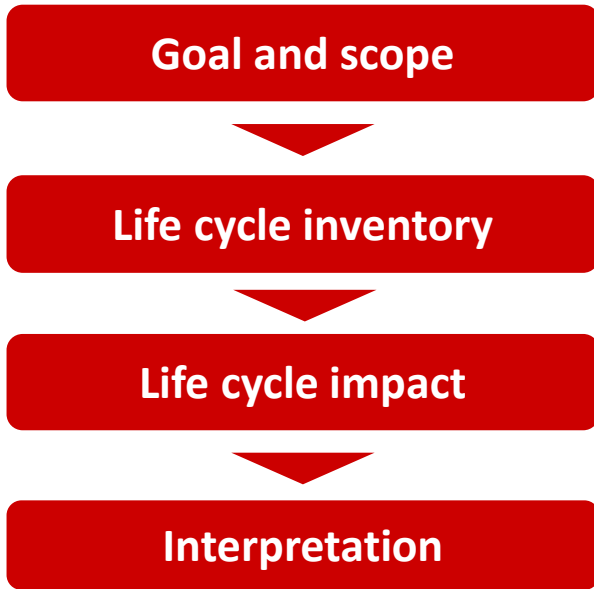


METHOD: EPS 2015

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

REFERENCE: Steen, B. (1999). *A systematic approach to environmental priority strategies in product development (EPS): version 2000-models and data of the default method* (p. 67). Chalmers tekniska högsk..

14. Social Life Cycle Assessment



REFERENCE: Guidelines for Social Life Cycle Assessment of Products, UNEP/SETAC, 2009



15. S-LCA - Stakeholders identification and mapping

STAKEHOLDER CATEGORIES	STAKEHOLDER SUBCATEGORIES	STAKEHOLDER DETAILS	SPECIFIC STAKEHOLDERS
1. Human Resources	1.1 Staff Personnel	1.1.1 Blue-collar Workers	Gresmalt's Workmen
		1.1.2 Employees	Gresmalt's Employees
			Unimore's Researchers
		1.1.3 Managers	Urcj's Researchers
	Gresmalt's Managers		
	1.1.4 Top Management	Unimore's Professors	
		Urcj's Professors	
	1.2 Trade Unions	1.2.1 Confederal Trade Unions	Gresmalt's Directors
			Unimore's Department Directors
			Urcj's Department Directors
Italian General Confederation of Labour (CGIL)			
1.2.2 Independent Trade Unions		Italian Confederation of Workers' Trade Unions (CISL)	
		Italian Labour Union (UIL)	
		Spanish Trade Union Confederation of Workers' Commissions (CCOO)	
		General Workers' Union of Spain (UGT-E)	
2. Local Community	2.1 Local Public Institutions	2.1.1 Regional Governments	Italian General Labour Union (UGL)
			Italian Confederation of Free Workers' Unions (CISAL)
		2.1.2 Provincial Governments	Italian Workers' Autonomous Trade Unions Confederation (CONFSAL)
			Italian Confederation of the Base Committees (COBAS)
		2.1.3 Municipalities	Spanish Federation of Trade Union Associations (FASGA)
			Emilia-Romagna Region (Italy)
	Veneto Region (Italy)		
	Autonomous Community and Province of Madrid (Spain)		
	Valencian Autonomous Community (Spain)		
	Province of Modena (Italy)		
	2.1.3 Municipalities	Province of Reggio Emilia (Italy)	
		Province of Treviso (Italy)	
		Province of Castellón (Spain)	
		Municipality of Sassuolo (Modena - Italy)	
		Municipality of Fiorano Modenese (Modena - Italy)	
		Municipality of Maranello (Modena - Italy)	
		Municipality of Castelvetro (Modena - Italy)	
		Municipality of Scandiano (Reggio Emilia - Italy)	
Municipality of Castellarano (Reggio Emilia - Italy)			
Municipality of Casalgrande (Reggio Emilia - Italy)			
Municipality of Viano (Reggio Emilia - Italy)			
Municipality of Possagno (Treviso - Italy)			
Municipality of Castellón (Castellón - Spain)			
Municipality of Alcora (Castellón - Spain)			
Municipality of Onda (Castellón - Spain)			
Municipality of Villarreal (Castellón - Spain)			
Municipality of Almazora (Castellón - Spain)			
Municipality of Burriana (Castellón - Spain)			
Municipality of Nules (Castellón - Spain)			
Municipality of Villafamés (Castellón - Spain) Villafamés			





16. S-LCA - Stakeholders identification and mapping

3.Society	3.1 Private Business	3.1.1 Company's Shareholders	Gresmalt's Shareholders
		3.1.2 Association of Manufacturing and Service Companies	Confindustria Ceramica (Association of Italian Ceramics Manufacturers)
			ACIMAC (Association of Italian Manufacturers of Machinery and Equipment for the Ceramic Industry)
	3.1.3 Chambers of Commerce	Federchimica-Ceramicolor (Association of Italian Producers of Ceramic Glaze, Inorganic Pigments and Metal Oxides)	
		Assomineraria (Italian Petroleum and Mining Industry Association)	
		ANDIL (Italian Association of Brick Industrialists)	
	3.2 Public and Private Organization	3.2.1 Regulatory Authorities	ASCER (Spanish Ceramic Tile Manufacturers' Association)
			ANFFECC (National Spanish Association of ceramic Frits, Glazes and Pigments)
		3.2.2 Research Community	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)
			Arpae (Regional Agency for Prevention, Environment and Energy of Emilia-Romagna - Italy)
Spanish Environment Authorities ???			
University of Modena and Reggio Emilia (Unimore - Italy)			
Rey Juan Carlos University - Madrid (Urcj- Spain)			
3.2.3 National and International Public Institutions	Jaume I University - Castellón (UJI- Spain)		
	University of Bologna (Unibo - Italy)		
3.2.4 Civil Society Organizations	Ceramic Center Bologna (CCB - Italy)		
	Institute for Ceramic Technology (ITC - Castellón - Spain)		
	Institute of Science and Technology for Ceramics (ISTEC-CNR - Faenza - Italy)		
	Institute of Ceramics and Glass (ICV-CSIC - Madrid - Spain)		
3.3 Environment	3.3.1 Natural Environment	European Ceramic Society (ECerS - Mons - Belgium)	
		Italian Ceramic Society, (I.Cer.S. - Bologna - Italy)	
	3.3.2 Future Generations	Spanish Society of Ceramics and Glass (SECV - Madrid - Spain)	
Society of Environmental Toxicology and Chemistry (SETAC - Brussels - Belgium)			
3.4 Media	3.4.1 Newspapers	Italian Network of LCA (Bari - Italy)	
		Directorate-General for Environment (European Commission - Brussels - Belgium)	
	3.4.2 Professional Magazines	Ministry of the Environment and Protection of Land and Sea (MATTM - Rome - Italy)	
		Ministry of Environment and Rural and Marine Affairs (MAPAMA - Madrid - Spain)	
	3.4.3 TV and Radio	World Wide Fund for Nature (WWF - Gland - Switzerland)	
		Friends of the Earth (Amsterdam - Netherlands)	
	3.4.4 Internet	Italia Nostra (Rome - Italy)	
		Legambiente (Rome - Italy)	

17. S-LCA - Stakeholders identification and mapping

4. Consumers	4.1 Trade Channel Operators	4.1.1 Resellers	Gresmalt's Italian Resellers Gresmalt's Foreign Resellers			
		4.1.2 Trading Partners	Gresmalt's Italian Agents Gresmalt's Foreign Agents			
		4.1.3 Business Customers	Large Scale Retail Organisations Contract Manufacturing			
	4.2 Final Consumer	4.2.1 Private Customers	Household Customers			
		4.2.2 Consumers Associations	European Consumer Organisation (Brussels - Belgium) Consumers International (London - UK)			
	5. Value Chain Actors	5.1 Suppliers	5.1.1 Large-Scale Suppliers	Manufacturers of Ceramic Machinery and Equipment Producers of Ceramic Glazes, Inorganic Pigments and Inks Producers of Raw Materials and Minerals Producers and Distributors of Electricity and Gas Producers of Ceramic Tiles Banks and Financial Institutions		
5.1.2 Small-Scale- Suppliers				Producers of Speciality Chemicals for Ceramic Tiles Suppliers of Graphics and Decorations for Ceramic Tiles Contractors Specialising in Cutting, Grinding and Engraving Processes Producers of Packaging Systems Producers of Carpentry and Electrical Equipment Producers and Distributors of Water Suppliers of design and fitting out of show-rooms, sales points and shop-in-shop corners Various Craftsmen		
				5.2 Partners	5.2.1 Practitioners and Professionals	Process Consultants Project Consultants
				5.3 Competitors	5.3.1 Direct Competitors	Others Ceramic Tile Manufacturers
					5.3.2 Indirect Competitors	Producers of Natural Stone, Wood and Synthetic Materials

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

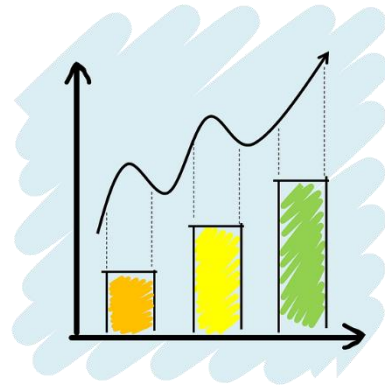
$$Damage_{tot,var} = \sum_i \frac{Damages_{i,input}}{Data_{i,input}} \cdot Data_{i,var}$$

19. LCSA implementation

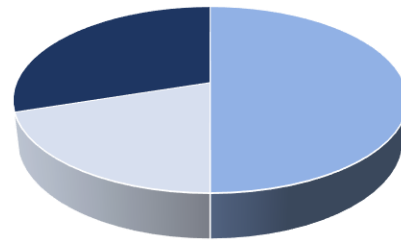
LCSA = LCA + LCC + S-LCA ✓



SPREADSHEET FOR THE DYNAMIC EVALUATION OF SUSTAINABILITY



MULTI-CRITERIA ANALYSIS



■ 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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