Porcelain Stoneware tiles containing 85% of recycled materials

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Editorial

Today it is possible to produce porcelain stoneware minimizing the use of natural resources.

This has been one of the challenges of the last few years and, with WINCER project, we have been able to go beyond the already ambitious goals set. The initial idea of making tiles with 70% of waste materials has realized with the industrial production of tiles containing 85% of second raw materials.

These tiles obtained the UNI Keymark and LEED certification, thanks to the passion and collaboration of all the people who have contributed to this goal.

It is an important milestone for environmental sustainability that once again confirms the world leadership of Italian and European ceramic industry.

Elisa Rambaldi
Wincer Project Coordinator

Co-funded by the Eco-Innovation Initiative of the European Union

PROJECT DETAILS

PROJECT NAME:
Waste synergy in the production of INnovative CERamic tiles

PROJECT ACRONYM:
WINCER

PROJECT REFERENCE:
ECO/13/630426/WINCER

PROGRAMME ACRONYM:
CIP-EIP-Eco-Innovation

SECTOR:
RECYCLING

START/END:
Jan 2015 – Dec 2017

PROJECT WEBSITE:
www.wincer-project.eu

Table of Contents

The Environmental footprint of the ceramic sector

The ceramic industry sector is a large consumer of natural resources, energy, and a large emitter and generator of waste and CO_2

The production process of ceramic tile consists of five stages:

1. Ball crushing and grounding of the raw materials and additives to obtain a ceramic slurry
2. Spray drying of the ceramic slurry to obtain a spray dried powder
3. Uniassial pressing of the spray dried powder to obtain the ceramic tile
4. Drying of the tiles at 230°C and glazing operation if the product is glazed
5. Firing at a maximum temperature of about 1200°C both for glazed and unglazed tiles

NATURAL RESOURCES used are sands, feldspars and clays.

More than 50% of them comes from foreign countries travelling by truck for the 35% (62g CO_2/ton-Km), by ship for the 51% (34g CO_2/ton-Km) and by train for the 14% (26 CO_2/ton-Km).

The THERMAL ENERGY used in the process is usually obtained by combustion of natural gas

which is fossil fuel whose oxidation produces emissions of carbon dioxide, a greenhouse gas. Spray drying and firing can therefore be considered as the main responsible of CO_2 emissions.

WASTE produced are:

unfired scrap tiles, fired scrap tiles, mud coming from washing lines, lapping and polishing mud, dried grinding residues, exhausted lime. Almost all of these wastes (pre-consumer wastes) are reused in the same process, in a closed loop cycle. Only exhausted lime is landfill confined as dangerous waste, to avoid any risks in its reuse in a traditional tile mix (i.e. rheological risks and risks related to workers' health and safety).

The European regulations encourage and boost industries towards a green and circular economy in which the "reuse" and "preparation for reuse" are the key words to reach an Innovating-to-Zero, ideal future at zero emission, zero waste, zero not-recyclable products.

In the last years, with the target to demonstrate a reduction of the environmental impact and a significant reuse of End-of-Waste materials, a **new concept of "traditional" ceramic** has been developed by replacing higher amount of natural raw materials with:

1. New glassy raw materials for traditional ceramics coming from vitrification of different wastes able to crystallize during firing

2. Different type of wastes opportunely balanced to obtain a sort of "wastes synergy" during firing

The use of several kind of wastes in traditional ceramic tiles have been investigated since late 90s. Many literature works deal with recycling of different wastes in traditional ceramic materials, in particular **porcelain stoneware** tiles.

Glass cullet waste (Soda lime glass - SLG) coming from urban collection, is one of the **most widely recycled** form of waste employed in traditional ceramic tile formulations, but until now it was not possible to recycle high percentages of material (**higher than 20-30%**).

Unfired green tiles waste (GT) are generated after the shaping process, during the unfired tiles handling on conveyor belts or rollers, in an amount of about 4 wt% of the production and generally are reused in the productive **cycle** without any problem.

Anyway the percentage of wastes recycled is quite low (generally below 10-15%).

Project OVERVIEW

3 years
Duration

2015
Starting year

3
Partners

1,489,312 euro
Total Cost

744,656 euro
EU Contibution

WINCER project contributes to improve the European ceramic industries through the acquisition of the world leadership in waste-based ceramic materials by proposing and innovative porcelain stoneware tile obtained by a process that permits to save natural raw materials and to reduce both CO_2 emissions and energy consumption

In fact, in WINCER tile production, natural raw materials are substituted by about 85wt% of recycled materials from urban and industrial wastes, of which:

- 55wt% of soda-lime glass cullet waste coming from urban collection: **packaging glass** (soda-lime based) comes separately from urban collection and it is washed, purified and wet milled to be suitable for its reuse in the glass industry in a closed loop cycle (glass with particle size 0.1-0.8 mm). **The fraction containg impurities and the finer fraction**, below 100 micron, are **not suitable for re-melting use** in the glass industry (about 30% of the total urban collection).
The finer fraction is employed in WINCER tile formulation, as a substitution of feldspar flux.

- **30% of unfired green scrap tiles**, that are generated during the unfired tiles handling on conveyor belts or rollers, before the firing step. Generally this waste is reused within the same productive process till about 4 wt%.

Products on the MARKET

COMPARISON OF TRADITIONAL CERAMICS, SUSTAINABLE PRODUCTS ON THE MARKET AND WINCER TILES

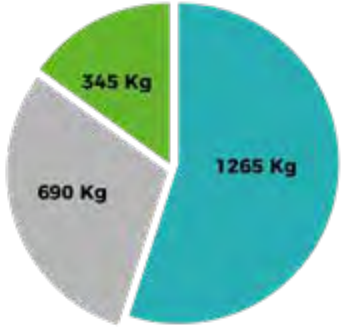
	TRADITIONAL CERAMICS	SUSTAINABLE TILES ON THE MARKET	WINCER TILES
Sand and feldspar coming from national and foreign mines and quarries	60%	25% - 50%	**0%**
Clays coming from national and foreign mines and quarries	36%	25% - 36%	**15%**
Soda lime glass waste coming from urban collection (or similar)	0%	3% - 10%	**55%**
Unfired green scrap tiles generated during the industrial ceramic process	4%	4% - 20%	**30%**

RAW MATERIAL Mass Balance

To produce 100 m^2 of ceramic tiles are needed:

TRADITIONAL stoneware tiles

WINCER tiles



With WINCER tiles it is possible to reach both a significant saving of natural resources due to the total substitution of feldspars and siliceous sands (100% of saving) and the partial substitution of clays (more 62% of saving). It allows also a significant reduction of cost for the body mix preparation (around 33% of cost saving).

Energy Balance & GHG emissions

WINCER tiles are produced both in 30x60 cm glazed and unglazed versions, as well as in 15x15 cm glazed one.

Project RESULTS

The body contains the following raw materials:

- **Soda lime glass as secondary raw material and unfired scrap tiles as by-product of the traditional ceramic process: 85%**
- **Clay as natural raw material: 13-15%**
- **Glazing raw materials only for glazed series (kaolinite, thinners, binders, etc.): < 2%**
- **Others (fluidifying agents, thinners, inks): < 1%**

The production process starts with **mixing the soda lime glass**, **unfired scrap tiles** coming from a traditional tile process and **clay,** in a continuous milling machine with water to form a slurry. This step includes **fluidifying agent addition** to improve the stability of the ceramic suspension.

The slurry produced is then sent to spray drier that is able to produce a granulated powder suitable to be pressed to form tiles.

FINCIBEC's industrial production of innovative and sustainable ceramic tiles (250x250 mm) containing 96% of secondary raw materials. These products, according to EN 14411, belong to class BIIb (water absorption 6 < E ≤ 10%)

This pressed grain carpet is then **dried at about 200-230°C** and than **glazed** (for the glazed series). Glazes are prepared with many different raw materials like kaolinite, alumina (Al_2O_3) and several inorganic oxide (K_2O, Na_2O, Fe_2O_3, etc.), sodium silicate, binders.

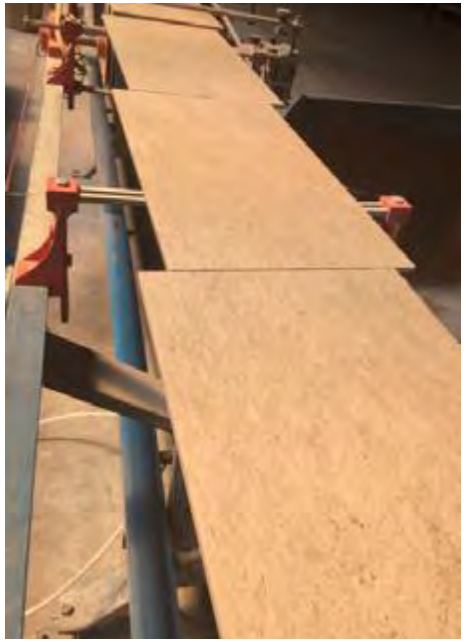
The firing phase reaches the **maximum temperature of 1025°C** (instead of 1250°C as for an usual porcelain stoneware tiles production) with a duration of 39 minutes from cold to cold like in a traditional process. This step is necessary to obtain a ceramic tile with characteristics and performances like those of a traditional porcelain stoneware that, nowadays, is still at the top among different ceramic products.

At the end of the process, **tiles are packaged and ready** for the on demand market.

Due to technical reason, this product production is performed in a dedicated production line not shared with other kinds of product.

15x15 PRODUCTION

30x60 PRODUCTION



Technical PERFORMANCE

30x60 cm glazed tiles are compliant with the standard EN 14411 and obtained the UNI-Keymark certification

WINCER tiles are all compliant with the standard EN 14411. **The series 30x60 cm** glazed tiles named "STONEWORK GL SR, type WINCER, code K1EH" obtained the **UNI Certiquality Keymark**.

In particular, WINCER tiles are shaped by dry-pressing at room temperature followed by drying and firing at 1025°C. This temperature is sufficient to reach a water absorption below 0.5%. Thus these tiles belong to group BIa and fulfill with the requirements of Annex G of the standard EN 14411.

The following performances have been evaluated:

- UNI EN ISO 10545-2: 2000:
Determination of dimensions and surface quality

- UNI EN ISO 10545-3: 2000:
Determination of water absorption, apparent porosity, apparent relative density and bulk density

- UNI EN ISO 10545-4: 2014:
Determination of modulus of rupture and breaking strength

- UNI EN ISO 10545-5: 2000:
Determination of impact resistance by measurement of coefficient of restitution

- UNI EN ISO 10545-7: 2000:
Determination of resistance to surface abrasion for glazed tiles

- UNI EN ISO 10545-8: 2014:
Determination of linear thermal expansion

- UNI EN ISO 10545-10: 2000:
Determination of moisture expansion

- UNI EN ISO 10545-11: 2000:
Determination of crazing resistance for glazed tiles

- UNI EN ISO 10545-12: 2000:
Determination of frost resistance

- UNI EN ISO 10545-13: 2000:
Determination of chemical resistance

- UNI EN ISO 10545-14: 2000:
Determination of resistance to stains

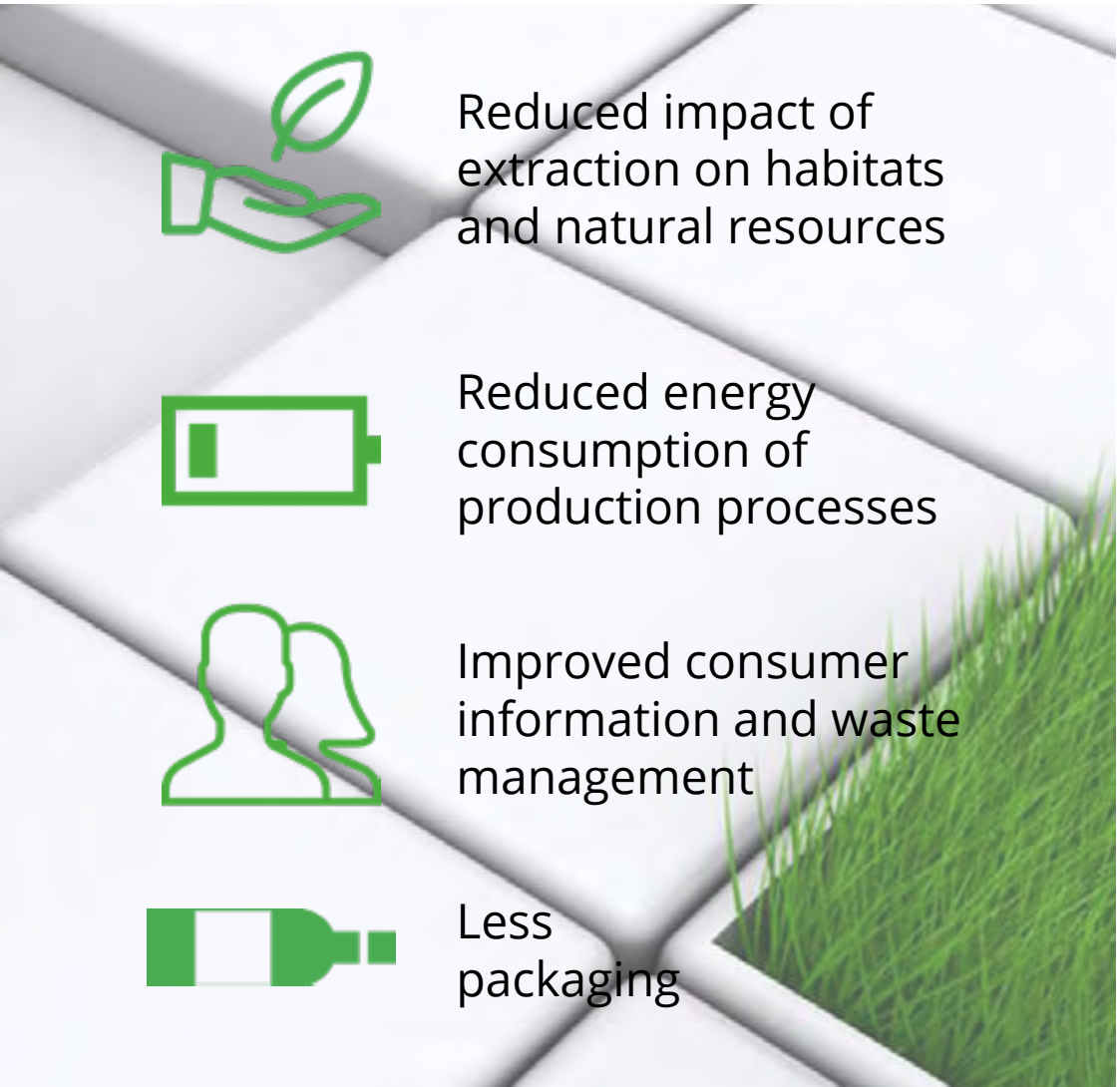
- UNI EN ISO 10545-15: 2000:
Determination of lead and cadmium given off by glazed tiles

The results of these tests fulfill with the standard requirements reported in ANNEX G of EN 14411.

Ecological BEHAVIOUR

WINCER tiles obtained the ***LEED Certification*** *for the waste material content (85%): 30% pre-consumer waste and 55% post-consumer waste*

WINCER tiles also meet criteria that guarantee:



- Reduced impact of extraction on habitats and natural resources
- Reduced energy consumption of production processes
- Improved consumer information and waste management
- Less packaging

To evaluate the environmental performance of WINCER tiles, the Life Cycle Assessment, LCA, study was performed following the "cradle to gate" criterion and according to ISO 14040 and ISO 14044.

The environmental impact assessment indicators considered (EN 15804) showed a significant improvement for WINCER tile respect to a traditional porcelain stoneware tile. In particular, for the Global Warming Potential (GWP) indicator that considers the greenhouse gases causes the climate change, the results are the following:

		Traditional Stoneware tile	WINCER tile
GWP	[kg CO_2-eq.]	24-25%	1.09%

Health in the WORKPLACE

Higher health and safety in workplace, due to the reduction of about 55% of crystalline silica (quartz) respect to a traditional spay dried powder. It means an important reduction of the Respirable fraction of Crystalline Silica (RCS) in workplace.

	RCS Potential
WINCER spray dried powder	1.9%
Traditional spray dried powder	5.2%

RCS in WINCER spray dried powder is reduced of about 63% respect to a traditional porcelain stoneware.

The MARKET

Ceramic MARKET

Among ceramic tiles, **porcelain stoneware** is the most diffuse product, representing the **78% of the Italian total productions** (416 M m^2 in 2016). About 15% of these tiles is addressed to outdoor application, especially those simulating natural stones or cement.
The most diffuse formats of ceramic tiles are both **squares and rectangular.** Nowadays different formats are rare. Dimensions vary from small (few centimetres, like mosaic tesserae) till 60 cm and more. Concerning the thickness, the most diffuse varies from **8-10 mm**. Thickness higher than 20 mm is addressed to outdoor applications. Recently, very thin tiles (till 3 mm) were also introduced on the market.

The most versatile format is the 30x60 cm. It can be included in the "LARGE FORMAT" group but it is not too large both for outdoor (garden, terrace) or indoor destinations.

In the last period the market is evolving toward the high quality products while the low and medium quality are rather stable even if there is a tendency to the larger formats. The high quality products are differentiated as **medium-large** formats (60x60-75x150 cm) and **slabs** (80x160-160x320 cm); both of them are then differentiated as: **natural stones** or with **surface finishing** (lapped, polished).

The graphical evolution of the ceramic tiles is even more rapid respect to the dimensional one. **The wood or cement finishing is almost outdated**. The envisaged products for Cersaie 2017 are mainly natural stones with colours that vary from almost completely black till extra white. But the major amount of colours is represented by **gray tones**.

WINCER tile OFFER

WINCER tiles belong to class BIa of the international tile classification (UNI EN 14411) that corresponds to the commercial definition of "**porcelain stoneware**".

The reference format for WINCER tiles is 30x60 cm and thickness 9-16 mm. Other smaller formats were also considered, 15x15 cm.

The type of approach is to i**mplement production concepts for "small series", "on-demand"** and **"just in time"**, where it is produced only according to the needs and tastes of the market by varying in a wide variety of formats (e.g. 15x15 cm, 15x30 cm, 20x20 cm, 20x40 cm, 40x40 cm, 30x30 cm, 30x60 cm), thicknesses (6 mm to 20 mm) and surfaces (from smooth to structured with different tones, together with rustic or tone shades typical of natural stones, woods, cement, resin, etc).

European ADDED VALUE

Thanks to 31.3% of export outside the EU and a positive trade balance of € 4.5 billion, **the European ceramic industry provides over 200,000 jobs in Europe** (approximately 80% of which are in small and medium-sized enterprises).
The European Union can draw on the results of **WINCER project** to promote the circular economy for certain types of waste, such as scrap glass not suitable for the glass industry, **making ceramic more competitive, sustainable and respectful of the environment**.

Main benefits at EU level are:

- Acquisition of the **world leadership in waste-based ceramic materials**; the use of at least 85% of recycled materials strengthens EU market for waste, which becomes a valuable resource and helps preserve natural stocks of virgin and important minerals in Europe such as clay, limestone and feldspar and also reduces the imports of minerals such as zircon, bauxite and magnesia from overseas;

- **Widening of the ceramic products market** by including more sustainable ones in substitution to other materials such as stone, marble and wood that determine stronger environmental impacts; WINCER tiles are able not only to minimize the environmental impact of the extraction of natural materials in the quarry or the felling of trees but also to divert waste from landfill and reuse industrial waste;

- **Reduction of energy consumption** of the milling and firing processes (electricity and methane are the highest factors of impact on the production cost of the tile);

- **Higher health in the workplace** thanks to the lower amount of free crystalline silica in the ceramic mix.

WINCER tiles developed at national level, will boost for further fruitful international activities to **develop sustainable, cost-effective, structural ceramics from "waste synergy"**; since in the next years the environmental legislation and EU policies (like that on "Product Environmental Footprint") will become more restrictive, the obtained results are very helpful for the companies at which it will be required to respect regulation for wastes recycling, that are currently dumped.

The PARTNERS

CENTRO CERAMICO BOLOGNA is a non-profit Italian Technology Transfer Research Centre. Its objective is to support the scientific-technological progress and competitiveness of the Italian ceramic industry, through technological research, technical assistance, standardization and advanced training in the following sectors: raw materials, ceramic bodies and glazes, ceramic manufacture.

ROLES IN THE PROJECT:
- Lead Project Management and Coordination of all activities
- Preparation of innovative body mix for tiles
- Support to Pilot Production
- Support to Certification
- Environmental Monitoring,
- Market Replication

MARAZZI is the leading company worldwide in the design, manufacturing and sales of ceramic and porcelain stoneware floor and wall tiles ant it is the largest Italian tile manufacturer. Since 1935, MARAZZI is one of Italy's major companies, a world leader and a benchmark in the international ceramic market, mainly defined by regional and local players.

ROLES IN THE PROJECT (From Month 19):
- Market Introduction & Replication
- Exploitation and Business Plan
- Dissemination

MINERALI INDUSTRIALI S.R.L is an Italian company dedicated to the production and sales of raw materials for the production of glass, tiles, sanitary and agglomerated stones. Founded in 1984, it owns several mines and quarries in northern Italy and in central Italy, and plants for the treatment of these raw materials. MINERALI INDUSTRIALI aimed at substitution of primary raw materials by waste, preserving landscape and reducing energy costs and CO_2 emissions of customers.

ROLES IN THE PROJECT:
- Preparation of relevant amounts of glass cullet from urban waste disposal suitable for ceramic tiles formulations
- Waste Characterization for Pilot and Industrial Production

FINCIBEC S.P.A. is a leading company at an international level in the production of ceramic tiles for floors and walls. FINCIBEC Group is one of the most reliable and important player in the ceramic manufacturing sector across the international scene.

ROLES IN THE PROJECT (Till Month 18):
- Lead Project Management and Coordination of all activities
- Pilot Production
- Industrialization activities
- Market Introduction & Replication
- Exploitation and Business Plan
- Dissemination

Contacts:

PROJECT COORDINATOR

Elisa Rambaldi
Centro Ceramico
rambaldi@centroceramico.it

This Layman's Report has been written and compiled by Elisa Rambaldi, Project Coordinator of WINCER.
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