XLI Incontro di Studio del Ce.S.E.T.: 777-787

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The evaluation of innovative production to ensure quality in sustainable buildings*

The LaboReg has spent years to focus on the purpose of internal research on practical application of the achieved results and the involvement in all phases of business, governments and local entrepreneurs in order to anticipate times and procedures to make a decision towards sustainable solutions.
The synergy created between the academic world, the local government and the businesses has put together a research whose main objective is oriented towards the implementation of the productive sectors of the local construction materials to be used in the restoration and rehabilitation of historic buildings and new green building measures in the prospective of environmental sustainability and energy conservation.
Within the research programme, interesting results have emerged in the field of experiments called "New Historical Materials."
In this field of activity a research has emerged on the implementation of a prototype of a "new town photovoltaic roof tiles".
The study has provided a first significant result, that is the development of a model of assessment and control of production processes, and some innovative materials.

Key words: *Quality, sustainability, product innovation, process innovation, knowledge management systems*

1. Process and product innovation for the creation of a "New photovoltaic historic tile"

Betting on the objective provided by a scientific research programme can be sometimes frightening, on one hand because even today the role of university departments is not recognized by local communities, and on the other hand because the transfer of knowledge and expertise through a scientific institution is seen as something that belongs to a different dimension from that of the real problems of the territory.

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* The present industrial research pertains to one of the strands of activity LABOREG. Here, it transmits a first progress (Scientific Responsible Prof. E. Mollica, A. Postorino Scientific Coordinator, staff: S. Caroleo, M. Gulli). At the writing of this paper have collaborated S. Caroleo (section 3,4,5) and M. Gulli (section 6).

[1] Laboratory of Scientific Research applied to historical centres for technology transfer and testing of local construction materials was born in 2002 in agreement with the Department of Industry of the Calabria Region (Article 36, paragraphs 3 and 4, regional law 02.05.2001, 7. the LaboReg was directed by Prof. Edward Mollica and scientifically coordinated by the architect in operations research. Postorino Antonella. the lines of scientific laboratory research derive the setting outlined by prof. Mollica and continue in their evolution thanks to his teachings. Prof. Mollica's dream was to make a contribution in the field of research, but a new change in southern Italy is struggling to start.

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Within the research programme, interesting results have emerged in the field of experiments called "New photovoltaic historic tile".

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The study has provided a first significant result, that is the development of a model of assessment and control of production processes, and some innovative materials.

This model tends to provide indications that support the production of a innovative system to be experienced in urban areas, big or small (historic and contemporary suburbs) that can give more quality to the buildings, in architectural terms, energy, and economic integration.

2. Methodological approach

Assuming that the contemporary scenes are increasingly influenced by the need to orient innovation at the service of development of an area, the purpose of this research is to demonstrate that the appropriate connection between knowledge production and the means of finding opportunities, can support and direct inputs into local markets, innovative products with high environmental features of integration.

The prototyping of "new historical materials", in this case, the photovoltaic tile, supports a model for monitoring and evaluating the process of formulating the same materials, through the parametric analysis of factors affecting the calculation of the quality of the product and its process of production.

In this formulation and application of this model is a means used to support the patentability, to determine the implications in terms of production, design, management, economic and financial aspects which make it worthwhile putting into a future production.

The methodology of approach to issues related to process innovation and product in a territorial context, that for experimental reasons is identified with the Calabria, in which we tend to import products from other cultural backgrounds tend to move with an ex-ante issues directly related to the context of local production to proceed with an assessment of the opportunities (and potentially affordable) from the market and the needs expressed in latent form both in the recovery and the construction of new buildings.

The model is built taking into account two different urban realities and building features, so they are contextualized by giving birth to two solutions needed to control the degree of flexibility of the same model.

The first model is structured in a village with strong connotative historic and architectural features while the second one, whose phases of analysis are still underway therefore undisclosed, is constructed by considering the analysis of contemporary buildings in which there are already innovative and sustainable systems and technologies.

The first results of scientific research highlighting the need to use the tools of operational and assessment.

The experimental application can initiate a change in the trend established in the production process, through the elevation of quality levels, customized production, the formation of suitable tools to ensure the durability of the product in the market.

These activities cannot, however, be regardless of the development of a strategic programme of spreading the results. The activity of transferring knowledge to the local business and the professional world, too little sensitive to the demands of the sustainable and compatible building restoration, is one of the activities that fall within the purposes of LaboReg, which also offers assistance to companies aiming at the introduction of elements into the process and product innovation both in production and in those areas of installation of products.

The activity has ended with the realization of the prototype and the realization of the model, both the results are being refined so that they can be proposed for their possible patentability.

The first progress of the research was completed with the construction of the prototype and the realization of the model, both the results are being refined so that they can be proposed for their eventual patentability.

The research program is divided into the following phases:

a. Stage of Knowledge:
- The process of brick production in history (from craft to industrial production);
- The mining resources in the Province of Reggio Calabria (raw materials and quarry equipment);
- The brick manufacturing plants in the Province of Reggio Calabria (monitoring of active enterprises).

b. Phase analysis of the market:
- The type of brick production plants (monitoring of local businesses);
- Analysis of the products in the domestic market (types of photovoltaic tile).

c. Phase of the verification rules, constraints and incentives:
- Regulatory tools to support deployment of renewable energy (the "Energy Account").

d. Phase of prototyping:
- Comparative analysis of the parameters of economic and environmental sustainability of existing products;

- Process innovation: the range of fuels (biogas and solid biofuels);
- Product innovation: the prototype of the "New photovoltaic historic tile".

e. Phase control of the production process:
- Definition of the production process;
- Definition of production costs.

f. Phase Simulations of urban sectors:
- Simulation in the center of the province of Reggio Calabria;
- Simulation in a contemporary neighborhood (in progress).

3. Process innovation: eco-friendly choices

Often, historical and landscape constraints that persist in some areas, prevent the entry of preventing innovative construction systems to enjoy the benefits deriving from them. The idea of a "historic photovoltaic roof tile" starts from the need to want to combine the local building tradition (namely Calabria) with the use of modern technologies in order to ensure continuity of production to the market for bricks and lay the foundations for the variation of our local green economy. To do so is a process which is knowledge of the historical production systems, both of extractive resources and facilities in the territory of the Province of Reggio Calabria. The analysis was carried out through the development of control systems (analytical cards) that have permission to build a picture of the state of the art.

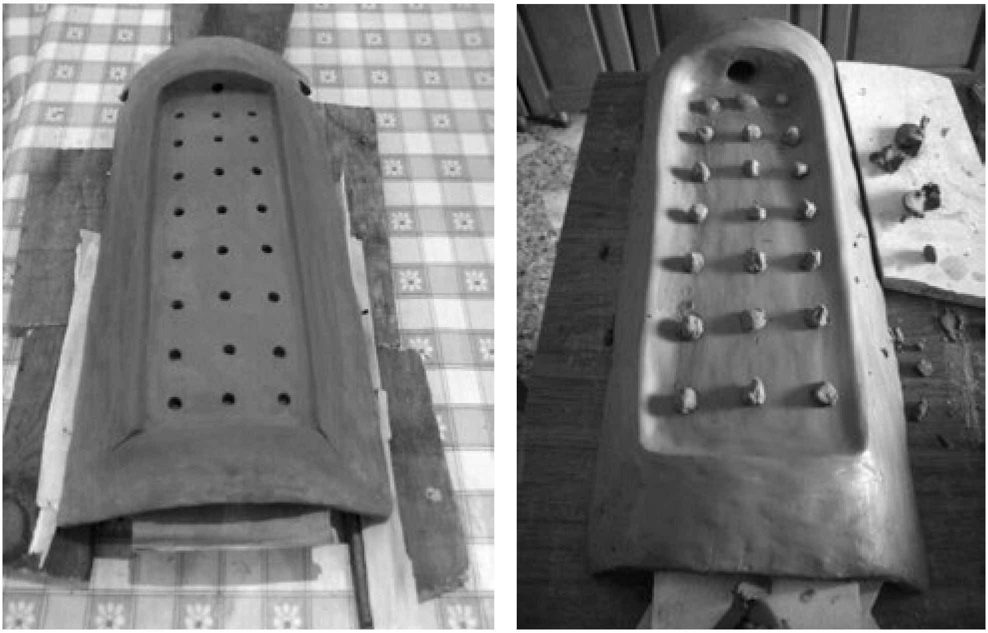
The projects collect data on the clay pits in order to identify areas for the establishment of an innovative production process, without causing irreversible environmental problems as the aim is to create a product ECO-LOGICAL.

Identified the area of supply of raw materials has proceeded with the analysis of production systems and the use of any fuel. The choice fell on the plant is a type of tunnel kiln, while for the fuel has reached the conclusion that we should focus on the use of renewable energies.

All this made possible by the integration of a production process fueled with biogas. This choice, in terms of energy, guarantees savings of 40-50 per 1000 t of TEP brick and subtracts an emission of gases into the atmosphere equal to 100 - 200 tonnes of $CO2$, making the process compatible with the ecological and sustainable production parameters .

The system object of experimentation lies in the Ionian coast of Calabria and his choice was evaluated according to the type of production system, availability of raw materials, logistics and supply of transport fuels.

Figure 1. The prototype of the "New photovoltaic historic tile".



4. Parameters of economic and environmental sustainability of the product and financing instruments

Before defining the criteria needed for the formulation and implementation of the "New photovoltaic historic tile" has launched a study on the types of photovoltaic tiles in the domestic market and these if they have made a general classification as a function of other parameters.

The performance analysis based on the verification of requirements and performance held by the products on the market, in terms of welfare, security, integration, management, appearance and cost, through a comparison of the experimentally determined values, provided the optimal values for the definition of the prototype.

The study took into account the material with which they were commercially made tiles (clay or plastic), the m2 necessary to achieve 1 kW of power, the power installed, the type of panel and cost.

The technical choices overlapped the regulatory framework (the fourth in tariff) that led to the formulation of the performance levels of the "New photovoltaic historic tile".

The Energy Bill is the fourth program of incentives for operating expenses for the promotion of electricity from solar energy, which gives an economic incentive as a function of kWh produced by the plant. The new facility is governed by Ministerial Decree 05/05/2011 that establishes four types of plants. Among these four types of what has been considered for searching is laid down in Title III of the DM which states that the photovoltaic modules that use non-conventional and special components, developed specifically to integrate architectural elements to replace the buildings, are entitled to specific tariffs that are listed in Table 1. From this it follows that the photovoltaic tiles are among the innovative and integrated systems and can therefore benefit from maximum incentives therefore create a new product that has both performance and quality standards can be applied in contexts undergoing bond, guarantee the question of compatible materials for the recovery of historical interventions and also for bio-architecture.

Table 1. Rates provided for in the Ministerial Decree 05.05.2011

Rate Power	Renge corresponds
KW	€/KW
$1 \leq P \leq 20$	0,427
$20 < P \leq 200$	0,388
$P > 200$	0,359

5. Product Innovation: The prototype of the "New photovoltaic historic tile "

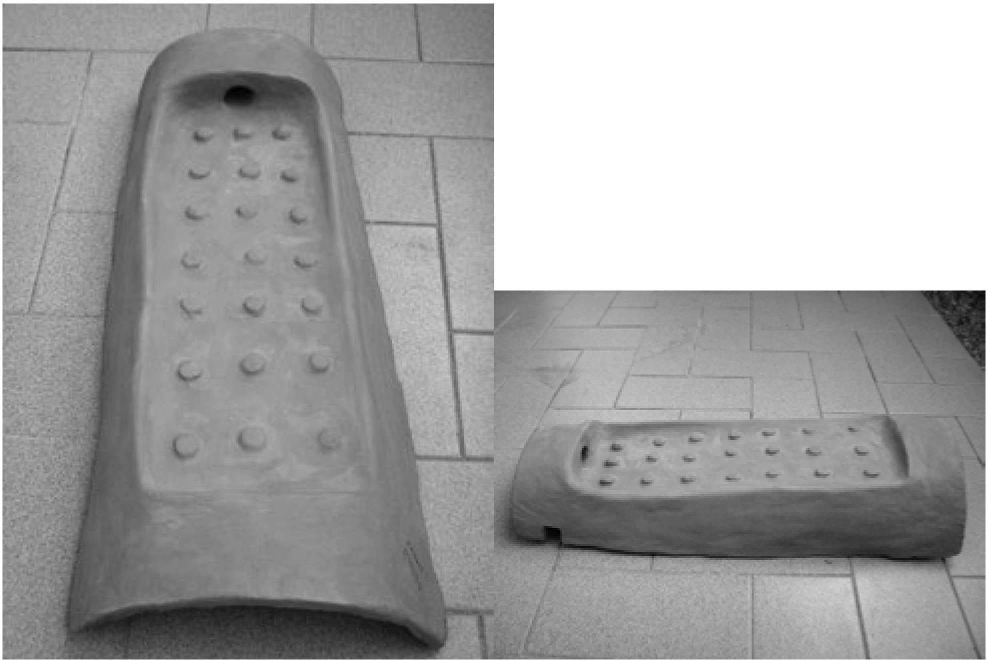
After defining the quality parameters are passed to the design and construction of a new prototype of a photovoltaic tile, with a new design that respects the traditional tile used in the Calabrian town centers. It is a clay tile which have been made have not been added materials of chemical origin. This type of tile is mounted as a traditional tile, panel, monocrystalline silicon is housed on its concave side, where was built a circular base with buttons sloped to allow ventilation and to ensure an adequate temperature value for the purpose of increased production of energy. The upper end of the housing has been made a hole for wiring.

A preliminary test shows that when you can install a panel with a capacity of 4.8 Wp, but it may be replaced later with a more powerful one.

On the sides of the upper extremity of the tile were made of interlocking connection terminals to ensure the fit between the tiles.

The prototype captures all the functional features of a traditional brick and tile modern photovoltaic technology, while maintaining almost unchanged appearance of the building which will be mounted. In conclusion, we must also point out that are not edited or altered the properties of heat storage of the typical brick and even those of the outflow channels and the installation of a bypass makes the system free from problems created by mobile or unexpected shading (trees, chimneys, antennas, leaves, etc.)

Figure 2. The prototype of the “New photovoltaic historic tile”.



6. Definition of the production costs of the “New photovoltaic historic tile” and experimental application in a historic village

At this stage the main objective of the research was to combine the principles of conservation of historic towns with technological innovation and renewable energy production.

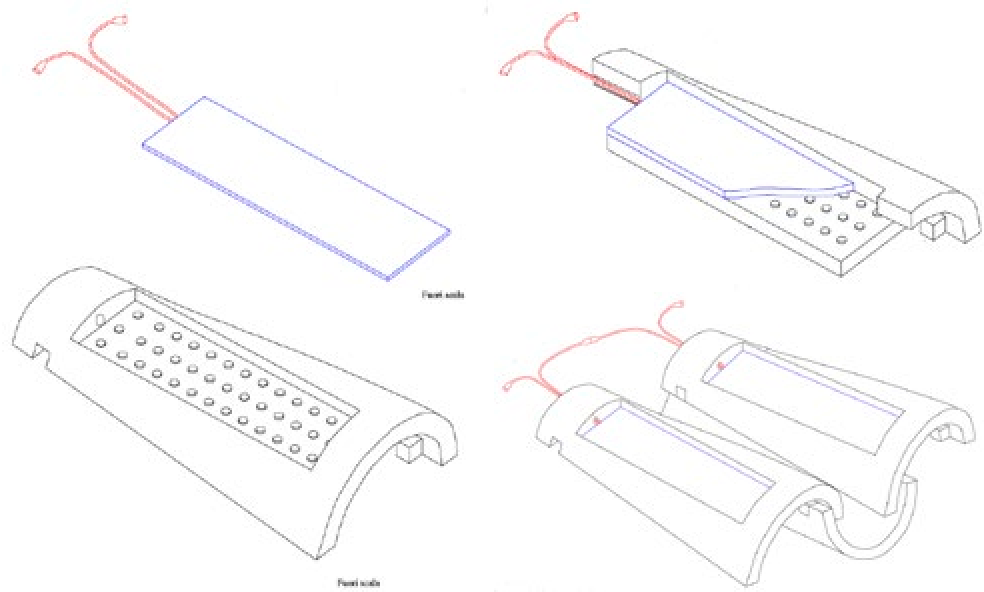
On this basis the “New photovoltaic historic tile” developed on the basis of tiles traditionally found within the building Calabria, differs from photovoltaic tiles on the market as the surface of the solar panel is fully incorporated in the element in tile, so the ‘visual impact is minimal and can be used in the recovery of a village with certain characteristics and historical construction’.

In the definition of the prototype, as well as to assess the purely technical aspects related to design and satisfaction of quality parameters were monitored production costs in brick element and solar panel integrated into it.

Through an analysis of prices[2] has estimated the cost of experimental production of tile corresponding to 19.43 euros, complete with photovoltaic panels and connecting cables.

[2] For the cost you would like to thank the collaboration of ANTICHE TERRE SRL

Figure 3. The prototype of the “New photovoltaic historic tile”.



With this type of tile, to produce 3 kW of energy must be used n.3 photovoltaic panels cover an area of approximately 28.5 square meters for a total cost of 13,532,61 euros, so for a square meter of the cost of ‘whole system is 522.31 euros / sqm’ (table 2).

By comparison with the application of an integrated photovoltaic panels that will produce 3 kW of energy must be used No 14 (186x86) that occupy an area of approximately 22.39 square meters for a total cost of 10,350.00 euro, so that for a square meter of surface the cost of the entire system is equal to 508.49 Euro / m^2 (Table 3).

This comparison shows that the system with photovoltaic roof tiles at a cost of 522.31 euro / sqm, while the one with photovoltaic panels at a cost of 508.49 euros / m^2, for a difference of 13.82 euro / sqm. The annual energy production, assumed at this stage of experimentation, is equal to 3kw and can hardly meet the needs of all residents of a city center, but it can help provide electricity for public lighting through an agreement between private individuals and entities public.

A plant produces about 3kW 4300Kw year, net of any losses, using the incentives currently in force (Decree of 05.05.2011), under the energy bill for the month of November 2011, you configure two different scenarios:

1. Photovoltaic system with tile: state incentives for innovative plants (defined as “systems on buildings”) amounted to 0.32 euro / kW, which multiplied the annual output of 3 kW is a plant will have an annual cost of:

Table 2. Estimated cost of an integrated innovative 3 kW produced with the "New photovoltaic historic tile".

System components	Unit of measure	Quantity	Unit Cost Euro	Total Cost Euro
Roof tile brick (4.8 W)	n.	627	19,43	12.182,61
Framework of field	n.	1	300,00	300,00
Inverter	Kw	1	300,00	300,00
Wiring	Kw	1	200,00	200,00
Manpower	A body		300,00	300,00
Education practice	A body		250,00	250,00
1. Partial cost system with innovative integrated photovoltaic roof tile				13.532,61
Maintenance (2 (2% di 1)				270,65
Replacing the inverter (5% of 1)				676,63
Insurance (3% of 1)				405,98
2. Total cost system with innovative integrated photovoltaic roof tile				14.885,87
Estimated cost sqm				522,31

Table 3. Estimated cost of an integrated 3 kW photovoltaic panels

System components	Unit of measure	Quantity	Unit Cost Euro	Total Cost Euro
Photovoltaic panels with dimensions of 186cmx86cm (220 W) n.14	Kw	3	3.000,00	9.000,00
Framework of field	n.	1	300,00	300,00
Inverter	Kw	1	300,00	300,00
Wiring	Kw	1	200,00	200,00
Manpower	A body		300,00	300,00
Education practice	A body		250,00	250,00
1. Partial cost system with innovative integrated photovoltaic roof tile				10.350,00
Maintenance (2 (2% di 1)				207,00
Replacing the inverter (5% of 1)				517,50
Insurance (3% of 1)				310,50
2. Total cost of photovoltaic panels				11.385,00
Estimated cost sqm				508,49

4300Kw x 0.32 = EUR 1376.00 euro / year

2. System with solar panels: state incentives for simple (called "other photovoltaic systems") amounted to 0.28 euro / kW, which multiplied the annual output of 3 kW is a plant will have an annual cost of:

4300Kw x 0.28 = EUR 1204.00 euro / year

The difference between the incentives provided by the energy bill currently in force is 172 euro more provided by an integrated innovative as that of tile "historic" PV, the highest costs to be incurred in a plant of this kind with respect to the traditional can be recovered over a period of time quite low.

At present the costs assumed are those of the trial and are not representative of a production system, must therefore be further examined and evaluated.

Figure 4. "New photovoltaic historic tile " and experimental application in a historic village.

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