Il progetto Life Eclat: sostenibilità ambientale e tecnologie emergenti nel processo ceramico

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2016-2019

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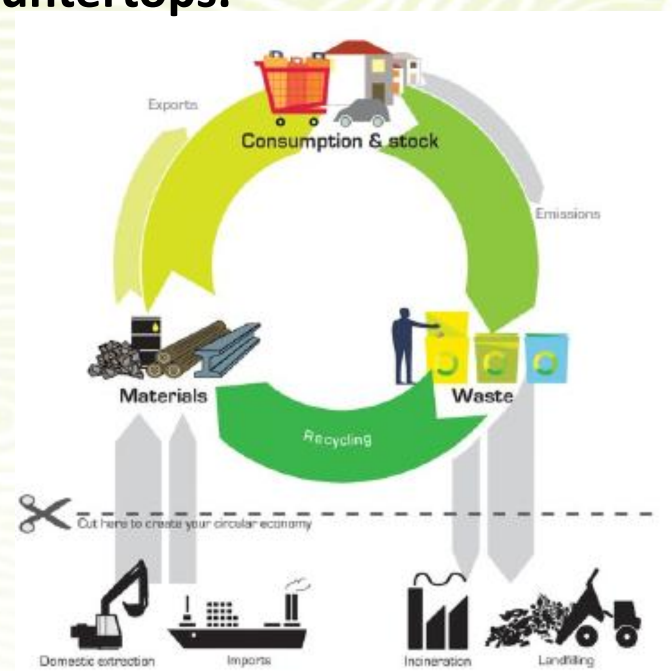
Associated Beneficiaries:

Dipartimento di Scienze e Metodi dell'Ingegneria

Dipartimento di Ingegneria "Enzo Ferrari"

ECLAT – Project objectives

Realize and validate the principles of the circular economy approach to the manufacturing of endless ceramic slabs for tiles, kitchen tops, bathroom countertops.



Close the manufacturing cycle, which starts from the incoming atomized powders, up to the recycling of end of life products claimed by deconstruction operations.

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PROJECT INTRODUCTION

Ceramic tiles

VERSUS

Engineered Stone

polymeric resin + stone

APPLICATIONS

Commercial

Living

Outdoor

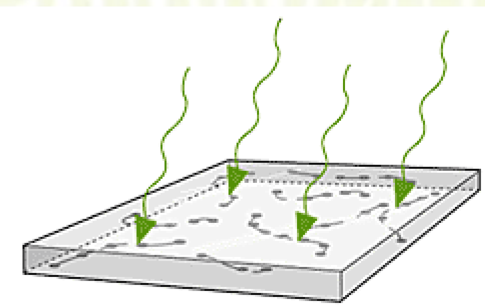
Bathroom

Custom made

Environmental Problems:

Engineered Stone

Intrinsic problems related to environmental issues, like recycling (it is a hybrid material, difficult to separate into components and hence recycled).



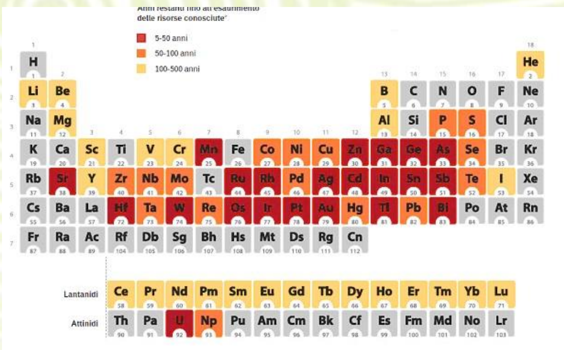
UV exposure

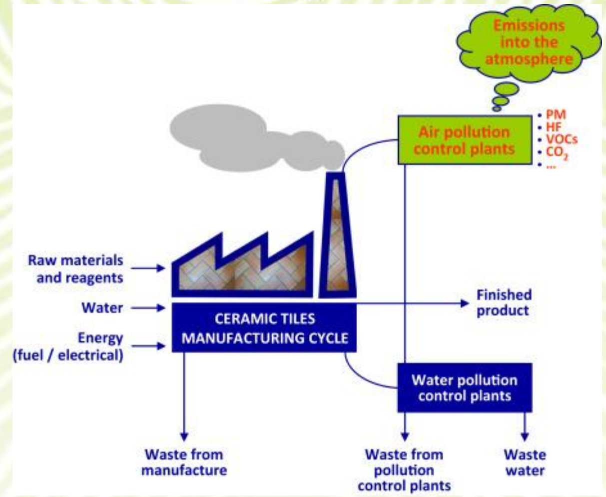
The polyester resins are not completely UV stable and this can cause discoloration of the stone, and breakdown of the resin binder; the material is also damaged by direct application of heat, a situation often happening in kitchens.

Environmental Problems:

Ceramic tiles

Non renewable resources as raw materials





Emissions: magnifying at a local level the environmental problems

Waste produced by the Italian district:

1’077’265 tons of waste per year to manufacture 729’000 tons of ceramic products, with an hazardous waste generation of more than 12’700 tons/year

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

EPD Italian Ceramic Tiles - ECO EPD Ref. No. ECO-00000444

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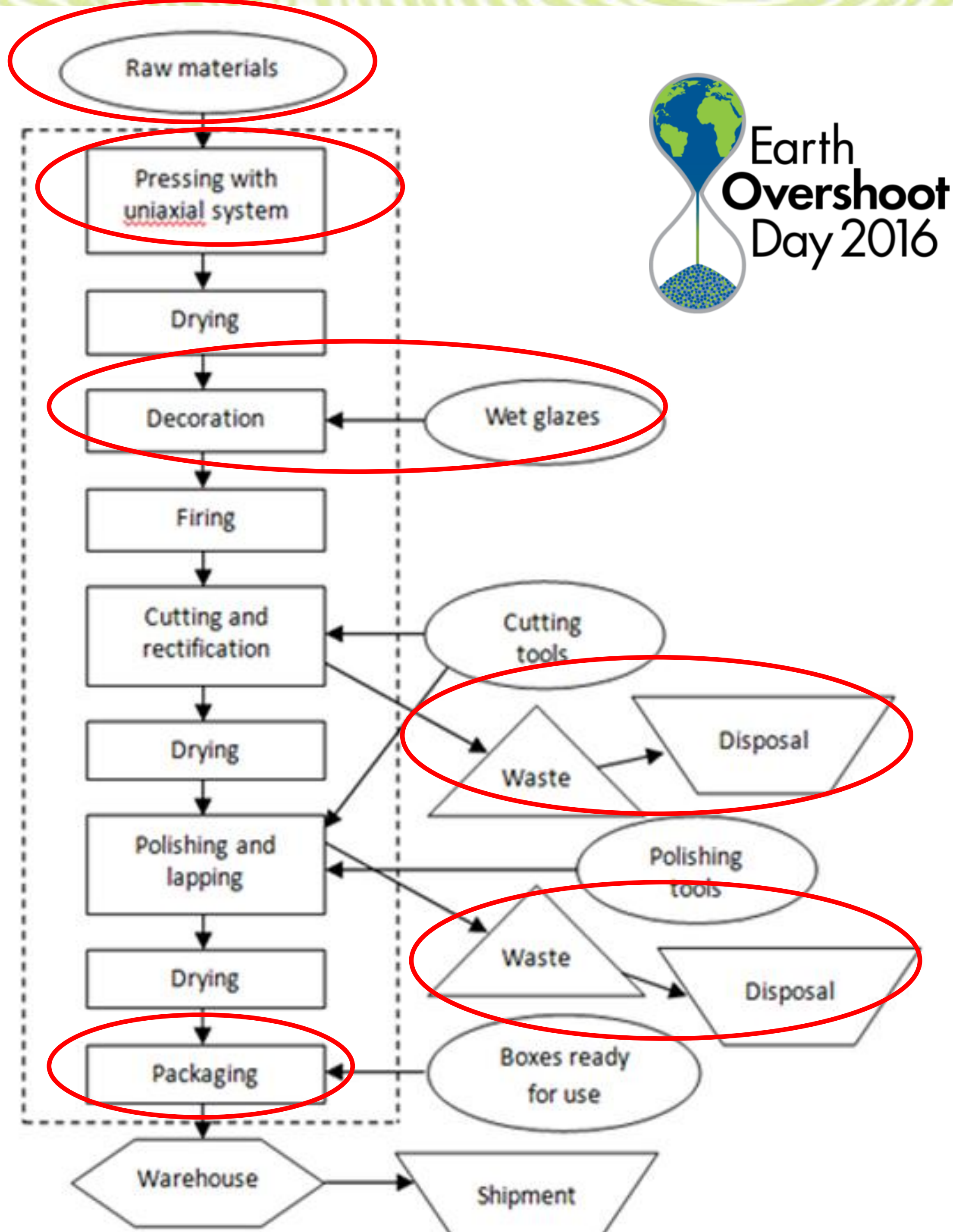
Earth Overshoot Day 2016

State of the art



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ECLAT - Approach

- Life Cycle Assessment
- Life Cycle Costing
- Social Life Cycle Assessment

ACTION ON RAW MATERIALS

- Design of an “eco” composition of ceramic body, able to withstand green machining after belt pressing and recyclable up to 40% weight in its own composition.

VALIDATION

INNOVATED SOLUTIONS

ACTION ON PROCESSES

- DOE
- Definition of the best practice for use and end of life

ECODESIGN

- Design variable belt pressing system.
- Design preliminary green decoration system by dry or semi-dry ink jet printing.
- Design of green machining equipment and tools.
- Packaging on demand

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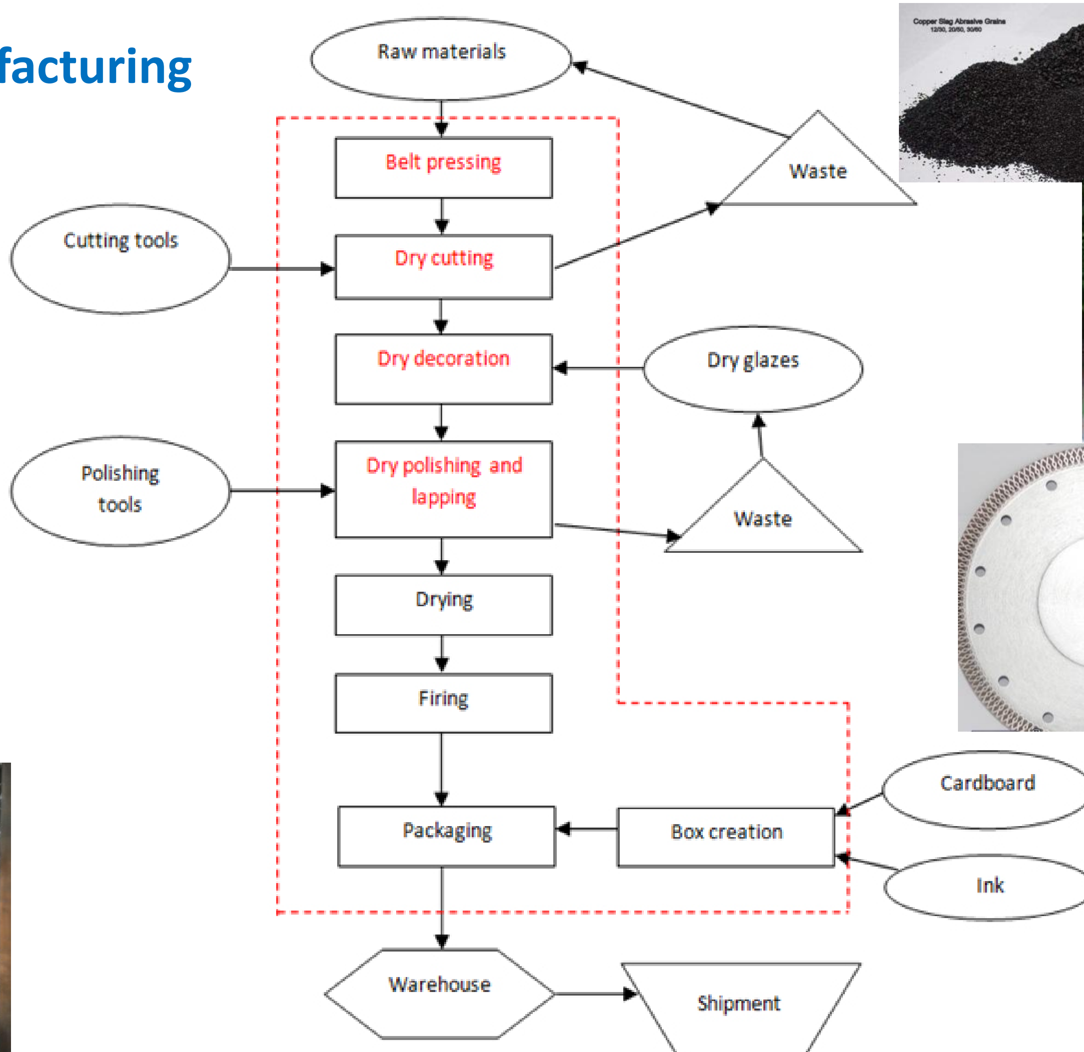
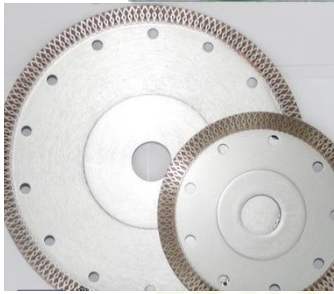
ECLAT PROCESS
large ceramic slabs manufacturing





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Traditional composition

✓ ***What we need to make ceramic tiles?***

1. **Clay** (*ca. 30*-40 wt% to give plasticity)

$(Ca,Mg, Al, Na)_3Si_2O_5(OH)_4$ $(Ca,Mg, Al, Na)_3Si_4O_{10}(OH)_2$

2. **Feldspar** (*ca*. 30-40 wt% fluxing agent)

$(K,Na,Ca) AlSi_3O_8$

3. **Quartz sand** (*ca.* 20 wt% inert material, dimension stability)

SiO_2

4. **Talc** (*ca*.10 wt%)

$Mg_3Si_4O_{10}(OH)_2$

✓ ***Which is the chemical composition of each raw materials used in ceramic tiles?***

	SiO2	Al2O3	K2O	Na2O	TiO2	Fe2O3	CaO	MgO	L.O.I
CLAY	48/50	35/38	0.3/0.7	0.3/0.6	0.1/0.3	0.2/0.4	0.2/0.4	0.2/0.3	ca. 12
FELDSPAR	69/71	18/20	1/1.5	ca6	0.2/0.4	0.2/0.4	0.1/0.3	0.2/0.5	0.5
QUARTZ	97/98	0.5/1	/	0.1-0.3	/	0.2/0.4	0.1/0.2	0.1/0.2	0.2

Ceramic body composition

✓ ***WASTE MATERIALS CHARACTERIZATION***

- X-Ray fluorescence (XRF)
- X-Ray powder diffraction (XRD)
- Hot stage microscope (HSM)
- Particle size distribution by Laser granulometer
- Scanning electron microscope (SEM)

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Ceramic body composition

DoE to optimize ceramic body raw material composition in order to achieve controlled thermal properties and firing temperature, as determined by thermal analysis, as well as green machining capabilities

✓ *DESIGN OF EXPERIMENTS (DOE)*

This branch of applied statistics deals with planning, conducting, analyzing and interpreting controlled tests to evaluate the factors that control the value of a parameter or group of parameters.

A strategically planned and executed experiment which provide information about

- What are the key factors in a process?
- At what settings would the process deliver acceptable performance?
- What are the key, main and interaction effects in the process?
- What setting would bring about less variation in the output?

through the creation of a mathematical model

ex. $y = \boldsymbol{\beta_0} + x_1 \boldsymbol{\beta_1} + x_2 \boldsymbol{\beta_2} + \ldots + x_n \boldsymbol{\beta_n} + x_{1,2} \boldsymbol{\beta_{1,2}} + x_{1,3} \boldsymbol{\beta_{1,3}} + \ldots + \varepsilon$

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✓ CONCLUSIONS

✓ The selected waste materials can be used in a ceramic body composition.

Three/four optimized compositions have been obtained:

1. CULLET GLASS as fluxing agent (75wt%) + spray dry powder
2. *CULLET and LABORATORY GLASSES and CERAMIC WASTE POWDER FROM DRY-SQUARING (40wt%) + clay*
3. *CULLET GLASS AND CERAMIC WASTE POWDER FROM DRY SQUARING (40wt%)+ clay*
4. CULLET GLASS and COPPER SLAG 50wt% + spray dry powder

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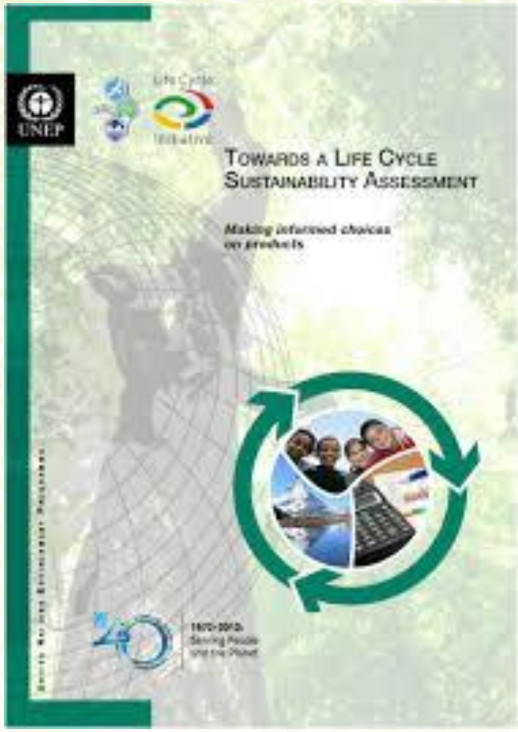
Life Cycle Sustainability Assessment

Methodological approach for the assessment of all environmental, economic and social impacts and benefits in decision making processes for improving the sustainability of a process or product throughout its entire life cycle.

«Towards a Life Cycle Sustainability Approach» UNEP-SETAC 2011



LCSA = E-LCA + LCC + S-LCA

W. Klöpffer (2008); Finckbeiner et al (2010)

ENVIRONMENTAL DIMENSION: Life Cycle Assessment (LCA)

ECONOMIC DIMENSION : Life Cycle Costing (LCC)

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

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Environmental impacts of a glazed porcelain stoneware tile - traditional ceramic process

vs

Environmental impacts of the innovative ceramic slabs - innovated solution

LCA of a glazed porcelain stoneware tile

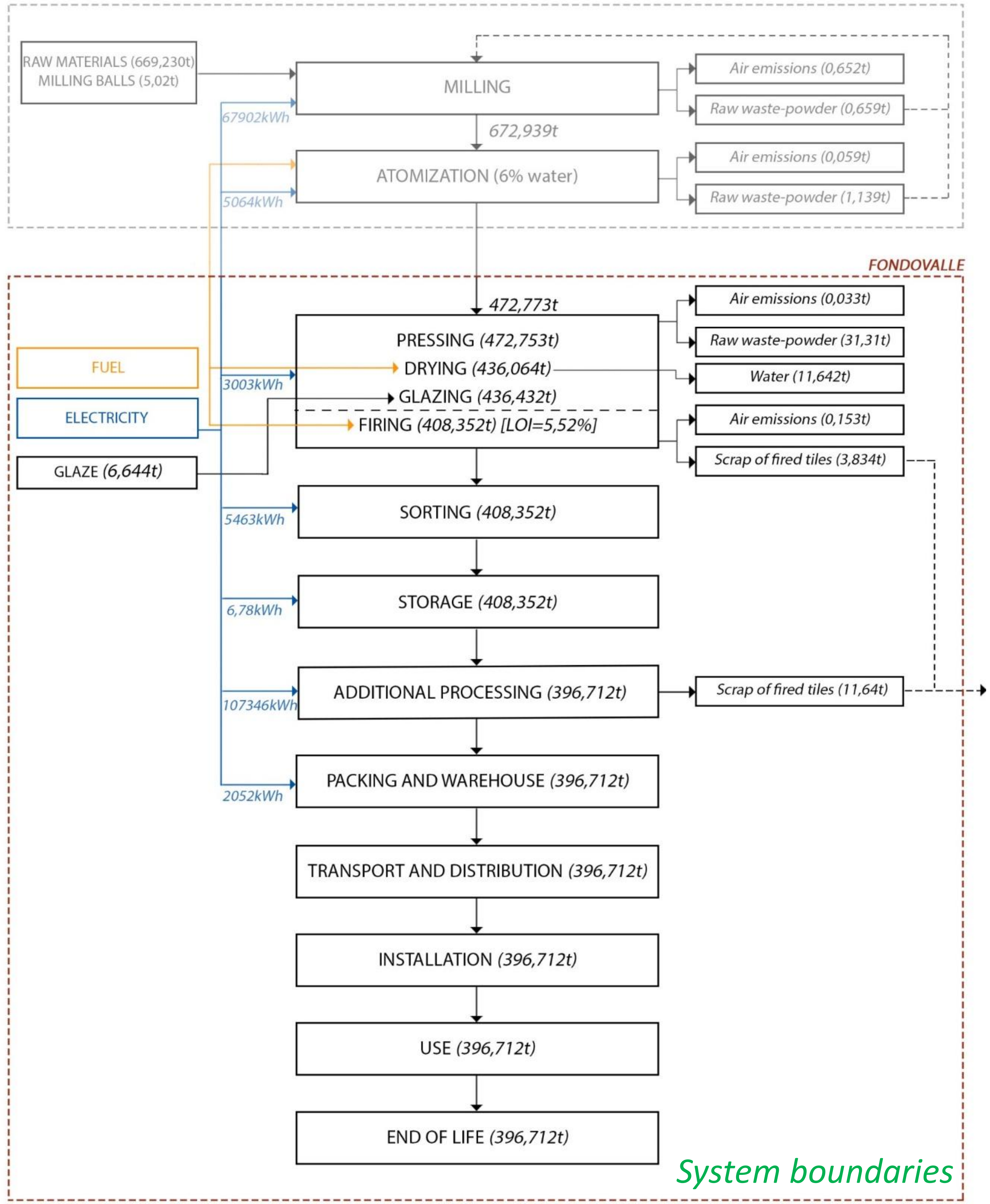
Traditional ceramic process

Functional unit: 1m^2 of porcelain stoneware tile, assuming a lifetime of 50 years.

Life cycle inventory: Primary data referring to the traditional ceramic tile production were collected directly in Ceramica Fondovalle S.p.A. and were referred to the plant located in Marano sul Panaro (MO). Secondary data have been obtained from Ecoinvent database (Ecoinvent Center, 2009).

Software: Simapro 8.3

LCIA Method: IMPACT 2002+



Composition of ceramic body and glaze - Traditional glazed porcelain stoneware tile

Annual production 396,7 ton (final product) ~ 19835 m^2

RAW MATERIALS (ceramic body)		
Water	t/yr	211,67
Clay	t/yr	146,23
Feldspar	t/yr	183,03
Sand	t/yr	126,50
Sodium silicate	t/yr	0,89

RAW MATERIALS (glaze)		
Water	kg/yr	72,66
Sand	kg/yr	2716,43
Clay	kg/yr	3042,64
Kaolin	kg/yr	1,16
Engobe	kg/yr	10,36
Feldspar	kg/yr	388,05
Petalite	kg/yr	79,27
Zirconium silicate	kg/yr	317,10

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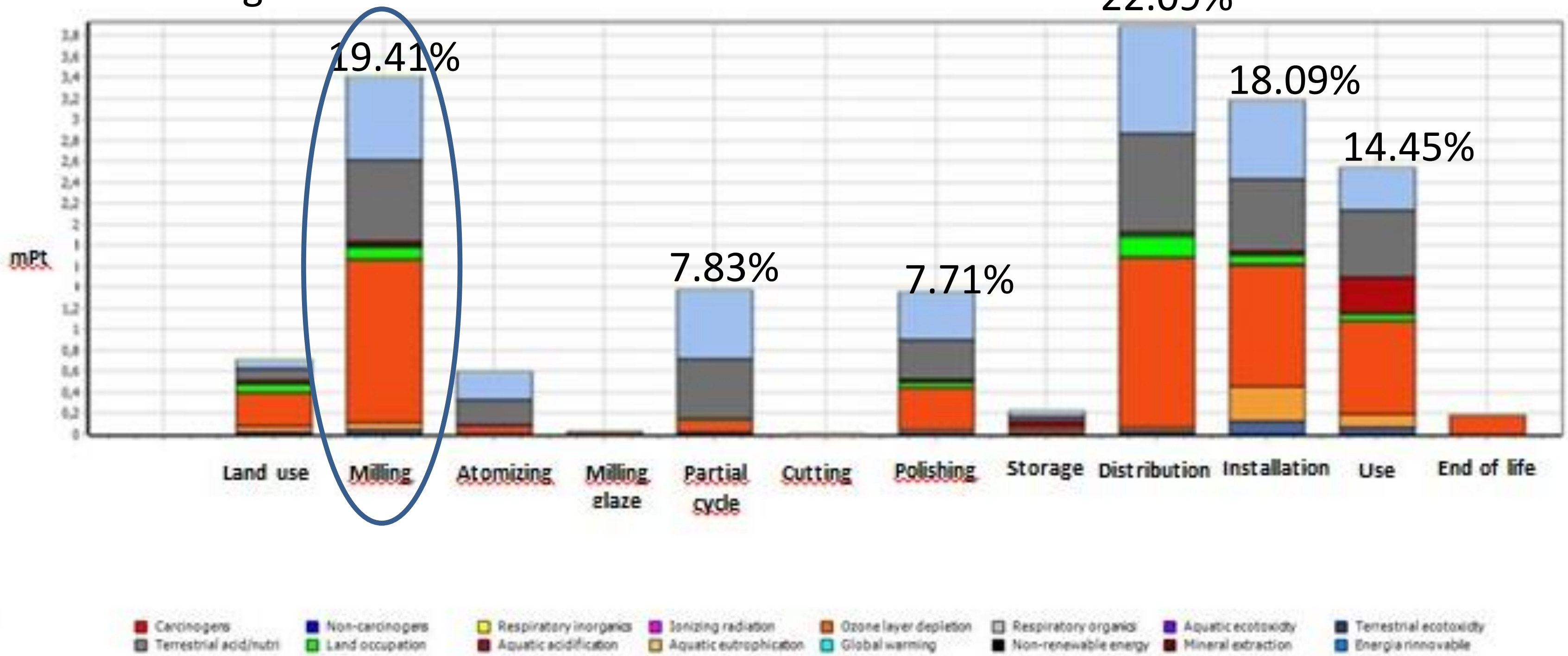
LCIA of 1m² of a traditional glazed porcelain stoneware tile

Total damage: 17.64 mPt



42% the Human health (7.42 mPt)
26% Resources (4.61 mPt)

25% the Climate Change (4.39 mPt)
7% the Ecosystem quality (1.23 mPt)

Future/ongoing research steps

- Data collection to model Life Cycle Inventory (LCI) of the life cycle of the innovative ceramic slabs, focusing on the composition of the innovative slab.
- Data collection of all internal cost associated to the life cycle of the innovative ceramic slabs
- Use of Social Hotspot Database (SHDB) to model and evaluate the social aspects

Grazie per l'attenzione

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