



## ENERGEO Project

Insulating high strength-controlled porosity geopolymer floor tiles for the mitigation of global warming



ecodesign

eco-innovation

circular economy

production process

eco-friendly products

reducing environmental impact

## PROJECT DESCRIPTION

The production of flooring materials, in particular ceramic tiles and concrete bricks, has a strong environmental impact in terms of **greenhouse gas emissions** and **energy consumption**, considering the quantity of energy required for the production and the **generated air pollution**. The energy consumption varies from 1.710 to 2.805 kJ for each kg of tiles or bricks produced, 90% of which comes from the combustion of natural gases; the consumption levels can instead exceed 20.000 kJ/ kg if we consider the entire life cycle of the product (especially for those fired at high temperatures). Furthermore, the need for thermal energy and the combustion processes determine a CO<sub>2</sub> production greater than 1,7 kg per each kg of finished product. To understand the dimensions of the environmental problem, it is sufficient to consider the annual ceramic tiles and concrete production at European level: in 2012, for example, the production of ceramic tiles amounted to 1.168 million m<sup>2</sup>, for a medium weight of 20 kg per m<sup>2</sup>, while the concrete production exceeded 300 million tons. A possible alternative to mitigate the effect of climate change related to these productions has been found in the development of a new material that does not require high temperature production processes and that can be manufactured industrially using also local and recycled raw materials.



## OBJECTIVES

The general objective of ENERGEO was to contribute to the reduction of CO<sub>2</sub> emissions and energy consumption during the production of flooring materials, using a new generation of **geopolymers** (a category of synthetic materials based on aluminosilicates formed by chains or networks of mineral molecules held together by covalent bonds, with very rapid demolding times, compatible with continuous industrial productions). To this end, a pilot plant was set up to demonstrate the feasibility of the application of geopolymers for industrial scale production of eco-compatible tiles.

## PROJECT PHASES

The project was divided into two main phases: the first focused on the definition of geopolymer mixtures (some compositions allow to obtain products with technical characteristics similar to those of conventional tiles, but through a completely different and highly eco-compatible production process); the second one concerned the realization of a pilot plant able to treat materials with particular chemical characteristics.

The activities implemented during the project concerned:



- characterization of suitable raw materials and identification of stable production waste;
- study and development of 3 precursors of geopolymeric compounds and foaming agents, producible from **industrial waste**;
- **laboratory tests** to determine the best conditions for solidification and thermo-chemical-mechanical characterization of the obtained geopolymers;
- study and design of structured planar anti-adherent **molds**, and molds with permanent or temporary coatings;
- realization of a **mold prototype** and test of the experimental geopolymer compounds;
- construction of an **automatic weighing station** and a **grinding group**, including sieve phase, for mixing the liquid compound of the precursors and correcting viscosity;
- design and construction of a **forming station** (mold filling) and a **demolding station** (removal of the solidified product from the mold);
- design and construction of a **treatment cabin** for the post-demolding phase to ensure final solidification with controlled humidity and temperature;
- sizing and construction of a **grinding / cutting / cleaning and surface finishing station**;
- assembly of the single stations in a continuous or semi-continuous production line and evaluation of the production potential of the line when all its parts operate simultaneously;
- mass and energy balance sheet of the pilot line and **measurement of the environmental benefits** achieved in terms of emission reduction, energy saving and waste recycling.

These purely technical activities were accompanied by an extensive dissemination of the project results.

## PROJECT RESULTS

Through the realization of a pilot process for the production of a new generation of geopolymers, ENERGEO has demonstrated the possibility of manufacturing products for flooring and insulation coatings that can contribute to the reduction of CO<sub>2</sub> emissions and energy consumption compared to the production models of conventional tiles, highly polluting and unsustainable ([video](#) of the developed process and achieved results). For the production of these new products, called **Geopolfloor**, new generations of geopolymers have been developed that are compatible with continuous or semi-continuous industrial production (with very fast demolding times) and allow to **recycle waste from the ceramic industry**. In numerical terms, the **environmental results achieved** (which confirmed the forecasts made in the design phase) can be quantified as follows:

- **80% reduction in CO<sub>2</sub> emissions** (from 1,7 kg to 0,35 kg of CO<sub>2</sub> per kg of tiles produced);
- **60% reduction in energy consumption** (from 1900 Kj to 750 Kj of energy per kg of tiles);
- **zero VOC** (volatile organic compounds) **emissions** in the environment deriving from the pilot line;
- **recycling up to 60%** (instead of 40%) by weight of the waste deriving from ceramic production, which are normally sent to landfills due to their varying chemical composition. This waste is compatible with the characteristics of the new products.

Moreover it was confirmed the possibility to obtain the technical characteristics of the products, identified in laboratory in the initial phase of the project, on an industrial scale and also that the same flows of the pilot production process are compatible with the industrial production. In fact, the technical results achieved at the end of the project validated the physical and chemical properties of the developed products:

- **mechanical and thermal properties** (for example bending strength > 7 MPa, resistance up to 800 ° C);
- **thermal and acoustic insulation properties** (mainly in the Foam version);
- **no limits to the achievable dimensions**;
- **more easiness to create complex structures** (compared to stoneware / single-fired tiles);
- **no intermediate drying** (direct pouring into the mold);
- **rapid production cycle** (after 2 hours the piece can be removed from the mold);
- **no dilatometric compatibility problems** (for example splitting, cracking, bending, etc).



**Acronym**  
ENERGEO

**Number of reference**  
LIFE09 ENV/IT/000108

**Reference Programme**  
[LIFE](#)

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Ceramiche Gardenia Orchidea S.p.A.

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**EU contribution**  
926.869

**Call Year**  
2009

**Start Year**  
2010

**End Year**  
2013

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**Region**  
Emilia-Romagna

**Description**

Emilia Romagna