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SUSTAINABLE CLAY BRICK PRODUCTION – A CASE STUDY

Fritz Moedinger[1]

[1] Ziegelei Gasser Mattoni GmbH S.r.l., Schabs 104 Ziegeleistr., Naz-Sciaves BZ 39040, Italy Southtyrol, fritz.moedinger@gmx.net

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Summary

Energy sources used in the clay brick making process worldwide are dominantly derived from fossil fuels. However, through innovative development it has been shown possible for the these traditional sources to be successfully replaced by renewable alternatives reducing greenhouse gas emissions to almost zero. In a further innovative step it has been possible to introduce a selective blend of solid by-products wastes into the manufactured bricks to partially replace normally quarried clay.The challenge we face is to achieve an equitable development for all human beings, including future generations, while preserving the integrity of the global environment. One way to do so is to aim at a new growth paradigm and a higher quality of life through wealth creation and competitiveness on the basis of products with a smaller environmental footprint using less resources. In this case study implementation and communication to various stakeholders of this paradigm related to a clay brick production process is discussed.

1. Introduction

Organic, ecologic / environmentally friendly, sustainable. These terms are frequently interchanged one for the other leading to misunderstandings. Ecology defines interactions between organisms and their physical habitat, which can be described as the sum of local factors like climate and geology, as well as the other organisms which share its ecosystems and biosphere. In daily life we use the term "organic" commonly for food that is produced respecting existing complex eco-systems and their interactions. Sustainable stands for the ability to maintain into perpetuity our habitat and lifestyle without exhausting any natural resources.

The degree of sustainability of a production process can be measured by these criteria:

- Total energy content - i.e. the energy that is required to produce, package, distribute, use and dispose of a specific product;
- Consumption of the environment – land for building or mining, forest depilation;
- Emissions – greenhouse gases, dust, other chemical and natural substances;
- Raw materials – non renewable resources depilation;
- Waste generation – packing, production, use;
- Recyclability – generation of secondary waste cycles:
- Capital – least cost;
- Durability -longer periods of usage mean lesser consumption of resources.

The above criteria are dealt with in detail in this paper.

A possibility to communicate sustainability to stakeholders is be means of Environmental Product Declarations (EPD), based on Life Cycle Analysis (LCA). EPD's are a standardized vehicle to inform the recipient of the product about the comparative environmental quality of same or similar goods of the same class of products:

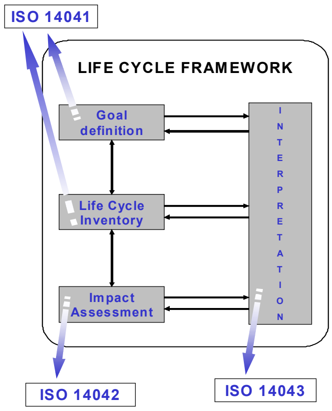

Figure 1: LCA scheme

LCA operate with a number of environmental impact categories, such as “climate change (global warming)”, “stratospheric ozone depletion”, “human toxicity”, “eco-toxicity”, “photo-oxidant formation”, “acidification”, “nutrification” and “land use”.

There are several benefits from using systematic environmental information schemes in the construction sector. EPD information, published in the form of a type III ISO 14020 compliant environmental product declaration checked and verified by an independent and competent third party, will assist stakeholders such as architects, contractors, and purchasers in their choice of products (for a specific application) and in the use and maintenance of construction works. Certified environmental product declarations do not include any form of subjective judgment or valuation of the environmental performance. Hence, no predetermined performance levels are set, but a carefully specified calculation and reporting procedure to be followed and the result communicated disclosed to the public on a transparent and understandable way.

Such information will allow environmental impact benchmarking of construction materials and hence finished buildings. This is true especially if a LCA design approach is used that allows for environmental impact appraisal already at the design stage. Companies will hence be able not only to analyze and monitor their own progress in comparison to others with regards to sustainable production but will certainly be a key factor in consumer decision in favor of a given groups of products or method of construction (i.e. choosing a brick wall over a concrete wall by example).

In the construction sector information about the environmental performance of materials and products has been collected and published for several years in a number of countries (AIMCC in France, AUB in Germany, the BRE Environmental Profiles in the United Kingdom, MRPI in Netherlands, RTS Format in Finland and SIA Deklarationsraster in Switzerland) albeit most of this systems are not comparable as they are not ISO compliant. The information value of non compliant environmental product declarations is to be doubted.

2. Why reducing the environmental footprint

Gasser tries hard to be a socially responsible corporate citizen. Good relations have been established with all stakeholders since the Gasser company has been established in 1889. In the early days the brickyard used to be the only employer in the area then granting a place of work to more than 100 people.

Figure 2: Aerial view of the brickyard (on the left the brickyard – village of Sciaves to the right)

In the interest of ever improving the relationship between the brickyard and the various stakeholders, not the least tourists, this project aimed at reducing the environmental footprint of the operation has been undertaken. A lot of things are left to do: for example the waste energy of the brickyard could be used to heat nearby houses and hotels saving about 1,500 to 3,500 tons of heating oil or the equivalent in natural gas.

3. Criteria of sustainability of a production process

3.1 Energy content

Clay masonry units are usually and generally understood as a sustainable product. The environmental impact of the production process is mostly due to the consumption of energy for the firing of the bricks and quarrying of raw materials. The average direct energy consumption of the production process is to be found ranging between 1.840 and 2.800 kJ/kg of fired brick (of which about 150 kJ/kg are electrical). Today bricks are usually fired in a tunnel kiln in which fire remains stationary and bricks are moved on kiln cars through a tunnel divided preheat, firing and cooling zones. To the process energy content of the product, or grey energy, energy contents due to transport and production of raw materials must be added in order to obtain the overall environmental impact. A good assumption is to calculate this additional energy content with about 800 to 1.250 kJ/kg of fired brick.

Table 1: energy content values for selected construction materials

	Bulk density kg/m3	Energy content MJ/m3
Brick fired with fossil fuels	700	2,524.20
Reinforced concrete	2,400	5,264,90
EPS	20	1,928.00
Rockwool	80	1,399,40

All of this energy used is traditionally generated with fossil fuels. At the Gasser brickyard fossil fuels have been substituted successfully with renewable fuels such as biogas and liquefied rendering fat. The biogas is generated in an own plant based upon a process patented internationally by the brickyard itself. Rendering fat is supplied from rendering plants. Renewable fuels have the main advantage over fossil fuels that the resulting flue gases feature a lower content of contaminants such allowing to heat up the brick dryer directly by recycling the flue gases instead of having to have a separate source of heat to run the dryer. The achieved total heat requirement reduction alone by this measure is about 30% of the former total heat requirement.

Table 2: energy content fossil fuel fired brick ./. renewable fuels fired brick

	Bulk density kg/m3	Energy content MJ/m3
Brick fired with fossil fuels	700	2,524.20
Brick fired with renewable fuels	700	910

The brick fired with renewable fuels features the least energy content of all building products available on the market today.

3. 2 Land for mining

Traditional brick production requires extensive mining operations using land. The term “land use” is used to denote those human activities which occupy an area of land. In the field of life cycle assessment, the term “land use” or “land use impacts” is used to denote the environmental impacts related to physical occupation and transformation of land areas. At Gasser mining of raw materials has been greatly reduced by substituting quarried materials with waste materials. Nevertheless quarry operations require great attention in the future in order to further minimize the impact. A measure to reduce the impact of the mining operations is to rebuilt mining areas at the end of their useful life. At Gasser we have been really successful in this. The soccer field of the village of Schabs is built in an area formerly used as a quarry.

3. 3 Emissions of the production process

The emission data for the Gasser brickyard running on renewable fuels are among the lowest in the industry.

Table 3: emission data fossil fuel fired brick ./. renewable fuels fired brick

	Unit	Industry		Gasser 2004
		Min	Max	
Dust	mg/m^3	1	30	2.63
NO_x as NO_2		10	550	22.0
SO_x as SO_2		10	200	4.53
Fluoride as HF		1	120	0.28
Chloride as HCl		1	20	4.04
Total organic		50	250	Not measurable
Ethanol average	mg/kg brick	3,1		<0,01
Benzol	mg/m^3	1	65	
Methanol avera	mg/kg brick	5,7		
Phenol	mg/m^3	5	100	
Formaldehyde		1	20	
Aldehyde (S C1 – C4)		1	180	
Carbonmonoxide		<300	< 1.500	78.52

It has been possible, as a result of the carbonaceous and fluxing properties of the by-products used in substitution of traditional raw materials and optimization of the feedstock, to reduce the firing temperature of the bricks considerably resulting in a much lower heat requirement than before. The emission of non fuel related substances such as chlorides and fluorides have been reduced drastically due to optimization of the firing process itself.

Table 4: avoided emissions due to the use of renewable fuels in tons per year

	t/a
CO_2	3.900
SO_x as SO_2	3.950
NO_x as NO_2	1.752

3.2 Raw materials

The successful introduction of a selective blend of solid by-product wastes into the feedstock replacing quarried raw materials has an immediate effect: The lesser the use of primary raw materials the lesser the environmental footprint of a production process.

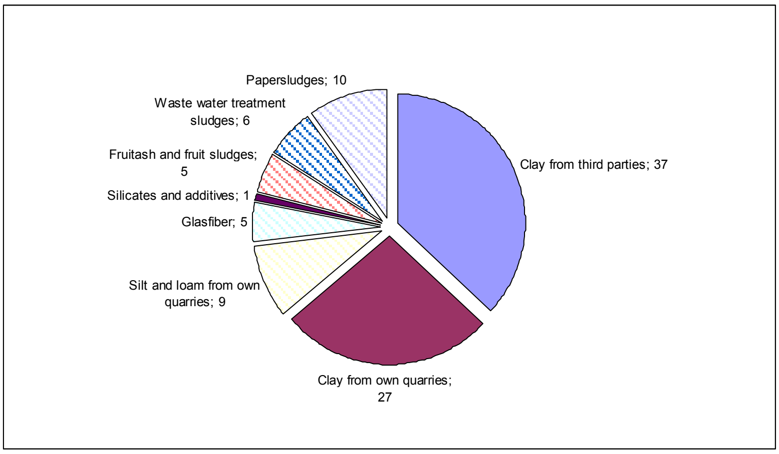

Figure 3: Material consumption in % of total material input flow

3.3 Waste generation

During the life cycle of the brick only a very limited amount of waste is generated. Industry studies put the waste generation at around 1.2 g per kg of product. This includes packaging waste at all levels of the production and use phase of the brick itself. At Gasser schemes for recycling any packing material used in shipping the produced clay bricks are in use.

3.4 Recyclability

Clay bricks themselves can be recycled without any problems if they have not been contaminated during their use phase with any substances or products that will make it difficult of impossible to recycle them. The substances that might cause problems in recycling bricks are mortars, glues, wire and plumbing, paint and similar substances. It is the obligation of the planner to design for future recyclability by considering how the building can be recycled and possibly disassembled.

3.5 Cost

Common believe is, that everything sustainable is necessarily expensive. Money is a resource on pair with others. Producing at lower costs hence means a greater degree of sustainability. The most prominent single expense in brick manufacturing is energy:

Table 4: energy expenses of the brickyard

	2000	2003
Fuel	100	25
Electricity	100	100

The electricity bill has not changed. This is in part due to an increase in the price of electricity itself, between 2000 and 2003 an increase of 8% and installation of new machinery that has offset the savings achieved in the existing plant. A dramatic change will occur once the brickyard will start the production of green energy with a biogas powered plant.

Table 5: raw material expenses of the brickyard

	2000	2003
Quarry	100	90
Third party	100	0

The cost of the quarry operation does not change over the years. A certain amount has to be set aside for every ton of material extracted for future environmental reconstruction of the quarry site. A dramatic change has occurred in the cost of material from third parties: the substitution of bought raw materials with recycling materials has more than offset the expenses up to then sustained.

3.6 Durability

Any construction activity requires resources that are incorporated into the building. These resources are consumed for as long as the building is used. Longer periods of usage hence means lesser consumption of resources. A similar concept applies for renovation or modification during the lifecycle of the building itself. The service life of brick buildings is long. The building itself can be adapted to new or changed uses with relatively little effort and expenditure.

Brick buildings also require limited maintenance during their life cycle.

4 Milestones of the sustainable clay brick production project

We have come a long way since Gasser decided to reduce the environmental foot print of its brick making operation well below all known industry standards. Milestones “on the way to sustainability”:

- 1999: development of a proprietary and patented conditioning process for waste water treatment sludge to be used as pore forming substance in brick making;
- 2001: Substitution of the hitherto used pore forming agents with conditioned waste water treatment sludge:
  Reduction by 15% of the consumption of fossil energy;
- 2002: Development of a Ceramic Matrix Body with a firing temperature of 760°V (instead of 960!) allowing a further reduction in the quantitiy of fossil fuels neeed.

Increase in the use of waste water treatment sludged thus reducing the volume of quarried materials;

- 2003: Laboratory test with renewable fuels. A two stage post kiln internal post combustion system is installed and put into service. First tests with a transportable biogas plant.

Figure 4: Containerized biogas test plant

The hitherto used #5 boiler oil is gradually substituted with rendering fat. With the end of the year no more fossil fuels are used in the brickyard.

- 2004: Substitution of the hitherto used paper sludge with waste water treatment sludge in order to reduce process related CO2 emissions (carbonization). Installation of a flue gas recovery system thus reducing the direct energy need by 30%:
A new electronically controlled dual fuel high speed burner system is installed:

Figure 5:Installation of new dual fuel high speed burners

A second biogas plant, based on the patented Gasser ECOGen process, is built and put into service:

Figure 6: Building of the pilot plant

5 Conclusion

Decreasing the environmental footprint of the plant operation is a win win situation for the Gasser company both from a financial as from an environmental point of view.The substitution of traditional raw materials with selected waste materials and of fossil fuels with renewable fuels in the Gasser brickyard is a good example that "renewable" and "sustainable" does not have to the consequence of an increase in costs but can rather lead to substantial savings.

The relationship with all stakeholders has greatly improved: All measures have been taken without any detrimental effects on product quality or workplace safety.

Using a sustainable product such as the one presented here for building is a contribution to greatly reduce the environmental footprint of an entire project without causing any additional expenses.

6 Literature

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