ENERGY EFFICIENCY BEGINS WITH THE DESIGN OF THE CERAMIC PLANT

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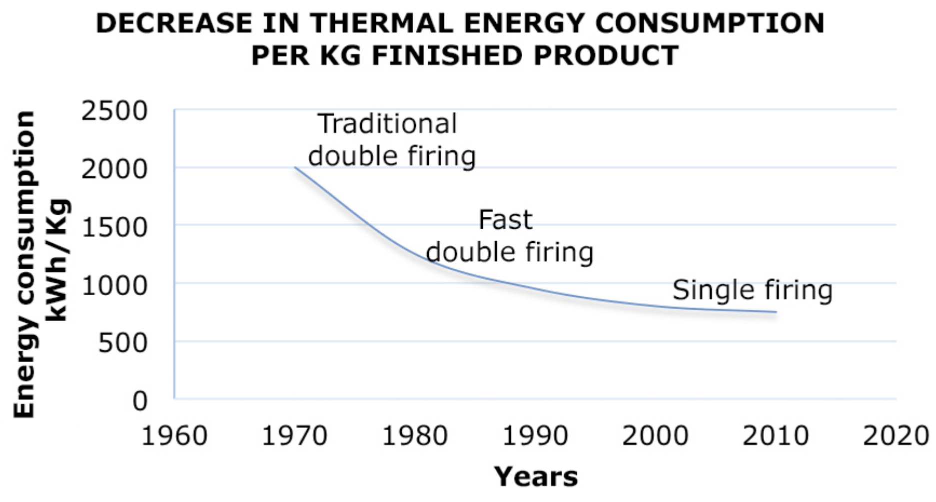
ABSTRACT

The current ceramic process is an example of intensive energy activity, whether in the form of electric energy or process heat. A standard plant demands tens of gigawatts of heat and electricity, both in the process and in the facilities and, owing to the great surface area it occupies, in lighting systems. This thus constitutes an industrial sector in which energy savings can be very high.

With the introduction of hydraulic presses and roller kilns, in a context of acceptable energy prices, the spectacular reduction in costs in all production factors provided good business prospects. This circumstance initially took some of the attention of industrial technicians and entrepreneurs away from reducing energy costs.

The gradual change in the energy scene and the entry into the ceramics market of competitors from geographically distant areas narrowed business margins and drove manufacturers of industrial facilities to develop and market more efficient systems. Thus, with lower specific energy consumption per unit finished product, the direct cost improved for their clients.



Source. Compiled by author from sector data.

Other important energy savings, stemming from improved design of building constructions and industrial facilities for the ceramic process, from energy recovery procedures between heat sources and sinks among process units, and the coordinated incorporation of alternative energy sources, **also contributed to reducing energy costs**.

THE ENERGY BATTLE

Since the ceramic process, as noted, consumes a large amount of energy, and energy costs are rising steadily without any foreseeable change in this trend, industrial ceramic sector companies that do not achieve better energy efficiency than their competitors will be faced with a deterioration of their competitive cost structure.

THE CO_2 BATTLE

Industrial ceramic sector companies must develop, in their operations, a culture of sustainable energy and materials use, in order to significantly reduce harmful emissions and evolve towards a low-carbon society by efficient use of resources and clean energies. **NOTE: 500 ppm CO_2 scenario in 2050**.

1. OBJECTIVE

This presentation sets out the criteria for reducing energy needs and presents an estimate of the results to be expected from:

1. Plant layout: Plant layout is understood as the relative situation between the different sections of the process and the factory buildings. Appropriate plant layout enables energy saving systems to be adopted or losses to be reduced, which in short means lower energy consumption.

2. Industrial buildings and installations: The buildings in regard to their constructive type, design, and orientation and the industrial installations (electric power, gas, air, water, wastewater, thermal conditioning, etc.) in their definition and situation with relation to the industrial equipment and regulation constitute an energy saving factor with a verifiable influence on the finished product cost.

3. The interrelationship between heat sources and sinks: The heat sources of the basic process itself (tile firing kilns) generate hot gases that, recovered to other points in the process where heat is needed (dryers and spray dryer) by gas pipes and heat exchangers, reduce gas consumption.

4. The application of renewable energy sources at points where this is feasible (electric power from photovoltaic panels and wind-driven generators, and heat from low-temperature thermal solar panels).

5. Lower greenhouse gas emissions.

The energy saving by the production facilities themselves is an issue addressed in the design and development plans of the manufacturers of industrial facilities.

2. THE MODEL PLANT

This presentation considers a plant with a large production capacity, in which the working facilities are not detailed, such as the modern plant with a high level of scale economies, which applies the extensive curve of sectoral experience. In short, it is a large production complex into which more sophisticated working cycles are introduced in heat production, use, and recovery.

The plant is assumed to be connected to an external high-voltage electric grid with sufficient power not to need turbines coupled to electric generators. In addition, it is also assumed to be connected to a natural gas pipeline with a sufficient volume flow rate to meet the heat generation needs of the installation.

The chosen product is Porcelain Tile in sizes up to 80x80 cm, the spray-drying and ceramic processes being linked in a single plant with the following features:

1. In spray-dried powder production, heat generation takes place exclusively by gas burners, as the risk involved in the variability of energy financial returns within the changing frame of the Electricity Regime advises against introducing a turbine–generator.

2. Decoration is performed by injection devices with engobe effect, of base glaze and decorations, with complementary machines in a centrally managed array, avoiding the use of water and, consequently, there being no channels for the collection of cleaning water (smaller capital outlay).

3. The facilities that determine production (spray-dried powder, presses, dryers, decoration, and kilns) are sized such as to always work simultaneously and continuously. Thus, spray-dried powder silo capacity is only for 50 hours'

consumption in the ceramic plant, the silos being compatible with cleaning or revisions in the spray-dried powder zone. To avoid production losses, the unfired and fired product buffers are also limited to a minimum compatible with the risk of breakdowns.

4. The finished product store is designed by combining cubic piling of the models with the greatest turnover (40%/50% of production) and automatic storage with stacker cranes for the other products.

PORCELAIN TILE (22 kg/m^2)			
ITEM	DESCRIPTION	QUANTITY	UNIT
1	FLOOR TILE Daily capacity	50.000	m^3/day
2	CLAYS / MPP	1.100	Tonne/day
3	METHANE GAS Kilns and spray dryers	135.000	Nm^3/day
4	ELECTRIC POWER	5.500	Kw
5	WATER	500	m^3/day
6	FINISHED PRODUCT STORE	5.000.000	m^2

PARÁMETROS GENERALES DE PLANTA

3. PLANT LAYOUT

Energy saving stemming from the design of the machinery layout in a plant is not usually envisaged as a company competitive advantage and quality factor. The basic ideas to be considered in the technical design of plant layout are as follows:

A. Sequential linking of the spray-drying process with the ceramic process.

When the spray-drying and ceramic processes are carried out together in a single plant, truck loading systems in the plant disappear as does transport of the spray-dried to the ceramic plant. In the direct costs, this leads to lower amortisation of tied-up capital and eliminates transport from the cost structure.

An enormous quantity of heat is released in kiln cooling. Owing to better design by machine manufacturers, part of this heat is used to raise combustion air temperature, reducing gas consumption in the burners

The rest of the heat, which would be lost through the stack and in the kiln environment, with an increase in ambient temperature, is recovered and mixed with ambient air in the spray-dryer burner, reducing gas consumption in these facilities.

B. Centrally positioning units with greater electric power.

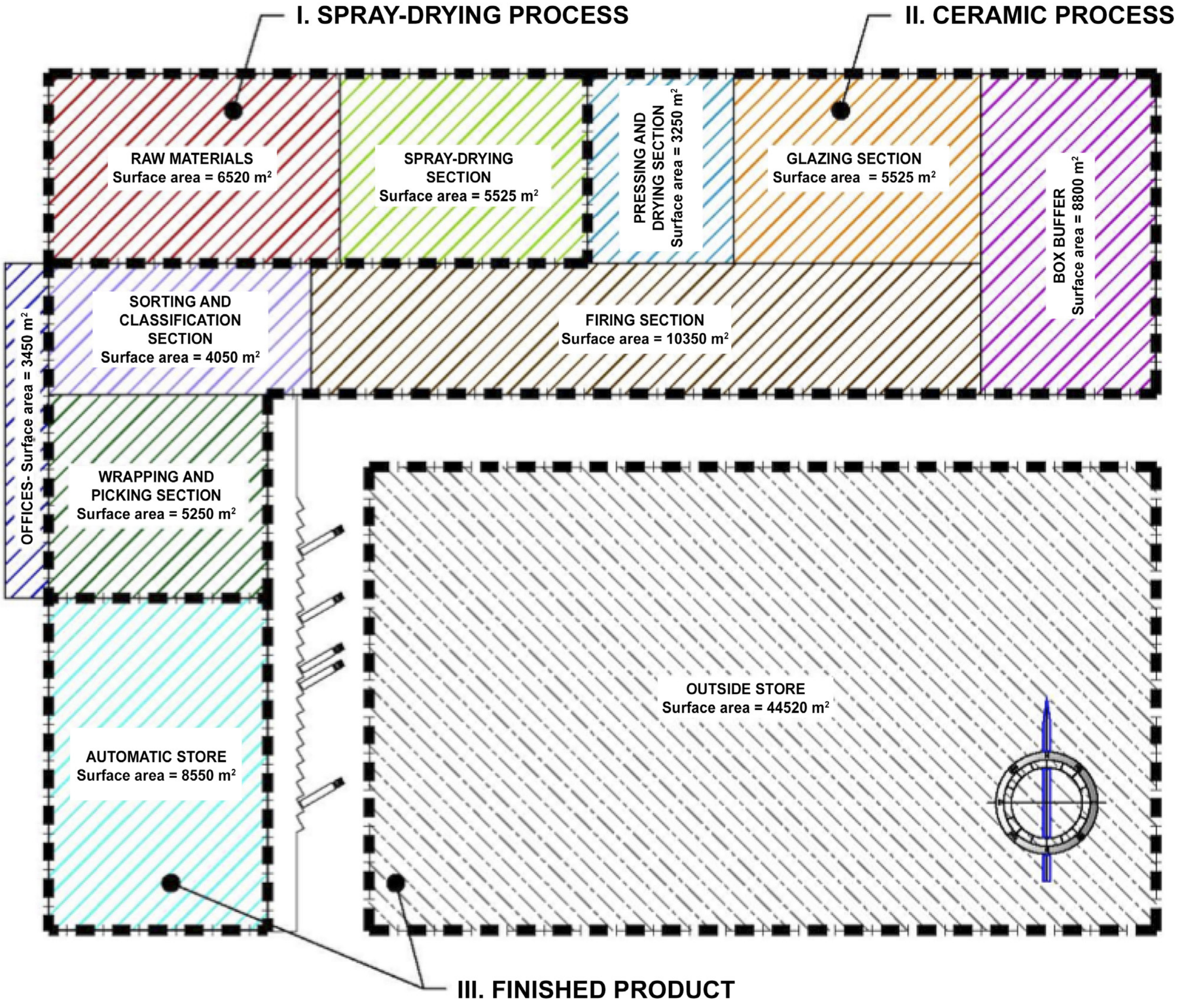
In the spray-drying zone in this plant, an installed power of 2000 kW is concentrated in a very small area. When the spray-drying process is joined with the ceramic plant, it becomes possible to mount the press and dryer section, also with an installed power of about 2000 kW, near the previous area. This concentrates 80% of the electric power in the factory in an area 100 metres long.

The transformers are set at the centre of gravity of that array of units and the internal LV distribution is set at 690 V, so that the savings from the layout units itself, from downsizing the section, and from lower losses in the conductors are very high.

C. Work in 3 shifts, 7 days per week.

In the ceramic process, the production rhythm is established by the kiln section with non-stop work 24 hours a day all year round (21 weekly shifts of 8 hours). If the other plant sections work fewer shifts per week, these will need to be made larger in order to be able to feed the kiln without any breaks.

With a non-stop way of working, all sections work 24 hours a day, 7 days a week, and production lines can therefore be smaller or fewer to keep up with the pace of the kilns. The buffers for spray-dried powder, unfired tiles, and fired tiles are reduced to a minimum to cover kiln input and output if breakdowns take place or revisions need to be made. The savings materialise in a smaller capital outlay in machinery and in greater efficiency of the installed machine.



AREAS ACCORDING TO THE PROCESS

4. INDUSTRIAL BUILDINGS AND INSTALLATIONS

The industrial buildings and installations are also designed for lower energy consumption according to energy efficiency criteria.

A. Thermal insulation of industrial buildings.

The temperature difference between the outside and inside of a building produces corrosive condensations (on belts and roofing, side building enclosures, lighting units, etc.), which fall as drops on the floor or working facilities, sometimes damaging these.

The energy saving from thermally insulating the buildings with roofing and façade enclosures with panel insulation, avoiding condensations, lead to longer service life of metal items, floors, and facilities, which require no capital outlay for renewal or repair.

B. Buildings taller than the industrial equipment.

If the height of building constructions hardly exceeds that of the production equipment and its installations, ventilation by convection is reduced, and charged, stratified atmospheres develop. This causes more condensations, also inside electric control panels and ducts, and produces an environment loaded with dust and humidity that can harm machines and people.

Making building constructions much taller than the height of the equipment substantially improves the working atmosphere, reduces the humidity and the temperature differences, and increases the free circulation of streams that carry away airborne dust, enhancing worker and machine productivity and producing less damage to equipment: in short, it provides energy saving.

C. Decoration zone – thermally conditioned glazing.

For proper operation of industrial inkjet or water-based glaze application units, temperature and humidity must be kept very precisely and steadily within a narrow margin (20–25 ºC/50–60% RH). This keeps down costs resulting from scatter in colours and calibres and decoration finishes: energy saving.

Consequently, this plant zone is separated from the other sections and from the outside by enclosures that insulate it thermally, and thermal conditioning and ventilation systems, which provide heating in winter and cooling in summer, are incorporated into it to always maintain the same ambient conditions.

D. The kiln zone is insulated from the rest of the plant.

This zone must be insulated from the rest of the plant in order not to affect ambient conditions, owing to the heat that is generated. The enclosures must be fitted with thermal insulation and there must be an extensive section for ventilation, with a certain ambient control in the building area, avoiding excess heat in summer and low temperatures in winter.

Fluctuations in the kiln ambient are reduced and kiln operating regularity is improved, thus producing greater stability in kiln chamber conditions and lower costs by reducing the scatter in colours and calibres: energy saving.

In addition, in winter, the heat from the kiln zone can be recovered in a controlled way to other areas of the plant that need it (sorting, box buffer, etc.) to control their ambient conditions: energy saving.

E. Building roofs.

The roof structure and the type of enclosure must be able to accept the extra load and anchoring of the features that use sunlight: thermal solar panels and photovoltaic solar panels. A certain percentage of translucent areas is installed, depending on the light conditions of the geographic zone involved, coordinated with the solar panels, to decrease the need for artificial lighting during the day.

F. The orientation and relative situation of the buildings.

The building orientation allows daylight to be used for internal lighting and the quantity of radiation received in the thermal and photovoltaic sheets to be optimised. Zones are left in external façades through which daylight can come in. In addition, in regard to their relative situation, the buildings are designed such that if production increases and machines are added, the new building constructions can be integrated into the initial ones without costs for demolition or unexpected and unnecessary renovation.

G. The automatic stand-alone store.

The pallets with finished products that have a lower turnover (50–60% of production) are located in an automatic store with self-supporting racks and stacker cranes, the pallets being loading directly from the pallet wrappers, thus eliminating most of the self-propelled pallet trucks: energy saving. The use of stacker cranes is the most economical way, requiring the least energy, of moving pallet loads.

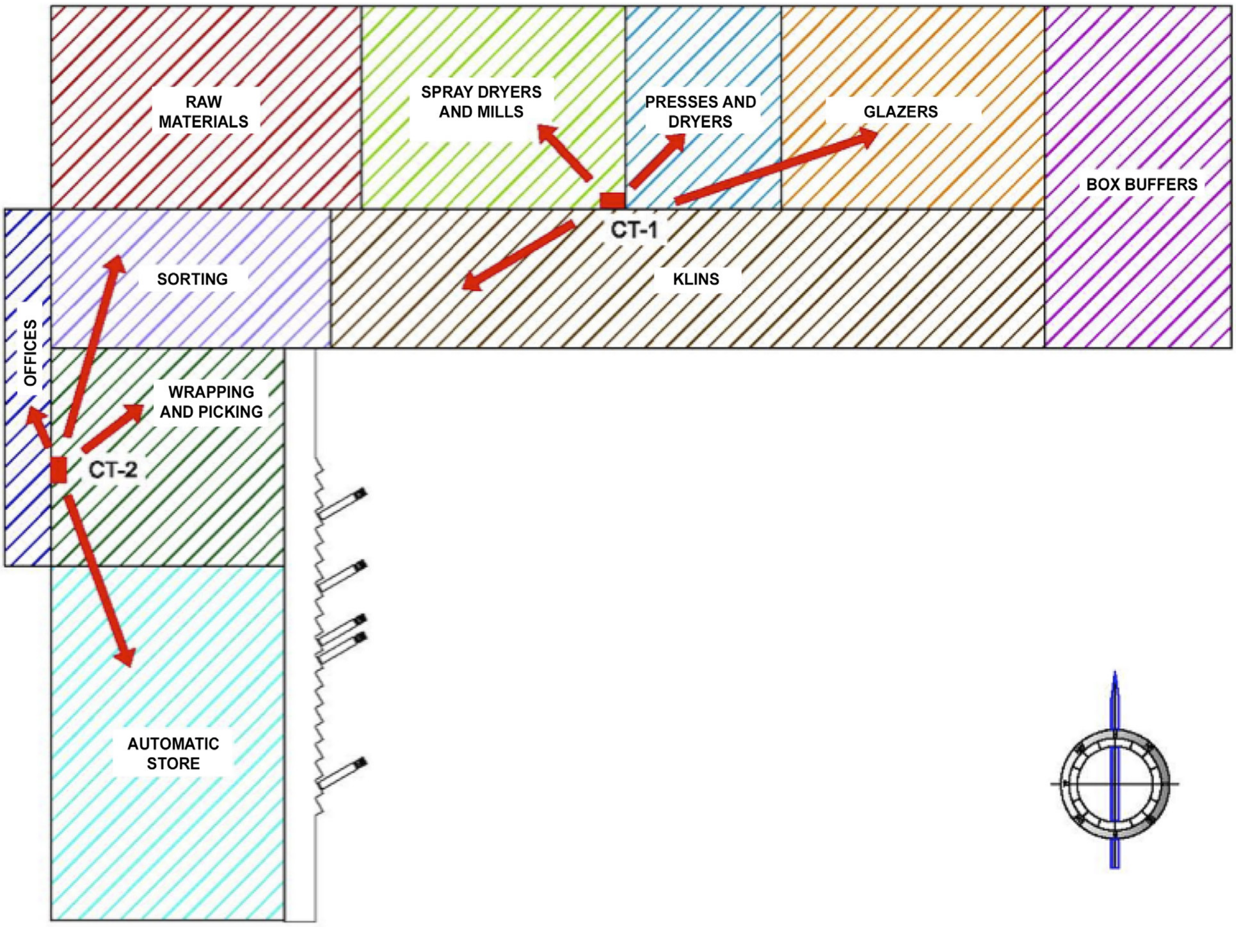
H. The internal electric power grid.

The internal electric power grid to reduce the losses in the conductors and the cost of these conductors is envisaged, as set out in section 3.C, such that:

- The high/low transformers are laid out through the production zone in the centre of gravity of the electric receivers, and they are linked to each other and to the connection with the public power grid by an internal high-voltage grid.

- The internal low-voltage transport grid is 690 V. Any conductors, power switches, and prefabricated electric ducts are valid because their maximum design voltage is 1000 V.

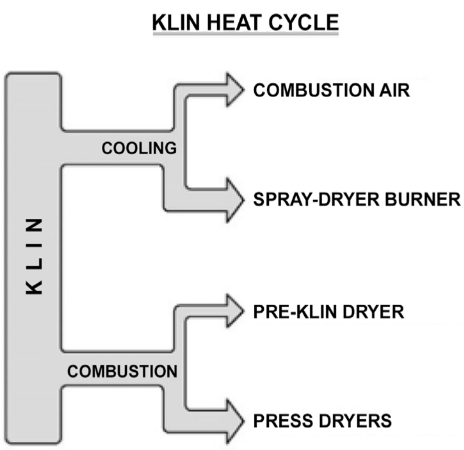
The sections and the losses in the conductors decrease, proportionally to the square of the circulating intensity: energy saving.



LAYOUT OF ELECTRIC POWER CHARGES

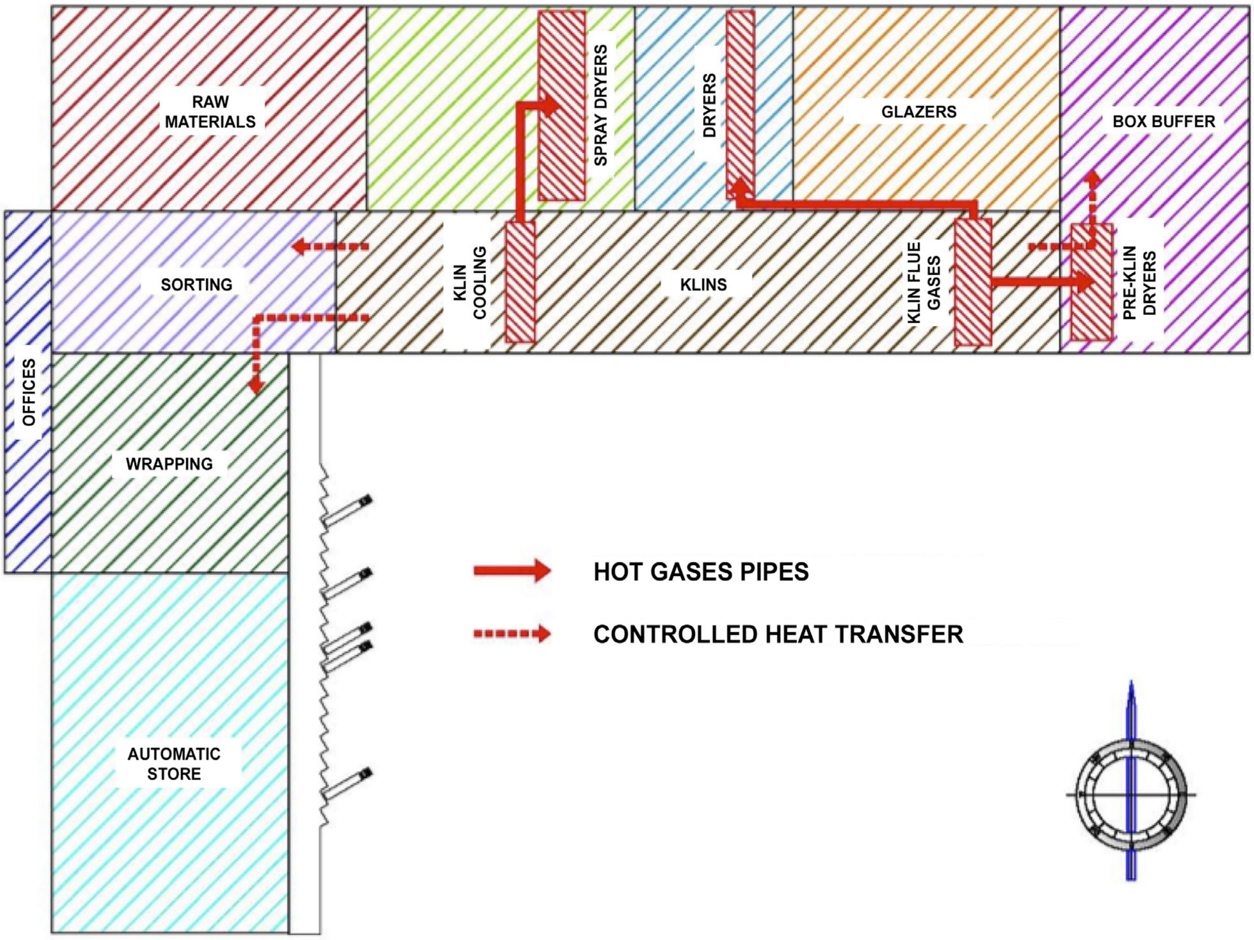
5. THE INTERRELATIONSHIP BETWEEN HEAT SOURCES AND SINKS

Kilns are a heat emission point that can be used in other sections of the production plant. Selecting an appropriate relative position between this thermal machine and the heat sinks (spray dryer, press dryers, and kiln pre-dryers/see section 3.A) enables the internal energy of the hot gases to be used and less fan power to be required for hot gas transport from source to sink.



In this case, the saving stems from a reduction in fuel consumption in the heat sinks and lower electric energy demand from the gas impeller fans in relation to a totally in-line layout.

The lower energy consumption in the kilns owing to heating of the combustion air is not considered because this technique is part of the design development of the manufacturers of such facilities, and it is deemed included in the standard characteristics.



ZONES AND HEAT EXCHANGES

6. THE APPLICATION OF RENEWABLE ENERGY SOURCES

A. Electric power.

The cost of generating electric power with renewable energy sources has reached "grid parity". That is, it is comparable to the electric power generated in the mix of conventional generation plus losses in transport and distribution in the general grid. It is therefore reasonable to generate energy by the following renewable systems:

- Photovoltaic panels mounted on the industrial hall roofs, which constitute a suitable surface for these units, without needing expensive structures on the floor (15.000 m^2)

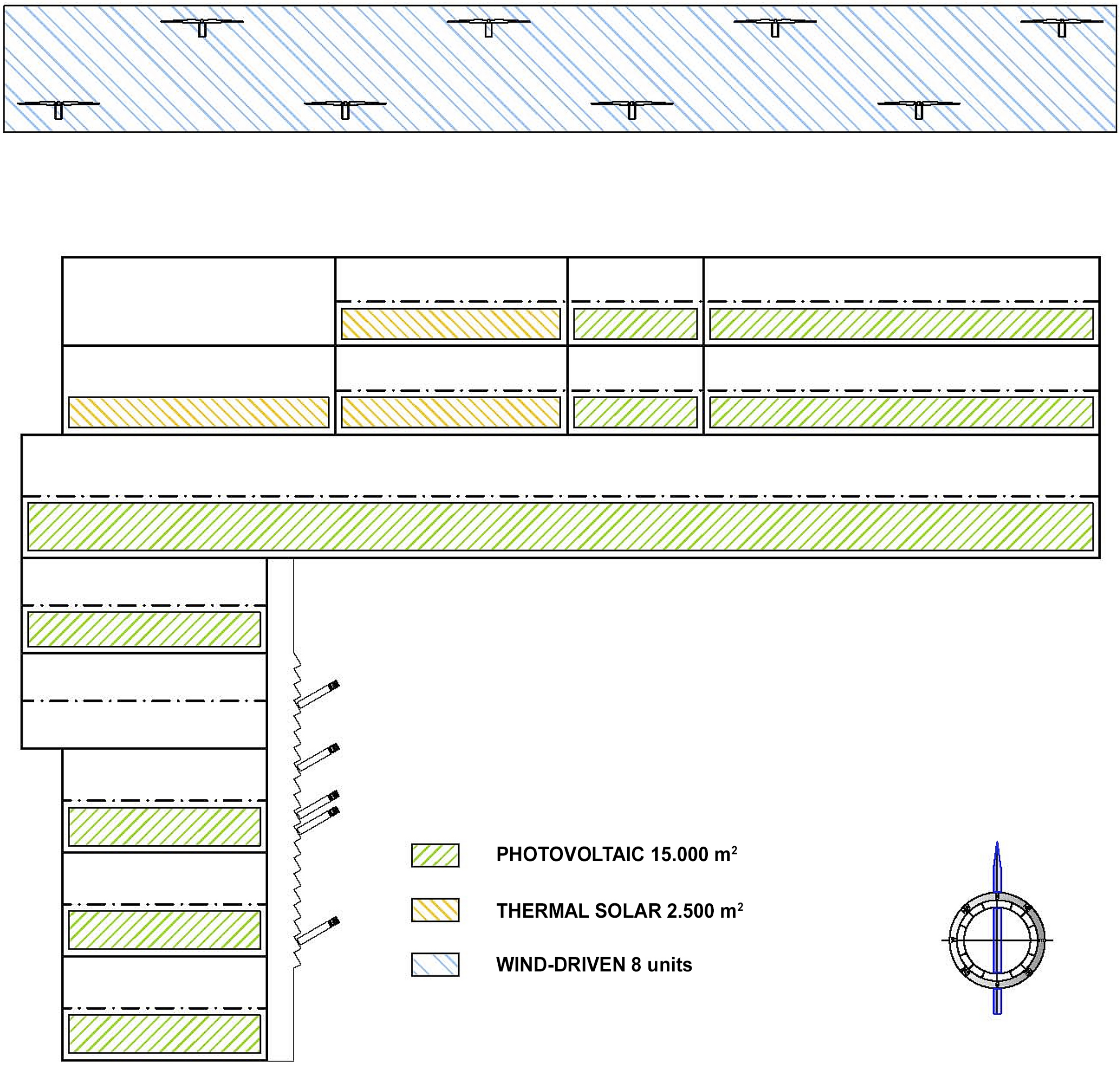
- Wind-driven generators (8 units x 250 kW/unit) located on the plant grounds designed for low average wind speed (v= 10/15 km/h). Layout and separation between wind-driven generators according to the technical criteria of this technology.

The generated energy is supplied to the internal plant grid by inverters and step-up transformers to the conventional distribution voltage (20 kV), as self-consumption and with a view to NET METERING.

B. Heat.

Thermal solar panels (2.500 m^2) mounted on the roof of the industrial halls, linked to a water collector container, use solar radiation to heat water that raises the temperature of the grinding water and of the slurry in the tank. Processing is improved and the slurry temperature is raised.

In addition, if the slurry tanks are built with thermal insulation and heat is input to keep the slurry temperature high, the slurry can be pumped to the spray-dryer diffusers at 80ºC, notably lowering fuel consumption of the air burner in the spray dryer. The saving stems from lower burner fuel consumption.



RENEWABLE SOURCES

7. THE SAVING IN EMISSION RIGHTS

The international regulations on the generation of greenhouse gases, incorporated into Spanish legal provisions, require payment for carbon dioxide (CO_2) emissions in industrial installations. Savings in natural gas reduce CO_2 emissions and also, directly, the debt to the system.

In addition, lower electric power consumption also reduces the CO_2 produced by the electric generation mix. However, the cost of generation is borne by the electric power producers and charged by invoice to the users.

8. COGENERATION: TURBINE AND SPRAY DRYER

Cogeneration (joint production of electric power and useful thermal energy), involving a gas turbine motor coupled to an electric generator in the spray-dry process, represented a cost saving for the user as a result of:

- Lower cost of the self-consumed electricity and additional profit from input to the electric grid of the surplus energy.

- Decrease in the country's overall (CO_2) pollution in the combustion of the combined spray-drying/electric power system as opposed to air heating in a burner.

However, in the present economic circumstances of high tariff deficits and costs of the electrical system, the special electric power regime that fostered the production of electric power in cogeneration systems may be reformed such that, compared with conventional burners, the use of cogeneration turbines might no longer be cost-effective.

Therefore, in this paper, gas burners in which air is mixed with hot gases recovered from kiln cooling are used as heat source for the spray-drying process. This is not deemed such an expensive installation in terms of capital outlay, nor is it as difficult to handle as the turbine generator assembly, unless the plant is located very far from a general electric power grid, or there are more favourable technical and administrative circumstances.

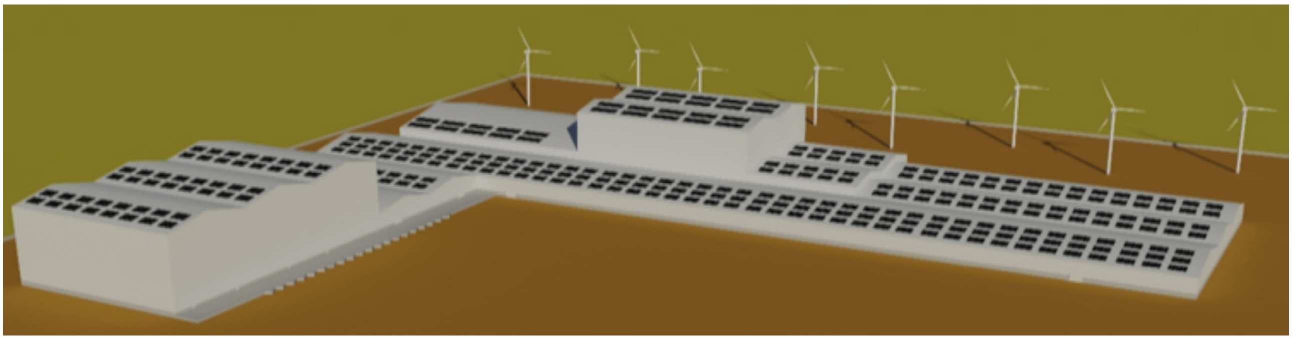
9. CONCLUSION: ENERGY SAVING IS "QUALICER"

At similar prices, a purchasing decision will favour the brand in which the client (energy social awareness) perceives a SUSTAINABLE and ECOLOGICALLY developed process **WITH THE LOWEST SPECIFIC ENERGY CONSUMPTION, CONSIDERING THIS TO BE A QUALITY FACTOR**.

This must be reflected in the business communication policy, in order for this reality to reach the specifications writer and constitute a sale argument that can be passed on to the end-user: in our company, the buyer attaches great importance to the respect that what is to be purchased has for nature.

Thus, under the current circumstances of global competitive environment, product uniformity and standardisation of organisational and production systems, **in order to reinforce the QUALITY FACTOR for their clients**, ceramic sector companies must also differentiate themselves by a profile of continuously decreasing energy consumption.

Organisations must be strategically implicated in an obsessive reduction of costs and must always have energy saving among their objectives. Those that do not will inevitably be faced with a deterioration of business results, which could lead to a traumatic shutdown of their operations.



ENERGY SAVING CONCEPTS				SAVINGS CALCULATION			
It.	SAVINGS SOURCE	Ref	DESCRIPTION	Thermal MWh	Electric MWh	Tonne CO_2	c€/m^2
1	PLANT LAYOUT	1.1	Linking the spray-drying process to the ceramic process	-	-	-	5.18
		1.2	Sequencing spray-drying and ceramic process stages	-	-	-	
		1.3	Concentrating consumption points near the CT	-	-	-	0.25
		1.4	Work in 3 shifts, 7 days per week	-	-	-	1.12
2	INDUSTRIAL BUILDINGS AND INSTALLATIONS	2.1	The industrial buildings are thermally insulated	-	-	-	-
		2.2	Buildings at least seven metres tall	-	-	-	-
		2.3	Decoration zone – glazing	-	-	-	1.04
		2.4	The kiln zone is insulated from the rest of the plant	-	-	-	-
		2.5	Roofs of the buildings	-	-	-	-
		2.6	The orientation and situation of the buildings	-	-	-	-
		2.7	The automatic stand-alone store	-	-	-	0.58
		2.8	Increasing the distribution voltage	-	-	-	0.18
3	INTERRELATIONSHIP HEAT SOURCES AND SINKS	3.1	Recovery from kiln cooling to the SPRAY DRYER	29745	-	6005	5.93
		3.2	Recovery from kiln combustion to the PRE-DRYERS	6053	-	1222	1.21
		3.3	Recovery from kiln combustion to the DRYERS	13316	-	2688	2.66
4	THE APPLICATION OF RENEWABLE ENERGY SOURCES	4.1	Photovoltaic installation	-	3742	-	2.31
		4.2	Installation of wind-driven generators	-	4875	-	4.07
		4.3	Thermal solar installation for milling	2777	-	561	0.35
5	THE SAVING IN EMISSION RIGHTS	5.1	Sum of emission rights 3.1, 3.2, 3.3, and 4.3	-	-	10476	0.32
			TOTALS c€/m²				**25.20**

NOTES:

1. Although such savings take place, the savings resulting from insulating buildings or raising them considerably above the industrial facilities (2.1 / 2.2 / 2.4) are not evaluated because no verifiable empirical or theoretical basis is available for determining the reduction in costs owing to decreased losses and fewer colour differences and calibres. The replacement or repair of corroded metal elements depends on the plant maintenance criteria.
2. The savings stemming from 2.5 and 2.6 are obtained by allowing the application of renewable energies (sections 4.1 and 4.3).

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