

**UNIVERSITAT  
JAUME·I**

**RECENT TECHNOLOGICAL INNOVATIONS IN THE  
SPANISH CERAMIC TILE CLUSTER**

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## **INTRODUCTION**

Currently, the competitive environment that surrounds companies is in continuous change, which means that many of them try to manage these changes through innovation and new technologies, these two aspects being key for the present, but above all for the future of many sectors, among them is the Spanish ceramic sector. Given its importance worldwide, the industry tries to reinvent itself and continue to grow day after day to develop better products and services and be more competitive, complying with environmental standards.

One of the subjects that has contributed the most to expanding students' knowledge about concepts that had not been studied in the Degree in Business Administration has been Análisis Industrial y Redes de Empresas (AE1043) at university. This subject focuses on the analysis of the different industries and the planning and competitive strategies of companies, especially SMEs. It also deals with economic models that we had not known in depth before. Related to these analyses, among other topics, the ceramic cluster was introduced and now carrying out this work on these points serves to finish understanding these aspects and expand them.

One of the objectives of this report is to present the current situation of the ceramic industry, which we will use as support to explain the current and future challenges of the companies that are part of this sector. Another objective lies in the need to learn about technological innovation so that organisations can contribute to the environment, which is already a concern, although for the coming years it is also an opportunity. It is motivating to analyse all this, obviously introducing appropriate definitions to better understand what we are talking about, because the ceramic cluster is an attractive industry for the beginning of professional life.

One reason that has prompted the completion of the final degree project on present and future challenges of Spanish ceramic companies is that the sector predominates in the province of Castellón de la Plana, where it is the most important ceramic cluster in Spain, of which we are to speak in this report. In addition, it is the most competitive cluster and one of the best in innovation in Europe. Therefore, it creates jobs for thousands of people, such as family and friends around us.

On the other hand, specifying more the investigation, we will analyse the technological innovations of the Spanish ceramic cluster, because it is essential for the present and for the coming years the capacity of change and adaptation of the companies

through innovations, thanks to these, the companies will be able to position themselves better in the market in the coming years. It is curious the way in which the members of the cluster fully exploit the available resources and their capacity for growth, thus avoiding being stagnant with respect to the competition and in terms of technological advances.

The *Report on Tiles in Spain* (Alimarket, 2021) is relevant, where it is indicated that the eight main groups of the ceramic cluster collect close to 60% of the total tile sales in our country, which denotes that it is the most important at the national and one of the most outstanding in the world.

This study analyses, as we have pointed out in previous paragraphs, the Spanish ceramic industry and, to a greater extent, the ceramic cluster located in the province of Castellón, providing objective data and verified information that allows us to know, from its theoretical and historical context, the current situation of the cluster, allowing us to highlight the present and future needs in terms of technological innovation. We will give importance to employees of the ceramic sector who know first-hand the current situation and the challenges of this industry. It is an ambitious challenge, among others, the arrival in the ceramic industry of concern for innovations in the environment, which we will deal with in depth, this being one of the fundamental axes of the report.

The structure of the work consists of three parts. The first chapter will focus on explaining theoretical concepts, using the concepts of cluster and innovation as theoretical bases, from there information will be provided that allows us to understand the particularities of these concepts that will be fundamental throughout the report. The second chapter will deal with the ceramic cluster of the province of Castellón, we will approach from its beginnings, going through its products and services, elements, characteristics, up to the present. In the third chapter, we will present innovative challenges facing the cluster and the ceramic industry, focusing their development on environmental challenges. Finally, we will make the final conclusions and references.

## **CHAPTER 1: THEORETICAL FRAMEWORK**

Before addressing the industry and the ceramic cluster and technological innovation in the cluster, it is necessary to provide a series of theoretical concepts in this first chapter that will help us to understand in a more profitable way the aspects explained in the report and to define the bases of this, this being the first part of the work.

### **1.1. Cluster**

The first theoretical element that we are going to introduce is the cluster, whose importance is significant when it comes to explaining the characteristics of the Spanish ceramic cluster that we will deal with later.

To strengthen scientific and technological advances and innovation in any geographical area that seeks to be more competitive through safe resources and methods, the cluster arises. Its function is to take advantage of competitive advantages, promote collaboration between its different members and relations between organisations and institutions in that specific environment.

In order to correctly explain the term cluster and its aspects, we refer, in many cases, to Michael Porter, being the first promoter of this concept.

#### **1.1.1. Definition**

In order to explain the cluster concept in the best way, we can make use of the definition established by Porter (1990: 95) in the book called *The Competitive Advantage of Nations*:

*Geographical concentrations of interconnected companies and institutions that belong to a certain field of activity. These clusters encompass a wide range of interlinked sectors and other entities that are important for competitiveness. These include specialised suppliers of components, machinery, services and infrastructure.*

In turn, Porter (1990) also pointed out that: *The competitiveness of a region is based on the competitiveness of its industries, which in turn is improved if an industry is submerged in a deep network.*

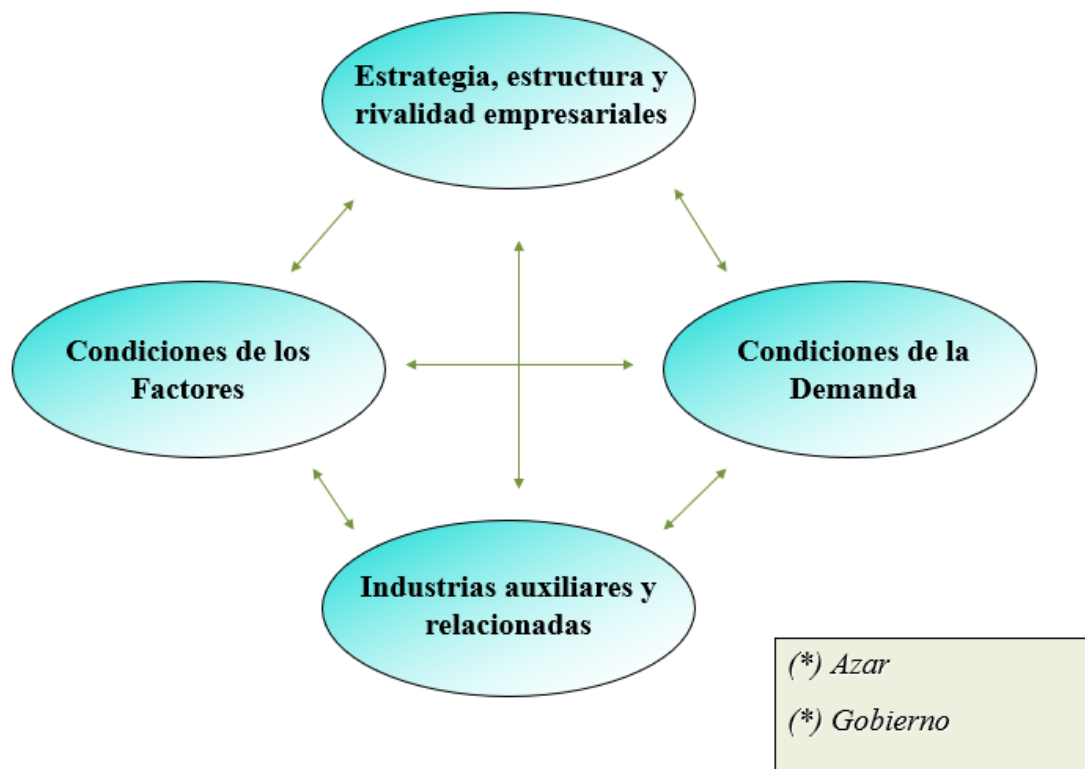
From this definition we break down the keywords: grouping, companies, competitiveness, productivity, collaboration and industry.



### 1.1.2. Components

Once we have seen the definition, in order to study the components of the clusters we are going to do it from Porter's competitiveness diamond. In the following scheme (Figure 1) we can observe the 5 factors, explained below, that favour the internationalisation of an organisation or a territory.

**Figure 1. Porter's diamond model of competitiveness.**



Source: Universidad Jaume I (2021).

#### - Factor conditions

Firms strive to be competitive, through innovation or by opening up to new markets, where rivalry is not a problem.

Regarding the endowment of factors, we can highlight the infrastructures and a wide variety of resources, such as physical, human, capital or knowledge, essential to grow in the industry. These factors can be basic, such as the weather, or generic, such as highways (inherited), and on the other hand they can be advanced, such as university education, or specialised, such as the specific training of personnel (created).

Depending on the conditions of the factors, some drawbacks may arise, such as inefficient exploitation that may be caused by the use of too many resources or innovation that may not generate profitability depending on the circumstances.

#### - **Demand conditions**

The most demanding groups of consumers make companies invest in R&D, taking their strategy towards differentiation. Requirements depend on local and national circumstances, distribution channels and factor conditions. Consumers need products and services for political and social, governmental or factor reasons. The composition of national demand is segmented into many industries, so that some areas are given more importance than others.

The size of local demand may depend on economies of scale or investment in R&D and having a greater demand does not favour internationalisation. What is positive is a greater number of independent buyers and growth to work with new technological advances. This favours being more competitive and implies anticipating competitors in other markets. Buyers can be locals travelling to other countries or multinationals with subsidiaries. In the internationalisation process, it is key to achieve advances in research and science, on cultural bases and creating collaborative alliances.

#### - **Auxiliary and related industries**

On the one hand, we have the supplier industries that serve as a competitive advantage for several reasons: access to efficient inputs is agile, benefits in the areas of improvement and innovation, and interest in local suppliers that are competitors at the international level. global to the detriment of foreigners.

On the other hand, it is worth mentioning the competitive advantages of the relative industries: the companies coordinate and support the activities and the demand for complementary products and services that depend on the products that are related, opportunities arise to exchange information, professionals and synergies are created with other industries.

#### - **Business Strategy, Structure, and Rivalry**

All business systems have their advantages and disadvantages. For this reason, experience and knowledge are relevant, since they can influence aspects such as norms, authority or relationships between people. The objectives set by companies are influenced by the structure of the business or the motivation and culture of the human factor. Instead,

people think more about the rewards, the relationships between the different positions, the training or the risks they can take. They are ambitious and seek challenges with an appropriate investment.

The foregoing is reinforced by an existing rivalry between competitors and the ability to access new businesses, through mechanisms such as spin-off, which are based on new processes, products or services based on what was learned in university education.

#### - **The role of governments (\*)**

The actions of governments can be important, favouring or harming, in the other factors of the diamond, although it is a secondary organism that does not affect the factor and money markets, imposes regulations, creates policies to avoid monopoly, avoid unfair competition and so on.

The elements of the Porter diamond depend on each other. That is why they are all important and play a fundamental role in the cluster. **Chance (\*)** also plays a role, as there may be unexpected circumstances that cause factors to follow a certain trend, such as inventions, exchange rate fluctuations, pandemics, wars...

#### 1.1.2.1. Components in territorial agglomerations

Apart from the classification that we have seen, we can also refer to components found in territorial agglomerations (del Corte, 2015), such as industrial districts, a concept that we will study in later sections. We make this classification to avoid possible confusion about the ceramic cluster, because it is also called an industrial district.

The first component is the **companies**, responsible for obtaining the profitability of both the main activity and related activities and companies. There are final companies dedicated to the production and sale of final products or services, specialised companies that sell capital goods, supplies or raw materials that are used in production to final companies, and integrated companies that are related to another industry but found within the territorial agglomeration.

The second and third components are the **labour** and the **capital market**. The first refers to the human resources that are essential for the activity and the second has a local financial offer that allows, among other things, to invest and create companies.

Lastly, we find **public institutions**, which are formal and responsible for facilitating infrastructures or lines of research. They can be academic institutions, whose infrastructures

are research centres and universities. Their importance is higher in the most innovative areas and they are responsible for training future employees and conducting research.

Depending on all these factors and industries, companies opt for a certain type of cluster.

### 1.1.3. Types

To explain cluster types we draw on previous academic work on Silicon Valley (Pitarch et al., 2021).

There are two types of clusters according to the industry association. On the one hand, the **vertical cluster** is created so that companies are linked through their supply chain, that is, their industries have to do with the relationships of buying and selling merchandise. On the other hand, there are the **horizontal clusters**, whose companies use their experience and information to feed each other operating in the same market.

Other cluster modalities stand out, among which the **industrial-type cluster**, characterised by organisations that are related to the distribution of goods and services and production, maintaining that link between the different members as suppliers or customers. And the **high-tech cluster**, which is oriented towards the latest technological advances that are adapted to the knowledge economy and whose research centres acquire great relevance.

### 1.1.4. Benefits

After introducing the concept, the components and the types of clusters, we can point out the benefits of belonging to them (Manene, 2014), which represent an economic and business improvement of the territory in question and of the companies that form them. Some of these benefits can be:

- The development of **competencies and skills** by organisations, allowing them to face competitors who would not be able to do so without collaboration.
- **Information, experience and knowledge** from situations that support learning.
- Taking advantage of **economies of scale** by being able to focus on purchasing, production and marketing jointly.
- **Culture and social integration through** relationships between companies that lead to synergies and a perspective that is understood by all members of the cluster.

- Improved **efficiency** through communication and sharing of business practices.
- **Infrastructures** specialised in the needs of companies, such as consultancies, universities, schools, related to the legal or security field...
- **Economic aid** from the government and banks.
- Possibility of accessing **new markets and businesses**, using resources that allow increasing technological advances, innovation and creativity.

We see how the advantages of belonging to a cluster model are many in various fields such as economic or social, although to take advantage of these benefits it is important to be clear about the characteristics of this model.

### 1.1.5. Characteristics

Porter defends the idea that organisations have to be able to act quickly when **changes occur in the environment** and those that are integrated vertically cannot respond quickly and effectively. Clusters are effective in this sense, they have companies that carry out similar and/or related activities, with high training and lower costs than other companies in general. In order for competitiveness within the cluster to be higher, it is necessary to have highly qualified labour and suppliers that allow obtaining the greatest advantages from raw materials (del Corte, 2015).

Taking into account the above, it can be said that the key factor for a cluster to be successful is the **strategy**, which consists of being unique and differentiating itself through activities that create value. Normally, the clusters that are more flexible to changes in the market and the sector outperform the others in terms of suppliers, technology, training, creativity... (del Corte, 2015).

The cluster arises from the need to create strategic alliances that lead to an improvement in profitability, through productivity or efficiency. **Mutual collaboration** gives rise to competitive advantages for companies and improves their weak points. As for the **clients**, they are presented with the possibility of obtaining greater benefits with the new possibilities of the organisations (del Corte, 2015).

Developed countries are increasingly making use of clusters, in which the **government** has a role that consists of providing information, investing in technology and resources, creating training programs, in short, supporting companies (del Corte, 2015).

Each **geographical area** has specific resources that favour the creation of a cluster of a specific industry. If it is sustained, it is a support for new companies and to invest in research and development (del Corte, 2015).

### 1.1.6. Examples

Given the information necessary to understand the concept of cluster, we can mention some examples<sup>1</sup> of this model in different geographical areas, although without going into them too much since they are not transcendental objects in the work.

#### - **United States**

This country is home to some of the world's most important clusters in its sector. As a first example we put *Silicon Valley*, being the most important innovation cluster in the world, located in northern California, where the headquarters of Apple, Google, Facebook, HP, or Intel are located. A second example is *Hollywood*, considered the most famous cluster in the world when it comes to cinema, located in Los Angeles. Third, we mention the automotive industry in Detroit, standing out for its dominance of the automotive industry and for supporting businesses with talent and resources.

#### - **Europe**

The European continent stands out in many industries and a consequence of this is the appearance of clusters, causing certain sectors to be strengthened.

We point *Terza Italia* as the footwear cluster. In Toulouse, France there is a cluster dedicated to the aerospace sector or the *Silicon Fen* in Cambridge, UK, which has activities in biotechnology and computer technology.

Finally, in Spain there are several such as the Valencian textile cluster, located in Ontinyent. *Madrid Network*, being a network of companies located in the Community of Madrid or the cluster of companies in the cosmetic sector in Barcelona

The clusters belong to a certain industry depending on the geographical area, since the resources of said area can be advantageous in technologies, innovation, raw materials, business... We have chosen these examples because they represent success stories in the countries in which they are located, notably highlighting the associated industry.

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<sup>1</sup> Information obtained from:  
[https://es.wikipedia.org/wiki/Cl%C3%BAster\\_\(industria\)#:~:text=Ejemplos%20de%20cl%C3%BAsters%20son%20Silicon.concentra%20la%20fabricaci%C3%B3n%20de%20autom%C3%B3viles](https://es.wikipedia.org/wiki/Cl%C3%BAster_(industria)#:~:text=Ejemplos%20de%20cl%C3%BAsters%20son%20Silicon.concentra%20la%20fabricaci%C3%B3n%20de%20autom%C3%B3viles)

### **1.1.7. Cluster vs. District Industrial**

It should be noted that there is some confusion between the term cluster and industrial district, since they are similar, but have certain differences. We explain it below (Navarro, 2019).

Both models are committed to locating production in strategic areas to obtain competitive advantages in the foreign market and to linking activities in order to create interactions that have a positive impact on profitability.

Clusters are related to industrial economies, they analyse the value chain, business strategy and ways to create competitive advantages. The industrial districts group regional SMEs, whose business is focused on a specific part of the industry. That is why large organisations are not usually found, as is the case in clusters, where there may be different sizes of companies and institutions. As a consequence, we say that the industrial districts are a cluster model but limited at the regional level.

Profitability in the clusters is obtained from natural external sources or supported by the government or other institutions, while in the industrial districts they come from local subcontracting and from how agile their model is in the social aspect and in incremental and reactive innovation that we will comment on later.

In the next few years, a hybrid model will be generated, because the industrial districts approach activities that are carried out in the clusters, such as competitiveness or strategic location that allows greater efficiency.

## **1.2. Innovation**

The second theoretical element that we are going to introduce is innovation, this being a fundamental pillar in the business world.

For business activities to continue, as well as globalisation, new products and services, competition in the markets and adaptation to changes in the environment of organisations, the need to innovate arises, it gives businesses the possibility of carrying out carry out strategies that make them more competitive and obtain greater profitability (del Corte, 2015).

It consists of creating diverse ideas to later share them and have the support of the members of the organisation taking into account the available resources and needs. Subsequently, the trial period is launched and after overcoming the obstacles, it is introduced into the market.

Innovating has many benefits, but it also involves risk, because uncertainty is present and a cost that can be negative considering the interests of companies. The definition is presented below.

### **1.2.1. Definition**

The concept of innovation is broad and many authors have defined it throughout history. One of the definitions that best explains its meaning is the one that appears in *Manual Oslo*, written by the Organisation for Economic Co-operation and Development (OECD) (2005) in the publication *Measurement of Scientific and Technological Activities*:

*Innovation is the generation of a new idea or a new, or significantly improved, product (good or service), a process, a new marketing method or a new organisational method, in the internal practices of the company, the organisation of the workplace or foreign relations.*

From this concept we can extract as keywords: idea, improvement, method, new, and product.

### **1.2.2. Types**

As we have seen, the definition of innovation is a very broad term, which gives rise to various classifications. We have focused this section on the classification based on the nature of the innovations (del Corte, 2015).



The first type of innovation is **product**, that is, introducing a new product or significantly improving an existing one, in terms of changes in basic characteristics, components, technical aspects or software that influence performance. Some classifications also include services, because they are aimed at the end customer, considering innovation if there are changes in the way they are provided.

Innovation **process**, which takes place with a new process or with the improvement of an existing one, product deliveries, production processes or delivery supplies, applying computer improvements, supply of raw materials or internal management. They focus on the internal levels of the companies and not on the final customers, as occurs in product innovation.

The third type of innovation is **organisational**, which has to do with new methods of organisation and lower costs. Technical innovations stand out, also called technological, being those that use technology to improve or create products and services in the technical system of organisations. The opposite happens with the administrative ones, their focus is the business structure, they are used in human resources and administrative procedures. Bringing these innovations together boosts efficiency inside and outside companies.

The fourth is innovation related to **marketing**, it is carried out as a new way of marketing that is accompanied by changes in packaging and product design, promotion or sales techniques. It seeks to satisfy customer needs and open up to new markets.

Another of the classifications that we can mention is the one based on the degree of novelty of the innovation (Universidad Jaume I, 2021), distinguishing between radical and incremental innovation.

Innovation **Radical** implies new resources and knowledge, causing important changes different from the previous one, through more creativity and different ideas. It is linked to existing needs and new products and markets.

Innovation **Incremental** starts from existing resources and experiences, leading to minor changes in the performance of processes or products that are already created. It is related to the satisfaction of what companies need in the market.

Lastly, according to innovation planning innovation **programmed**, that is, it is routinely planned and planned to improve an idea, and **unscheduled** which, unlike the previous ones, is not They plan and the idea can be modified.

Innovation comes from certain sources that make it possible to carry out techniques and take advantage of tools and resources to be able to adapt to the environment and its difficulties. These sources of innovation are briefly presented in the following section.

### **1.2.3. Sources**

Companies tend to innovate, as we have said before, in order to respond to inconveniences and changes. That is why organisations can be the main sources of internal innovation due to their interest in creating unique and different ideas. Some of these sources are also the R&D department or technological advances.

Science, learning and knowledge can be considered as other sources of innovation, they are incorporated into the production process to obtain benefits over a period of time.

The needs of the market are the starting point for innovation and many companies start from this base, as well as from sources of suppliers or clients, these sources being external to the industry. In addition to them, you can find other companies or institutions. Lastly, there may be general sources such as fairs, associations, patents or conferences.

It is essential that the sources (del Corte, 2015) interact with the components of the organisations, the integration of the elements and cooperation being important because the success of innovation depends on it.

### **1.2.4. Principles to promote innovation in companies**

To obtain the benefits that we have seen in the previous section, all organisations must follow and take into account a series of aspects necessary to innovate and be sure that they are following the correct steps. These points are the ones listed below (Universitat Jaume I, 2021).

1. The entire company must be innovative and not just some departments.
2. Empower the imagination to follow an innovative culture.
3. Apply techniques that support creativity.
4. Human diversity creates different ideas.
5. Cooperation.
6. Innovation takes time.
7. Flexibility, autonomy and participation.

8. Question and reflect.
9. Creative work areas.

In short, innovation is a process that needs time and resources, that is related to the business culture, has many benefits, and with good planning and strategy, companies can be more competitive and increase their value.

### 1.2.5. Benefits

As we have seen, innovation can be used in many business aspects and many companies choose to dedicate a large part of their activity to creating innovative ideas that make them stand out from the rest of their competitors. Some of the benefits (Martínez, 2016)<sup>2</sup> of these practices are:

- **Not settling** in and preventing the company from staying in the comfort zone, in order to face changes and future challenges.
- **Promote the talent of people** through creative ideas, training and knowledge that serve to improve performance.
- **Learning and experience**, such as taking responsibility when mistakes are made so that the business is strengthened.
- **Different roles** by the members of the work team to obtain greater knowledge and so that they feel involved, placing each person in the appropriate positions.
- **Compete** through a creative and innovative culture, generating opportunities and knowing the needs of customers.
- **Improvement of production processes**, applying new technologies and techniques.
- **Improve the vision of the environment** with innovative products and services and with novelties that attract the attention of consumers.

In conclusion, we can point out that there are different ways to innovate and therefore all possibilities should be taken into account and appropriate resources should be used in order to enhance creativity.

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<sup>2</sup> Information obtained from:  
<https://es.linkedin.com/pulse/7-beneficios-que-aporta-la-innovaci%C3%B3n-las-empresas-ignacio-mart%C3%ADnez>

### **1.3. Relationship between cluster and innovation**

Once the concepts of cluster and innovation have been presented, the need arises to know the relationship between the two (Becerra and Naranjo, 2008), with the aim of addressing the remaining chapters later.

Clusters are areas that favour innovation, given that it gives rise to ideas that allow solving problems and satisfying needs. That is why clusters are generally associated with business innovation.

Porter suggests the elements that lead companies to innovate within a cluster. Specialised suppliers make agility possible when it comes to innovating, as well as cooperation between companies and competitiveness, leading to investment in R&D and favouring new processes and strategies. Discerning buyers are a source of information on expanding markets and technologies.

The proximity between companies and the resources of the area make innovation possible, because the members of the clusters have more confidence and establish profitable relationships through knowledge, shared learning, specialisation and integration of personnel.

There are other reasons why innovation may be present in clusters, such as public and private financing or relations between industry and institutions or centres such as universities.

Finally, note that innovation serves as a boost for companies to invest in projects, learn about new trends and markets, rely on others to expand their knowledge, internationalise, achieve technological advances... Therefore, the relationship between clusters and innovation is close and necessary.

In this chapter, we have explained the concepts of cluster and innovation, as well as their relationship, thanks to which the following can be better understood.

## **CHAPTER 2: CERAMIC CLUSTER**

Having introduced the theoretical framework, we move on to the second part of the work, which consists of explaining the current situation of the Spanish ceramic cluster, as well as its main characteristics. For this, it is first worth mentioning characteristics of the national ceramic industry.

### **2.1. Spanish Ceramic Industry**

According to ASCER industry information<sup>3</sup>, the Spanish ceramic sector, whose main activity consists of manufacturing ceramic tiles, is one of the most agile and innovative industries at a national level and a world leader in design, quality of service and technological development. 75% of the total turnover of the industry are exports and the rest of the sales correspond to the national market. This industry is located as the third that contributes the most surplus to the Spanish trade balance. The strengths of the sector, such as the knowledge and experience acquired, have allowed national ceramic products to reach some 190 countries. The national ceramic industry employs most of its workers in SMEs.

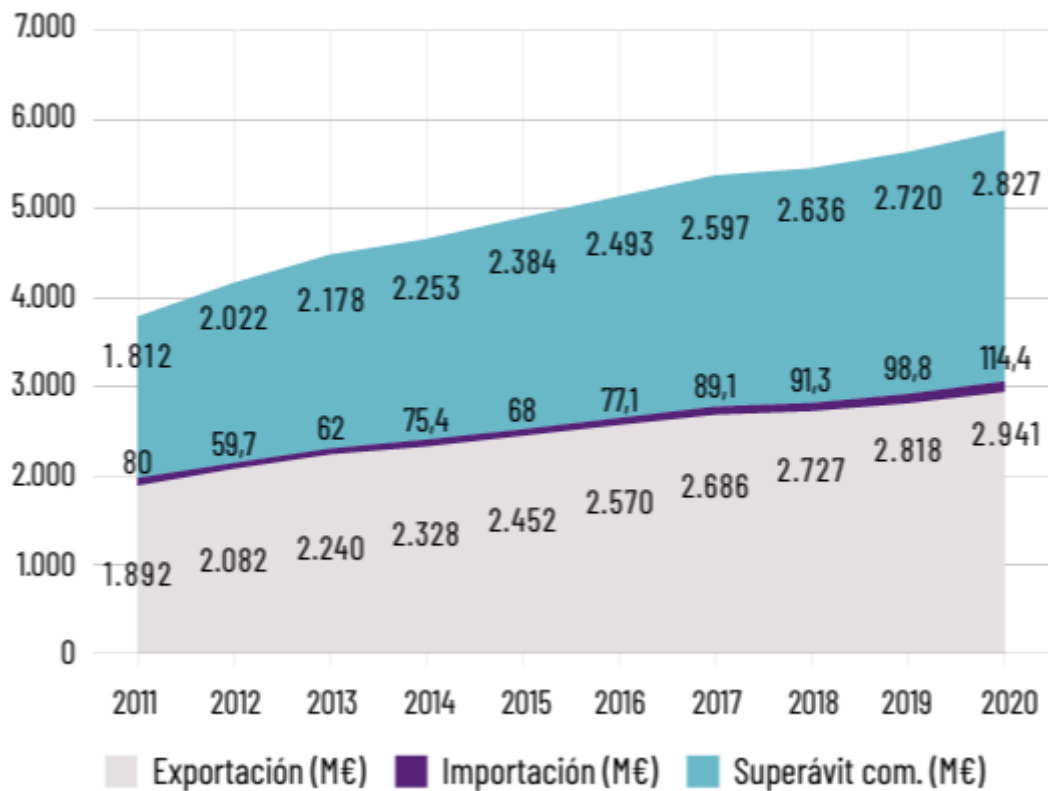
According to the *Spanish Ceramic Tiles and Flooring Sector Report* (Solunion, 2021), Spain is the fifth largest producer in the world, where China and India are very strong, second exporter by volume and third exporter by value, where the Italian industry is also very competitive.

Returning to the trade surplus, it can be seen in the graph (Figure 2), that the Spanish tile sector reached its maximum export level in 2020, approximately 75% of its sales were directed abroad, the majority to countries of the European Union. The main countries were France with 11.4% of total exports, the United States with 10.8% and the United Kingdom with 6.2%. Export capacity has been maintained despite the negative effects of the pandemic. To reduce inventories, liquidate stocks and increase cash, many tile companies have had to increase sales by reducing production.

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<sup>3</sup> Information obtained from: <https://www.ascer.es/sectorPlantilla.aspx?lang=es-ES&cual=descripcion>

**Figure 2. Evolution of the trade surplus in Spain.**



Source: Solunion (2021).

We see more data in the image (Figure 3), where it stands out that in the year 2021 is where the most favourable data have been recorded, counting from 2017. Production in 2021 was 587 million square metres, sales in the national market were 1,198 million euros and total sales of 4,855 million euros, therefore, the difference is exports. These are very favourable data for the national ceramic industry and allow it to continue growing.

**Figure 3. The ceramic sector in 2021.**

El sector cerámico en 2021					
<b>Producción</b>	587	<b>Exportación</b>	3.665		
<b>Empleo</b>	17.180	<b>Ventas totales</b>	4.855		
Producción y ventas del sector					
	2017	2018	2019	2020	2021
<b>Producción</b>	530	530	510	488	587
<b>Ventas mercado nacional</b>	824	870	939	901	1198
<b>Exportación</b>	2686	2727	2818	2941	3665
<b>Ventas totales</b>	3510	3597	3757	3842	4855

Ventas en millones de EUR y producción en millones de metros cuadrados

Source: ASCER (2022).

The final product of the manufacturing process is the tiles (ceramic tiles, floor and wall tiles), although more related activities take place, such as suppliers of raw materials or industrial machinery, which we will explain later.

### 2.1.1. Ceramic product

The ceramic product is the tile, as we have seen in the previous section. These products are flat pieces that have a small thickness and are made from clay, silica, and similar raw materials. They serve as pavements on floors and coatings on facades and walls. They are waterproof and the support is made of red or white firing clay that is later covered with enamel (ASCER, 2022).

Currently ceramic tiles and tiles can be present in many spaces, indoors or outdoors, public or private areas. Depending on the use and the location, such as in the bedrooms of the home or on urban sidewalks, a certain type of ceramic will be used.

### 2.1.2. Product portfolio

Ceramic products are very varied and are used both in architecture and decoration. We have seen that they can have many properties and requirements. Since there are so many types, we are going to use two classifications that we hope will summarise the types of ceramic products that we can find on a large scale. Classifications are by manufacturing process and by commercial classification.

Let's start with the **classification according to the manufacturing process**<sup>4</sup>, within this we can differentiate several:

- **According to the raw materials**

White paste: composed of a clay base without colourants and after firing it has grey shades.

Red paste: It has a component of dye oxide and manganese oxide, which gives it a brown, yellow or red colour.

Porosity: This texture appears when there is content of clay carbonates.

- **According to modelling**

Extrusion: Pass the paste in a plastic state through an extruder that forms the sheet. It is then cut and punched to the desired size.

Dry pressing: The mass becomes powder. When there is between 5 and 7% humidity, it is compacted with a hydraulic press.

There may be other processes.

- **According to firing**

Firing: Ceramic materials that only undergo one firing process.

Double firing: Ceramic materials that receive a firing for the support and then another for the glaze and decoration.

Third Fire: Extra firing is sometimes done after glazing to reduce moisture, usually at low temperatures.

- **Depending on the glaze**

Glazed: After firing, a layer or several glazes are applied to the piece, which adds shine and a more aesthetic appearance.

Non-glazed: The firing is only carried out once.

- **According to mechanical treatments**

Rectified: After the firing phase, the edges of the tiles are rectified for greater perfection, adjusting the size.

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<sup>4</sup> Information obtained from: <https://nivelacionceramica.com/blog/baldosas-ceramicas/>



Polished: Abrasion process that adds shine to the piece.

- **Depending on the destination**

Pavement: They are placed on the ground, so their material is resistant.

Coating: They are used to cover walls (tiles).

Facades: In outdoor spaces, with resistance to changes in temperature so that they retain their texture and shine.

Special ceramics: pieces that have a specific appearance that are used in decoration in a particular area.

The second classification that we are going to study is the one that has to do with the **commercial classification** of ceramic tiles<sup>5</sup>. To do this, we have drawn up a table (Table 1) that generally defines the different types.

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<sup>5</sup> Information obtained from:  
[https://www.construmatica.com/construpedia/Tipolog%C3%ADa\\_de\\_Azulejos](https://www.construmatica.com/construpedia/Tipolog%C3%ADa_de_Azulejos)

**Table 1. Commercial classification of ceramic tiles.**

TYPE OF TILE MOULDING	SUPPORT	MOULDING	STANDARD MEASURES (CM)	THICKNESS (MM)	GLAZE
<b>Tile</b>	Porous	Pressing	10x10 to 45x60	<10	Yes
<b>Stoneware flooring</b>	No porous	Pressing	10x10 to 60x60	>8	Yes
<b>Porcelain stoneware</b>	No porous	Pressing	15x15 to 60x60	>8	No
<b>Catalan tile</b>	Porous	Extruded	13x13 to 24x40	<8	No
<b>Rustic stoneware</b>	No porous	Extruded	11.5x11.5 to 37x37	>10	Yes/No
<b>Baked mud</b>	Porous	Extruded	Wide variety	>10	No

*Source: Own elaboration (2022).*

To conclude this section of the work, we can say that the Spanish ceramic industry is one of the most important sectors at a national level and an industry that is also competitive at a global level, whose processes and products are improving and innovating over the years, to offer customers the highest quality in its wide variety of products and services. With that said, let's move on to the ceramic cluster.

### 2.1.3. Production process

To reach the final product in the ceramic industry, a manufacturing process is necessary<sup>6</sup>, also called a value chain, which consists of several phases explained below.

The first thing that is done is to choose the raw materials (clays, sands, feldspars, carbonates and kaolin), which are used just as they are extracted from the mines. It is essential to ensure its homogeneity in order to be able to continue with the phases.

A process is carried out, dry or wet, called milling, which consists of dispersing and reducing the particles. The most normal thing is to do it wet, the clays are diluted in water, after passing through a mill, giving rise to the slip. Later, spray drying is performed to compact and dry, reducing the amount of water.

The slip is pumped, pulverised and dried in contact with a current of hot gases (air-gas burner or exhaust gases from a cogeneration turbine, reducing the energy cost of the drying phase) inside an atomizer. A very uniform and fluid atomized powder is obtained, allowing moulds to be filled and pressed.

To shape the pieces, it is passed to dry pressing, through hydraulic presses with a lot of compaction and productivity in pressing. The pieces obtained, with a humidity of between 5 and 7%, go to the drying phase to reduce it between 0.2 and 0.5%, being able to continue with the process. Doing this avoids possible breakage or fragmentation of the pieces.

After drying we come to the firing stage, in unglazed products. On the contrary, if they are, the piece is covered with layers of glaze. Enamel provides both technical and aesthetic properties (impermeability, colour, gloss, chemical and mechanical resistance...). Enamel is done continuously and some of the application methods are: by spraying, curtain, decorations or dry.

We come to firing, one of the most crucial stages of the process, given the change in the microstructure of the ceramic product, which gives it the necessary properties, such as fire resistance or ease of cleaning. The thermal cycle takes place, where the temperature, time and atmosphere of the oven influence, depending on the desired results.

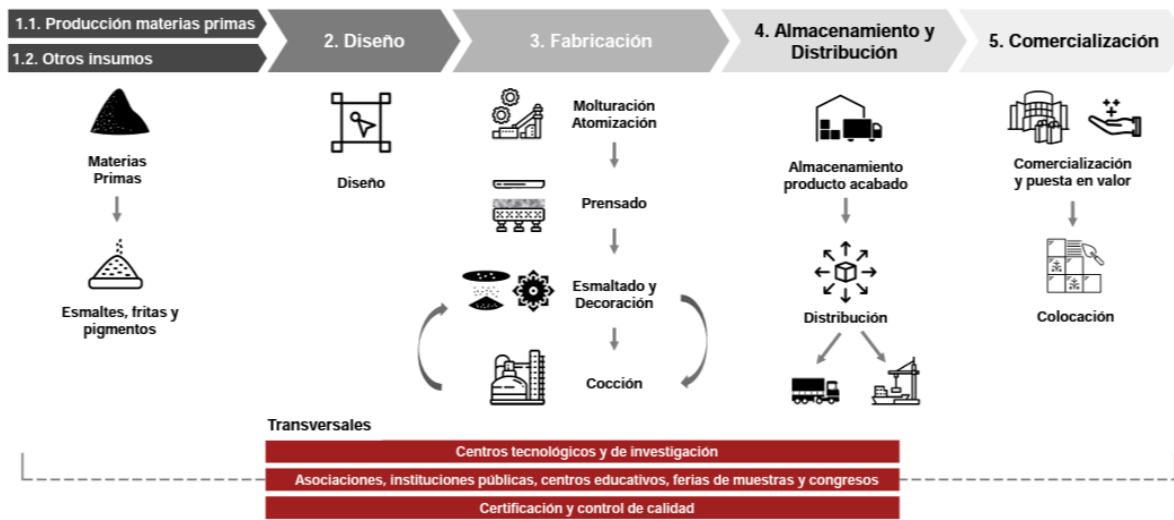
At present, rapid cooking predominates, which is done in single-layer roller ovens, shortening the cooking phases to less than 40 minutes, thanks to natural gas-air burners. To transmit heat, the two most used mechanisms are radiation and convection.

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<sup>6</sup> Information obtained from: <https://www.tileofspain.com/procesoFabricacion.aspx?lang=es-ES>

Once the cooking is done, the last stage can begin, related to the quality of the process. It consists of verifying the final characteristics of the pieces, that is, detecting the pieces with faults, through a recognition software the pieces that do not work are separated. Subsequently, the pieces are packed for distribution and with this the production process of ceramic products ends. Certifications and quality standards are also followed. Schematically we see in the following image (Figure 4) the process.

**Figure 4. Ceramic tile value chain.**



Source: ASCER (2020).

To conclude, we have appreciated that the production process of tiles depends on many factors and each one has an important role, depending on the company, the use of the manufactured products and other aspects, the manufacturing processes may vary. This means that there is no single production process for manufacturing ceramic tiles and, as we will see in the next point, there are various types of products.



The tiles are manufactured in three main places, which are Vila-real, L'Alcora and Onda. Vila-real stands out for its relationship with agriculture and over the years the number of companies in its territory has increased, especially with large organisations. L'Alcora has a ceramic tradition since the 18th century, but it was not until the 1960s that industrial ceramics were introduced. Onda also has a ceramic tradition and since the beginning of the 21st century it has not stopped its tile production. The owners of the companies are usually from these localities.

In order to understand the appearance and success of the cluster, it is necessary to study the evolutionary context of a large part of the national ceramic sector. It is taken for granted that the ceramic industry in Castellón began with the creation of the Real Fábrica de Loza de Alcora by the Count of Aranda, in 1727, moving from an artisan production to an industrial one. In order to produce more, the main product was fine earthenware, which gave rise to new means of production. This factory was built in Alcora due to the pottery tradition, because raw materials from the area such as clay and water could be used, fuels from natural products such as firewood could be used and it was a place near the port, used as an outlet for the production.

In the second part of the 19th century, architectural ceramics were produced in Onda and together with it the tile was introduced, a differentiating product at the time. The productive resources and the information obtained were used to advance in the production, as well as in the manufacture of tiles. Ceramic tiles reduced in size and increased in weight, improving quality, especially durability.

Regarding the 20th century, we can highlight technical advances in machinery such as the friction press, the tubular oven and electricity and in the processing of raw materials such as clay, improving the final result. The infrastructures were also used by means of the railway, with the Panderola. There would have been a great expansion of the sector had it not been for the crisis of 1929, the Spanish Civil War and the Second World War, events that reduced production capacity and exports.

The real expansion of ceramics in Castellón took place in the 1960s. This is due to the Stabilisation Plan of 1959, which allowed the opening of the Spanish economy and tile began to be used as a construction material, increasing its demand. Imports exceed exports, a situation that has not happened more times. Labour was introduced and further changes in processes and raw materials occurred. The automatic press that improved quality and speed was key, as well as the tunnel oven that facilitated production.

In the 70s, with the oil crisis, came the first industrial reconversion of the ceramic sector. Production processes are automated, exports increase and investment is made in tunnel ovens. In addition to this, the Spanish Association of Ceramic Tile and Pavement Manufacturers (ASCER) was created.

In the 1980s, the second industrial reconversion took place, thanks to the switch from fuel oil to natural gas. It goes from double firing to single firing, being a radical innovation in the technical aspect of the production system. The cluster is internationalised and the Institute of Ceramic Technology (ITC-AICE) is created.

In the 1990s, the Spanish ceramics industry was the main one in the world, thanks to the cluster. The competition becomes tougher, especially with Italy, but also with Brazil, China or Mexico. Production was going to continue to grow significantly, accompanied by energy saving systems such as cogeneration.

The production of the ceramic industry in the cluster continued to grow until the construction and financial crisis in 2005 and 2006, with 2009 being the worst year when production fell by almost half.

New business models were established that allowed a certain recovery in ceramics as of 2013. From this crisis we can conclude that the cluster is an example of sectoral heterogeneity. The floor and wall tiles sector suffered a market crash, but the consequences for enamels only lasted until 2010. The chemical part of the sector withstood the crisis better.

The next crisis that the sector faced was that of Covid-19, in 2020, but both the industry and the cluster were able to overcome it and maintain levels in the foreign market within what was possible, costing more in national demand.

Currently, there is a panorama of uncertainty caused by the conflict in Ukraine, which causes an increase in production costs. Raw materials such as white clay imported from Ukraine have also been affected.

As we have been able to observe in the previous information, the cluster is in a dynamic environment, in which new technologies and products can emerge. Crises affect the ceramic sector and it is up to the industry itself and other sectors such as construction to alleviate the consequences in the best way to avoid major inconveniences. The members of the cluster must be prepared for any unforeseen event, as well as take advantage of every market opportunity, getting the best out of each element that makes up the cluster.

### **2.3. Elements**

The elements that intervene in the ceramic cluster (del Corte, 2015) are agents that play a fundamental role in said geographical area and can be several, we study them in this section.

#### **- Companies**

The first essential component is the companies, these organisations tend to specialise and outsource, being part of their production system. Companies can be classified into three types.

On the one hand, there are the final companies, that is, those that carry out the last stages of the production process and have a direct relationship with customers. They are in charge of the pressing, enamelling and firing of the products. Its activity is related to the cluster (ceramic floor and wall tiles).

On the other hand, we find specialised companies, dedicated to the supply of technology such as machinery and the supply of products that are the result of phases already carried out in the production process, such as the atomization of clays. Companies are subcontracted for a specific part of the process.

Finally, there are companies that are integrated into the cluster but that carry out activities that are not so specific and belong to other industries, such as transport companies.

The businesses that manufacture floor and wall tiles are centred in Vila-real, Onda and L'Alcora, distributed evenly. The companies that are dedicated to the supply are usually located in coastal areas, especially those of machinery. Regarding the companies that are integrated into the cluster whose activities belong to other sectors, they are mainly located in Vila-real and Castellón de la Plana (Terrada, 2010).

In the ceramic cluster we can find a large number of companies that are important for the industry<sup>7</sup>. To mention some of them we refer to the following table (Table 2), where current data is shown.

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<sup>7</sup> Information obtained from: <https://www.einforma.com/>



**Table 2. Examples of companies that are in the ceramic cluster of Castellón.**

COMPANY	MUNICIPALITY	ACTIVITY	EMPLOYEES	SALES
<b>PAMESA PORCELÁNICO SL</b>	Almassora	Design and manufacture of floor tiles and ceramic products	447	619,210,000 €
<b>PORCELANOSA SA</b>	Vila-real	Manufacture of ceramic floor and wall tiles	794	148,140,074 €
<b>GRESANIA SA</b>	Castellón de la plana	Manufacture of porcelain stoneware and wall tiles	432	84,554,744 €
<b>ARGENTA CERÁMICA SL</b>	Vall D'Alba	Manufacture of ceramic tiles	671	208,437,783 €
<b>TAU PORCELÁNICO SL</b>	Castelló de la plana	Manufacture of ceramic tiles	438	170,222,000 €
<b>TORRECID SA</b>	L'Alcora	Manufacture of glazes and colours	585	165,389,489 €
<b>BALDOCER SA</b>	Vilafamés	Manufacture of ceramic floor and wall tiles	294	186,190,351 €
<b>ARCILLA BLANCA SA</b>	L'Alcora	Manufacture of mud and other materials	103	65,564,060 €

*Source: Own elaboration (2022).*

Organisations obtain benefits from the close relationship that exists between them. They can obtain resources and increase their chances of competing more efficiently.

#### - **Institutions**

Other organisations present in the cluster serve as support, solve problems and offer services to companies in the area are the regional, local and national institutions (Albertos and Salom, 2015).

- Business associations: Such as the National Association of Manufacturers of Ceramic Frits and Enamels, the Spanish Association of Manufacturers of Ceramic

Tiles and Pavements (ASCER), from which we have extracted a lot of information, and the Spanish Association of Manufacturers of Capital Goods for Ceramics.

- Professional associations: They are useful above all in the management of knowledge and information, such as the Association of Ceramic Technicians (ATC),
- Union Centrals: We highlight the regional delegations of the UGT and CCOO unions, which defend the conditions and rights of workers.
- Technological centres: Among the most relevant is the Institute of Ceramic Technology (ITC). It was founded in 1969 and became part of the Jaime I University of Castellón in 1993. The university has good relations with ceramic companies in the area, which allows it to advance in R&D, training or technological knowledge. Related to this, the Association for the Promotion of Ceramic Design (ALICER) was also created in 1993.
- Training Centres: Examples could be the Jaime I University of Castellón, especially the chemical departments, or Professional Training Centres, such as the Escuela de Artes y Oficios, or the Escuela Superior de Cerámica de l'Alcora, which offers the degree of superior ceramic technician.

In summary, we can say that the agents that participate in the ceramic cluster are essential to be competitive in the national and international industry and there is a wide variety of public and private organisations that generate synergies in order to be more productive and obtain competitive advantages.

## **2.4. Characteristics**

The cluster has specific characteristics (Albertos and Salom, 2015) that make it unique and a benchmark at a national and global level, as we have said previously. Its elements and evolution allow the most important resources and capacities to grow and adapt to the internal needs of each organisation and the environment, as we will see in the following factors.

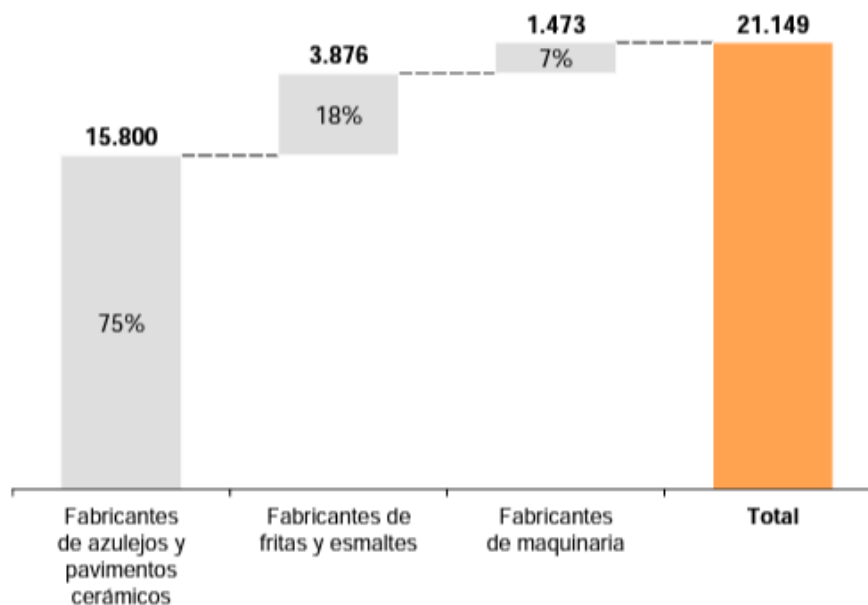
In recent decades, large companies have emerged in the cluster, an **internationalisation**, through exports and later, through multinational companies, with new plants in other countries and with foreign capital inflows, especially in one of the subsectors, the enamel one. According to ASCER reports, the **exports** of tile and flooring manufacturers in 2019, where the Covid-19 pandemic had not yet taken place, represented 75% of production, frit and enamel manufacturers 71% and manufacturers of machinery 41%.

The **subsectors** that predominate in this geographic area are: manufacturers of tiles and tiles, atomizers , producers of glazes and frits, and machinery companies. A part of the resources they use are imported from Italy.

The deal with **suppliers** is usually close and long-term, which means that lower prices and transport costs can be achieved, as well as a high level of involvement. The cluster also has specialised labour, that is, **employees** who have the appropriate knowledge to use the techniques of the industry and it is common for them to perform tasks in different areas and companies, supported by specialised centres and other organisations (Alfonso, 2015). Human **capital** usually has a high level of studies and specialised training and more than 85% of contracts are permanent and employment is stable, therefore, they are quality jobs.

In the following graph (Figure 6), we observe that the number of employees in 2019, the last year represented in this graph, was 21,149 people in the ceramic cluster, with growth since 2015 of 8.7%. We see that the manufacturers with the busiest were those of ceramic tiles and pavements, which represent 75% of the total (21,149), then with 18% those dedicated to frits and enamels and finally those of machinery with 7%.

**Figure 6. Employees of the manufacturers of the ceramic cluster of Castellón.**



Source: ASCER (2019).

In the image (Figure 7), contributions from the cluster appear at the local and national level, where it is relevant that the ceramic cluster contributes 8.9% of total employment in the province of Castellón, being a fundamental industry in the area. The data derive from the previous information in the year 2019.

**Figure 7. Contributions of the ceramic cluster of Castellón in employment.**



Source: ASCER (2019).

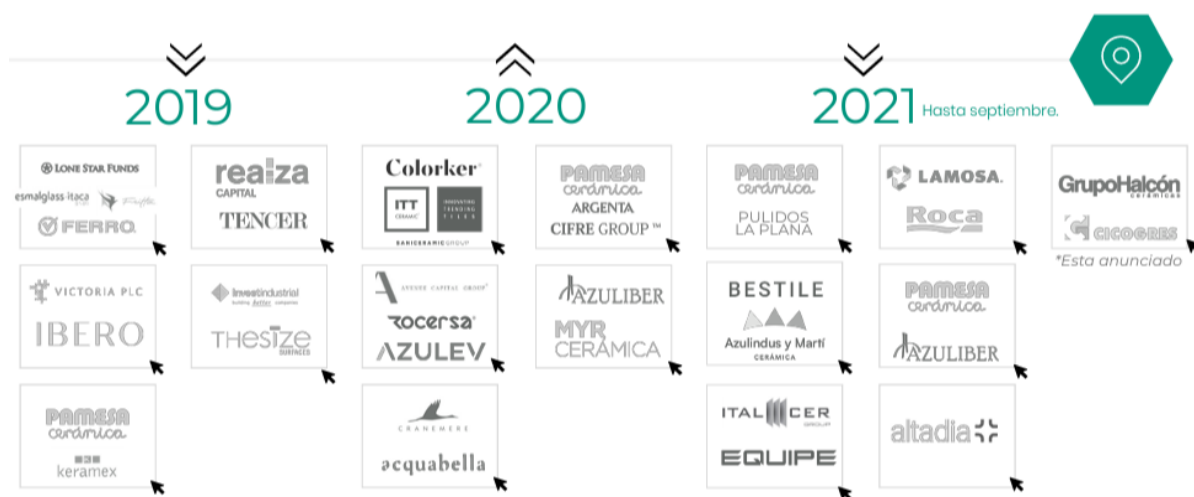
Regarding the **barriers to entry** in the ceramic industry, we can say that they are not very strict due to the ease offered by the cluster area, especially in obtaining resources and capacities, giving rise to the creation of new companies.

In the ceramics industry and obviously in the cluster, **technology** has evolved notably in processes and resources, such as clay atomization or control machines. Thanks to research centres, studies and others, technological knowledge has been transferred from one to another. Technologies are applied following environmental bases that we will discuss in the third chapter. Competition in **transport** is high, because costs have been reduced as a result of the coordination of the ports with the distribution of the area (Quintela, 2020).

Large business groups prevail over other companies, as we will see in M&A, explained below.

As we have said, one of the changes that has been growing over the years in the ceramic cluster has been **mergers and business acquisitions**<sup>8</sup>. The first ones are due to the fact that newly created companies are shrinking. The latter are motivated by the appearance of large groups of investors in the industry, where competitiveness has been maintained despite the pandemic. As we can see in the infographic (Figure 8), we see that in recent years there have been several M&A operations (acquiring or combining external companies or part of their assets to increase the company's profits) of companies in the industry, but also from Pamesa Cerámica or Azuliber, which are part of the cluster.

Figure 8. M&A transactions.



Source: Vigilancer (2021).

The parties that participate in this process are: investment funds, which are financial organisations that are responsible for managing capital in various sectors, industrial companies called holding companies and the cluster companies themselves also participate.

These processes are generally beneficial for tile companies that have slightly increased the number of employees.

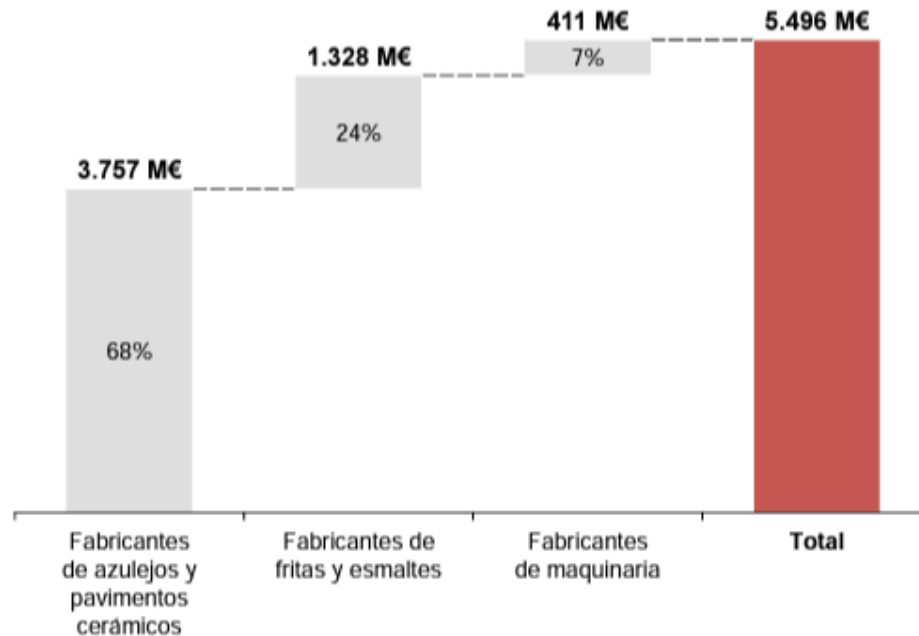
Finally, once the other characteristics have been explained, we arrive at the turnover of the cluster in 2019. To obtain this information, we look at the following graph (Figure 9) and we see that the total turnover for the year was 5,496 million euros, increasing from 2015 19.2%. The part that has contributed the most to this amount was the ceramic tile and

<sup>8</sup> Information obtained from:

<https://www.vigilancer.es/index.php/2021/09/16/adquisiciones-y-concentracion-empresarial/>

flooring sector, which represents 68% of total sales, followed by manufacturers of frits and enamels with 24%, and lastly, with 7%, manufacturers of machinery.

**Figure 9. Invoicing of the manufacturers of the ceramic cluster of Castellón.**



Source: ASCER (2019).

Related to the above and looking at the image (Figure 10), we extract more data from the cluster. It is noteworthy that its contribution in 2019 represented 30% of the value of Castellón's industrial production, yet another reason to continue affirming that its importance, especially at the provincial level, is highly noteworthy.

**Figure 10. Contributions of the ceramic cluster of Castellón in production.**



Source: ASCER (2019).

All these conditions favour **innovation** and an atmosphere is produced in which new methods can always appear to satisfy the needs of the clients. Competitiveness, so companies must differentiate themselves in some way, which is why they also invest in being more creative and innovative.

As we have mentioned, competitiveness and cooperation are two pillars of the cluster that make the sector one of the most dynamic when it comes to creating ideas and researching new processes or products. As we have seen in the data from previous years, the cluster is in a favourable situation and a large part of the maintenance of the Spanish ceramics industry depends on it.

## **2.5. Current situation**

Continuing with the analysis of the ceramic cluster, it is important to know what situation we are in so that later we can extract information about the challenges of the sector. The best way to see it is through SWOT analysis.

### **2.5.1. SWOT**

The SWOT analysis allows us in this case to clearly see the current situation of the ceramic cluster. We have done it based on *the Report on the Analysis and Challenges of the Ceramic Tile and Flooring Sector in Spain* (ASCER, 2020). We will talk first about the internal part, that is, about the most notable strengths and weaknesses, and second about some of the opportunities and threats, which make up the external part.

#### **Strengths**

- Competitiveness on a national and global scale, especially in exports.
- Prestige and good reputation abroad, for manufacturing high-quality ceramic products.
- Sustainable product with various uses that passes quality and environmental controls.
- Use of the circular economy.
- High productivity that allows them to compete also at international level.
- Increasing innovation with development in technological advances and investments in R+D+I.
- Comparative advantages such as being the industry leader in chemical products for frits and glazes.
- Associations committed to the cluster.
- Quality local raw materials.

- Nearby ports.
- Collaboration and transparency.

### **Weaknesses**

- Customers do not always see the quality and differentiation of the product in the price.
- Little production in foreign markets where there may be strategic business.
- High degree of dependence on energy resources such as fossil fuels, paying emission rights. The costs are high and the consequence is a reduced profit margin.
- Lack of information on other benefits of ceramic products, as well as knowledge on the part of manufacturers to market in a more profitable way.
- Difficulty in taking advantage of economies of scale due to the small size of companies, where medium-sized companies find it difficult to differentiate themselves.
- Too short-term vision, avoiding focusing more on strategic changes.
- Not a very high level of digitization in the production process.

We finish the internal part by pointing out that the ceramic cluster and its industry have many strong points that it is responsible for promoting, but it also has points to improve to be even more efficient in its processes and more profitable. Now let's analyse the external part.

### **Opportunities**

- Projects and funds that support the ecological process, digitization and reindustrialization.
- Improvement of infrastructures such as the railway or the ports in the Valencian Community.
- Production plants in countries with strategic markets.
- Search for new uses and trends for ceramic products.
- Changes in customer decision criteria.



- The increase in the purchasing power of the middle classes in developing countries may favour the expansion of the ceramic industry.
- Innovation, digitization and digital marketing.

### **Threats**

- Pandemics such as the Covid-19 have lowered the demand for ceramic products, generating uncertainty.
- Wars like the one in Ukraine and exceptional circumstances.
- situation geopolitical and increased trade barriers.
- Competitiveness in international markets.
- Increasing environmental requirements.
- Lack of local clay reserves.

In conclusion, the ceramic cluster is in a changing environment and must keep abreast of what is happening in it to avoid stagnation. It is essential to take advantage of the opportunities that may arise and to affect the threats as little as possible.

### **2.5.2. Employee perspective**

Taking into account the SWOT, a second aspect that gives us the opportunity to better understand the cluster in order to address its future challenges is knowing the opinion of employees in this territory who are aware of the present and future of the industry as well as your needs.

Emphasis will be placed on the opinion of two employees who work in companies that are part of the ceramic cluster<sup>9</sup>. They were asked for their opinion about the current situation of the industry and the cluster, as well as the trends they believe will continue in the coming years.

- The first employee is 28 years old, has a degree in Business Administration and has been working at Porcelanosa for 4 years, in the administrative department. The conversation with him took place on April 2, 2022.

His opinion about the current situation is based on the fact that the large companies are taking over the ceramic industry, that is, they are the companies that dominate and hope

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<sup>9</sup> Information obtained from an interview with each employee.

they will dominate, each time the more it is more difficult for SMEs to continue with their activities. The innovative capacity of his company caught his attention and he stressed that they try to be even more competitive every day. He also states that he works around very professional people, with extensive training and experience that allows him to learn more every day. Customers become more demanding over time and competition with other organisations is high, also in the international environment.

He showed his concern for the environment and affirmed that they must improve in this aspect, being the main challenge for the coming years, giving great importance to sustainability and the planning that must be followed through an energy and less polluting plan. Accompanied by this improvement, new technologies must go and provide employees with the necessary resources to develop efficient and quality products and processes, reaching an industry 4.0.

Lastly, he is curious about the little use of marketing in this sector in general, he believes that it should be better communicated and recognizes that the environment plays a fundamental role, an example of this is the Covid-19 and the conflict between Russia and Ukraine.

- The second employee is 22 years old, has completed a higher degree in computer science and has been working at Tau Cerámica for a year, in the production process. The conversation with him took place on April 8, 2022.

His year of experience in the company has helped him realise several things. The tile sector stands out in the province of Castellón not only for the amount of resources and raw materials that can be obtained, but also for being in the hands of people who know how to act at all times and in each situation. It attaches importance to the support of institutions and experts. It also analyzes the cultural diversity that exists in the industry and the need to change certain customs to obtain greater benefits and not remain stagnant, which can lead a company to disappear.

At the same time, he tells us that the sector should invest more in new materials and new technologies, taking advantage of the fantastic base it has. He thinks that the trends will be aimed at improving the quality of the products and trying to differentiate themselves from the rest of the competitors, hand in hand with innovations and technology. Product customization will be key.

To conclude, he pointed out that the pandemic had affected them negatively, but they have been able to recover and are now concerned about the conflict in Russia and Ukraine,

which he believes will lead to unemployment for many employees. He has been surprised by the strict regulations on the environment and the little digitization in the production process.

To summarise, this vision of people who are in contact with the ceramic industry serves as support to establish the trends of the sector and the cluster that will be fundamental in the coming years. We have been able to find many characteristics and elements of the ceramic cluster that allow us to extract its needs for the future.

## **CHAPTER 3: CHALLENGES**

Given the current situation, we come to the third chapter of the report where we intend to explain the challenges that the ceramic cluster faces and that will mark the future of the industry. As has been seen throughout the report, especially in the SWOT and in the employees' view, the aspect that most concerns the members of the cluster is the environmental issue. It is a concern that is growing over the years and that can favour certain innovations, it is also related to the demands of customers. It can be related to technological innovation and the new advances that are appearing in the environment.

Apart from the challenges in this area, we can mention others briefly, because we think that they are not currently priority objectives in the world of ceramic products, but they may become so in the future. Some of them may be: digitization, digital printing, investments in marketing, changes in human resources departments, reducing the waiting time to obtain products, new uses for ceramics, eliminating intermediaries, use of lasers, new materials... They are Examples taken from *the Spanish Tile and Ceramic Flooring Sector Report* (Solunion, 2021).

### **3.1. Technological and environmental innovations**

Over the years, a culture of innovation has been forged in the ceramic cluster that today allows knowledge to be broadened, both radical and disruptive. For the cluster to continue to be competitive, it is necessary to open up to the environment, in the sense that they can create links with external agents, such as other technology companies. Radical innovations can be carried out in medium technology clusters, but it is more agile in high technology level clusters (Albors, 2018).

According to the *Report on Innovation in the Ceramic Flooring and Coatings Sector of the Valencian Community* (Higher Council for Scientific Research, 2004), some of the drawbacks that may arise in technological innovations may be: financial problems, high costs, personal with lack of training, lack of customer interest... To reduce these risks, the members of the cluster must have a clear internal strategy and relate it to the business strategy and focus their activity on customers who are interested in products with technological innovations.

Therefore, the environment is linked to technological innovation, an aspect that makes sense to use in the ceramic cluster and that, as we have seen throughout the report, is and will be fundamental in the tile industry.

As Rocersa points out on its website<sup>10</sup>, the ceramic industry is undergoing a transformation, especially in technological innovation and sustainability. The trend in the sector is that we are heading towards production processes and consumption that are more respectful of the environment, where energy savings and recycled materials are particularly relevant.

The Spanish ceramic industry is considered worldwide as one of the most powerful in terms of innovation and technological development, thanks to its investments. Technology has become a fundamental resource for energy efficiency, sustainability, reducing pollution and saving. The legislation is very strict with these aspects and it is a challenge facing the ceramic companies in the province of Castellón.

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<sup>10</sup> Rocersa website: <https://www.rocersa.com>

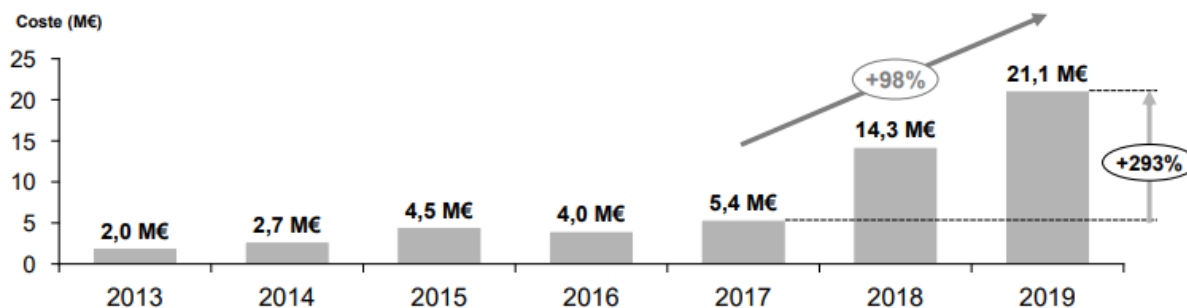
### 3.1.1. Environmental problems

The main problems of the tile sector are high CO<sub>2</sub> emissions and energy costs, environmental concerns, with a technological component, which pose a challenge for companies in the ceramic cluster according to the *Socioeconomic and Fiscal Report of the Ceramic Tile and Flooring Sector in Spain*.

In recent years, CO<sub>2</sub> emissions have been reduced in the value chain, reducing by more than 50% since 1985. Work on innovation is decisive, applying changes from liquid fuels to natural gas, technological advances such as single firing or with actions to improve energy efficiency.

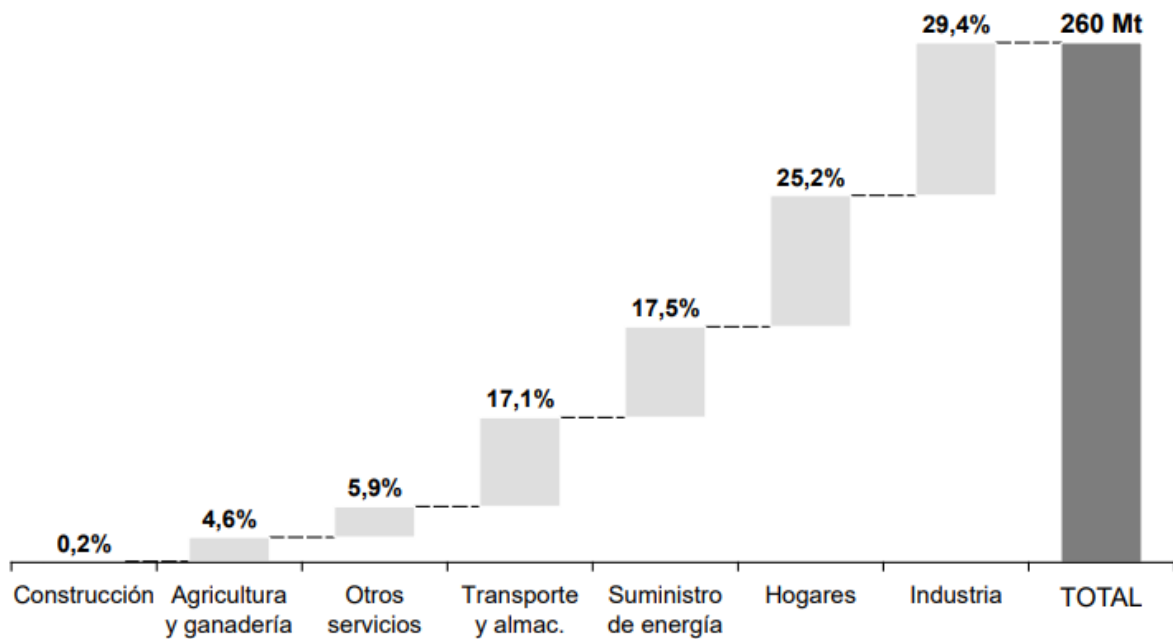
What is currently happening is that the payment of CO<sub>2</sub> emission rights has grown greatly since 2017. The tile and flooring sector contributed 21.1 million euros to the payment of emission rights in 2019, the year before the Covid-19 crisis. This figure has been growing over the years, as we can see in the graph (Figure 11). This is the consequence of the increase in the price of a ton of CO<sub>2</sub>, being its rate of 106% since 2017, it has grown by 326% since that year.

**Figure 11. Contributions of the Castellón ceramic cluster in emission rights.**



Source: ASCER (2019).

Total CO<sub>2</sub> emissions are present mainly in the industrial sector with 29.4% of the total, which was 260 million tons in 2019, as can be seen in the graph (Figure 12). They were reduced by 6.7% compared to the previous year.

**Figure 12. Contributions of the sectors in emission rights.**

Source: ASCER (2019).

The ceramic tile and flooring industry collects 1.1% of the total CO<sub>2</sub> emissions in the national territory and pays 1.7% of the total payment of rights.

As we can see in the graph (Figure 13), the energy bill is very high and its consequence is the loss of competitiveness of tile companies.

Figure 13. Energy bill in the ceramic sector.



Source: ASCER (2020).

To add more inconveniences, a report carried out by the ceramic cluster and the Energy Resources and Consumption Research Centre (Circe) has analysed that it is extremely difficult to replace gas, ruling out several possibilities (Ballester, 2021).

The report also contemplates the possibility of using **biomethane** which would be the most affordable change, but its high cost and scarce availability means that this option is ruled out.

**Electrification** has disadvantages, such as not having the correct technology and supply would not be possible.

Political institutions were betting on **green hydrogen**, but it has also been found that its cost is excessive and is growing, among other reasons. Green hydrogen will not be an option until at least 2050. ASCER proposes disruptive innovations that allow progress in this component.

**CO<sub>2</sub> capture** is also not a good cost option and is not beneficial for ceramic products, then this option is ruled out.

On the other hand, the *Report on the Environmental and Circular Analysis of Spanish Ceramic Tiles* (ASCER, 2021), it is especially important to know the impact of the main ceramic product on the environment. The most substantial impact is found in two phases. 17% of the emissions of the entire life cycle of the ceramic tile are produced in the extraction



of raw materials and 68% in the manufacture of the product. The impact comes from the energy consumption of the equipment and the combustion of natural gas.

In conclusion, the ceramic cluster companies will have to invest and create synergies with other industries to face this situation. The cluster will need more electricity to continue with this decarbonization process, whose technological contribution is also essential.

### 3.1.2. Possible solutions

In relation to the above, it is clear that the costs for the tile sector are high, as we see in the graph (Figure 14). A series of measures have been proposed to avoid these situations.

Figure 14. Costs in CO<sub>2</sub>.



Source: ASCER (2021).

To achieve this challenge, ASCER has planned some **short-term**, some of which are: continue to reduce electricity costs, reduce the gas and electricity tax, eliminate the tax on hydrocarbons, reduce VAT from 21% (general) to 10% (reduced) in ceramic products and reduce electricity and gas tolls. On the other hand, in **the medium term** they ask to change the marginal electrical system to eliminate the price of electricity in those of gas, improve electrical connections with France, use more renewable energies and gases or create a platform that manages the purchase of natural gas for control in Europe (Báez, 2021).

Consumers can also help avoid excessive greenhouse gas emissions associated with tile. To do this, they can increase the purchase of sustainable and locally sourced products.

It would also be useful to lay the tiles dry or with ecological substances that replace other polluting substances and at the end of their life cycle disassemble and separate the product in order to recycle parts.

Finally, according to the *Report on the Analysis and Challenges of the Ceramic Tile and Flooring Sector in Spain* (ASCER, 2020), the ceramic cluster faces a fundamental challenge for the future of the industry, such as decarbonisation. In addition, the European Commission chose to leave ceramics out of the sectors exposed to carbon leakage, which has caused an increase in the cost of CO<sub>2</sub> emission rights. To meet this challenge, new technologies can be found to produce or adapt the resources that already exist to use other fuels to end dependence on gas and reach an industry with clean energy and reducing CO<sub>2</sub> emissions. It is essential that all members of the Castellón cluster are committed, whether they are companies or public administrations.

### **3.1.3. Examples of environmental innovations**

As we are seeing in this chapter, environmental concern must be a priority and it is a challenge that is the most important today. For this reason, many tile companies in the ceramic cluster are investing in technological innovations related to this aspect. Here are some examples.

#### **- Grespania**

This example, obtained from a press article (Anonymous, 2022), shows that Grespania, a company that we have already discussed in other sections, attaches great importance to sustainability and energy efficiency and therefore always tries to produce in a sustainable way using technologies, before your competitors consider it. For this reason we have decided to expose their proposals.

One of the improvements that this company has recently made has been to control energy consumption and seek perfection in this area through an internal engineering department. In addition, with the aim of better managing the energy of the equipment and sections, establishing energy monitoring indicators and being more saving and efficient, they have implemented an Energy Management System (SGE).

Grespania also has an environmental training plan and a sustainability and energy efficiency program for all its employees, which consists of raising awareness of the importance of conserving the environment and being as efficient as possible. Therefore, they are committed to creating a green culture, because it is useless for only some parts of the organisation to be involved.

In terms of energy, it should be noted that the production plants work with the zero discharge concept, purify and recycle water, and the cogeneration plant saves on primary energy. Regarding the photovoltaic plant, they have started in photovoltaic self-consumption, since they have installed photovoltaic solar panels that generate a lot of clean energy and reduce CO<sub>2</sub>.

#### - **Esmalglass-Itaca**

This group came together in 1999. They are companies that have always been dedicated to the manufacture and sale of frits, glazes and ceramic colourants, one in Vila-real and the other in La Pobla Tornesa. We now proceed to explain its innovation (Anonymous, 2022). This case serves to explain that efficient projects can be launched without losing sight of the brand value and the quality of the final product.

In 2022 they have launched a set of innovative and sustainable measures, called Redesign Innovation, based on new technologies and research. Applying actions like this is one of the reasons why they stand out as a world reference in ceramic enamel and digital inks.

This project consists of products and responding to problems, betting on quality and respect for the environment. It highlights the continuous improvement implemented in the business, the ability of its members to never stop learning and the good relationship with customers, which provides added value to the brand. These solutions make customers feel involved with innovations and with nature.

To reduce waste, harmful gas emissions and water consumption analyse raw materials. This allows many of its products to be ecological, modern and with economic advantages in production and cost savings.

#### - **Rocersa**

This company has carried out its main activity in L'Alcora since 1977, manufacturing and distributing indoor and outdoor ceramic and porcelain stoneware. One of its priority objectives is the environment. To demonstrate this, its business values are based, among

others, on committing to sustainability, people and technological innovation. Below, we present their innovative and sustainable measures<sup>11</sup>. This example has been chosen due to the number of sustainable measures that can be introduced and to imply that it is a continuous process that involves all members of the company.

One of their main measures to preserve the environment is dry grinding, without having to use water in the process, also to reduce water consumption they are trying to implement water exchange systems, taking advantage of the high temperature of the furnaces and using them in the raw product dryers.

Finally, their products stand out for containing between 44% and 62% recycled materials and they try to increase it to manufacture almost totally recycled products.

As challenges, the decarbonization of the sector stands out, but also the digitization of the production process and industry 4.0.

#### - **BP**

BP is an energy company that is dedicated to natural gas and oil, it was founded in 1909. This company is not part of the ceramic cluster, but it influences it. In 2022, it established collaboration agreements with ASCER and ANFFECC to decarbonize the ceramic industry in Spain. They hope to achieve . no polluting emissions by 2050 at the latest (ASCER, 2022), this being the main reason why we chose this example

Resources such as green hydrogen are expected to become competitive in a few years and it is committed to growing sustainably. BP will turn the Castellón refinery into a clean energy hub, so that it can produce and also supply renewable energy to ceramic companies in the area.

These agreements seek to create synergies and solve environmental problems such as the replacement of natural gas with other more sustainable and nature-friendly energies.

All these examples have in common that environmental innovations take time and that is why in the challenges that we are seeing, many companies put the year 2050 as the limit.

### **3.1.4. Environmental trends in the future**

Bearing in mind the previous sections, we affirm that new technologies are a continuous process as well as the environment that is very changing. Information and

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<sup>11</sup> Information obtained from: <https://www.rocersa.com/innovacion-tecnologica-y-sostenibilidad/>

planning is essential to be able to deal with problems such as the one we have seen in the environment. Everything points towards some trends that we will see below and that in the year 2050 there will be important changes in various areas of the sector and the ceramic cluster (Quintela, 2020).

### **The market**

Many companies will be forced to reinvent themselves in order to have a good position in the market. It is expected that in 2050 the educational levels of the population will be higher and therefore there will be greater urbanisation and growth of the middle classes. This growth will affect the ceramic sector in a positive way, increasing global demand and the number of customers.

Urbanisation will cause cities to have to improve and increase their infrastructure, so the ceramic industry will increase its sales and production.

### **Energy**

The problem of high carbon emissions will be reduced considerably, thanks to the use of renewable energies and the use of better energy efficiency.

Investments and innovations will play a fundamental role in the supply of electrical energy, to promote the use of renewable energies, with what is intended to be the dominant energies in 2050.

As there are sanctions for using polluting energies, it will be more profitable to use clean energies. We assume that the government will take measures to encourage this change of energies.

### **The ceramic product**

To know what the product will be like in 2050 is complicated, but it is thought that there will be changes that will make it more ecological, reusing its utilities and being efficient.

Some of the future features may be: less thickness, larger products, glazes without water, more worked clays, greater flexibility in the processes and improvements in aesthetics.

Manufacturers will have to deal with possible substitute products and with technical and environmental specifications.

### **The manufacturing process**

It is expected that many processes will be automated and digitalization will be introduced, increasing the specification of specific products to satisfy even more, if possible, the needs of customers. The manufacturing process will be circular and it will collaborate with other sectors to expand resources and capabilities. As we have said, flexibility in processes and finishes will be a reality, as will the greatest possible energy efficiency and the recycling of parts and materials.

As a summary of these trends, we make use of the following comparative table (Table 3).

**Table 3. Comparative summary of trends in the ceramic cluster of Castellón.**

	TRENDS	ACTIONS
<b>The market</b>	Increasing population formation, urbanisation and middle classes, rising global demand, increasing sales and production	Businesses need to reinvent themselves, more infrastructure and investment in training
<b>Energy</b>	Carbon emission reductions, dominant renewable energies, energy shift	Use of renewable energies, energy efficiency, investments and innovations, government support
<b>The ceramic product</b>	Greener product, reusing its utilities, more efficient, changes in its features	Technical and environmental specifications
<b>The manufacturing process</b>	Process automation, digitisation, circular manufacturing process, energy efficiency	More specialisation in products, collaboration with other sectors, flexibility in processes and finishing, recycling of parts and materials

*Source: Own elaboration (2022).*

To close this chapter, we can affirm that the environmental challenge is the most important and it is essential that it be supported by new technological advances and although we do not know exactly the trends of the sector and the cluster, with the information we have it is expected that it will be a cleaner and more sustainable industry.

## **CONCLUSIONS**

Having analysed the case of the ceramic cluster, we can say that it is a model that is successful today. Being a powerful industry in the Castellón area, it is understandable that this agglomeration of companies has been located in this part of the Spanish geography. This fact has allowed it to grow in terms of data and infrastructures to the point of occupying a large part of the profits of the entire national sector. At an international level it is also a benchmark, although it has countries with which to compete, such as Italy or China.

The collaboration of the members of the cluster and the ability to learn means that they currently take advantage of market opportunities, being strong in resources, skills or professionals, although the constant changes in the environment make them continue with this continuous improvement and face threats. . As we have been able to verify, throughout history they have suffered crises and various problems, but companies, with the help of institutions, have managed to overcome and remain competitive at a national and international level.

The initially set objectives have been resolved, given that we have been able to learn about the ceramic cluster since its inception, as well as its innovations and improvements generally accompanied by technology.

We have been able to learn about the current situation of the ceramic industry and as employees of companies in the ceramic sector have pointed out, the main challenge is the one they have with the environment. This issue is difficult to tackle, because as we have been saying and based on the information that we have been able to present, the high CO2 emissions, the high energy costs and other drawbacks are difficult to replace with other energies that are more respectful of nature and whose costs allow them to obtain profitability. The important thing is that it must be a joint process that involves all the elements of the industry and that the best actions are studied so that in the future the ceramic sector continues to be a benchmark in sustainability as well.

One of the most surprising situations has been the ability of companies to generate synergies and the support they receive from associations such as ASCER or from universities and public institutions. They know that they must make the most of the activities that can be carried out in the cluster and the position they currently have in the market to continue innovating, thanks to new technologies and people, who plan any plan to invest in what is best for their businesses. We can also say that innovation is very important, that it is present in the vast majority of improvements and advances, not only environmental, but also

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in any aspect such as technological or social.

As possible future works, pending issues have been left that have to do with other challenges such as digital printing, the clay supply crisis, the use of marketing in the ceramic sector or the panorama that is coming with the war in Ukraine. These are avenues of research that, accompanied by appropriate references, can serve many people interested in knowing more about the ceramic world, which, as we have seen, is very broad.

Finally, I would like to end by saying that the Castellón ceramic cluster is a clear example of an innovative industry that aims to improve the figures of previous years and to continue with the prestige that it has been cultivating for so many years, making more and more young people interested in working in a company located in the cluster.



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