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Project

Master in Product Design Engineering

Sustainability communications and the ceramic tile industry

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Dedication

It is with genuine gratitude and immense respect to dedicating this work to Eduardo Guerra Franco Batalha, for the support, inspiration, and guidance he has been to me.

Acknowledgements

I want to state gratitude to those who assisted me in developing the current thesis report. Firstly, I would like to thank my first supervisor, Pro. Fábio Jorge Pereira Simões for their support and guidance. Next, I would like to thank my second supervisor, Prof. Ana Catarina Cadima Lisboa. Even though our meetings were less regular, your feedback and advice have been valuable to me. Furthermore, my gratefulness goes out to Pro. Artur Jorge dos Santos Mateus for being involved in this research by finding the case study companies. Finally, I want to thank Mota Ceramic Solution Group for their pleasant cooperation in the research work and Tabriz Tile Group for sharing the information.

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Abstract

This research project proposes to analyze the significance of communication in the success and announcement of ceramic factories, specifically in the sustainable production process, observing how communication works in disseminating sustainability and how it can be an advantage for the factories, working as a vital element of their communication strategies. Thus issues related to sustainability in the ceramic industry are discussed in this work. The importance of communication, its promotion of brand representation, and its relationship with the focus study group, namely architects, constructors, and interior designers, make the audience realize its sustainable practices. The research methodology used in the research consists of analyzing tools/media communication used by two companies, the Mota Ceramic Solutions group and the Tabriz Tile group, trying to know if they are communicating their sustainability-related activities efficiently. The data was collected mainly from the websites of leading ceramic manufacturing companies for qualitative analysis. In addition, a survey was done on end-users of the products, focusing on architects, constructors and, interior designers who decide on material selection for a building. The research emphasizes the gap and lack of guidelines for end-users to choose more sustainable products. Ultimately, after analyzing the results and following the theoretical background of the work, the two case study companies are recommended to improve their communicational methods through:

- Publishing environment-related actions
- Including sustainability indicators in products
- Publishing sustainability-related certificates
- Promoting Corporate Social Responsibility activities

Keywords: *sustainability, ceramic industry, marketing*

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ISO: International Organization for Standardization

LCA: Life Cycle Assessments

LCC: Life Cycle Costing

SLC: Social Life Cycling

EMAS: Eco-Management Systems

SB Tools: Sustainable Building Tools

LEED: Leadership in Energy and Environmental Design

BREEAM: Building Research Establishment Environmental Assessment Methodology

EPD: Environmental Product Declaration

ASCER: Spanish Ceramic Tile Manufacturers Association

CRM: Customer Relationship Management

Contents

Chapter 1

Introduction

1.1 Background

The tile history is a long anecdote back to thousands of years ago. Nevertheless, architects have applied Ceramic tiles as one of the most senior features of an applicable and decorative human-made piece of art because of their unique qualities and dynamic technical and mechanical properties.

Tiles provide aesthetic and decorative outlooks and their functionality as a hygiene product covering interior and exterior spaces with the proper size, trim, and surface appearance. They are compatible with installation indoors or outdoors, flat or curved surfaces, horizontal or vertical surfaces, and high or minimum humid conditions. Ceramic tiles require little maintenance to keep them clean and in good condition than other organic materials. Ceramic tiles are inert, very resistant to water and ultraviolet radiation. They have a long life span, which results in optimized raw material consumption and less environmental impact. They improve air quality because they do not transmit odors, volatile organic compounds and, bacteria.

Being a fire-resistant element, they have high thermal inertia and act as the heat regulator by saving it during the day and freeing it at night. Thus, they meet the requisite requirements for sustainable and energy-efficient buildings [1].

1.1.1 The environmental effect of the rising production, consumption, and demolition of ceramic tiles

According to the fifth edition of the publication " World Production and Consumption of Ceramic Tiles," produced by the Acimac Research Department, the World observed an increase in the production and consumption of ceramic tiles in 2016 [2]. The amount of this extension was 5.7% and 5%, sequentially. In Asia, this number was 8%, equal to 69% of global consumption of ceramic tiles. The manufacturing process of ceramic tiles in EU countries and Turkey annually produced 1.4 million tons of dry solid waste in the year 2014, and this number is increasing accordingly regarding the amount of 5% yearly growth in the manufacturing of ceramic tiles [3].

In addition to the diverse residues and scraps generated during the manufacturing process, energy consumed in every stage of the production process is notable. The sequential by-products of that consumption result in a significant environmental impact. The energy used as 80% of raw material for producing tiles is non-renewable. The primary energy consumption is in the sintering process that happens at a temperature of up to 2250 to 2350 degrees Celsius. The sintering process uses electrical energy. Along with energy consumption at such a high rate, nano and ultrafine particles are emitted to the environment causing lounge problems to people working there. Besides nanoparticles, other dangerous materials are also released, such as gases, wastes, and chemicals known as human toxicity. Along with electricity, another primary type of energy consumed in the manufacturing process is natural gas [4].

According to ISO standards, LCA's environmental impact aspect, for ceramic tiles, is categorized as Acidification, Eutrophication, Global warming, Ozone depletion, Photochemical ozone formation, Depletion of abiotic resources, Water consumption [5]. Furthermore, regarding waste generation within the EU, more than 450 million tonnes per year of construction and demolition waste are generated, the most significant waste, apart from mining and farm waste [6].

1.1.2 Sustainability in the ceramic industry

In this regard, many innovations have been applied based on eco-design strategies that concentrate on optimizing the end-of-life systems via designing and achieving new styles of installing and demolishing ceramic tiles. The ceramic industry can innovate the manufacturing process and reuse waste/by-products caused during ceramic tiles or other products, developing circular economy strategies and industrial symbioses. The ceramic tile industry contributes to the Circular Economy by optimizing selection criteria for raw material, product design, implementing strategies for resource efficiency, reusing the water in the same manufacturing process or other industries, reusing the residues such as broken ware mass residues [7, 8].

Academics and policymakers focus on the relationship between environment and industry by growing natural and social science research activities to make environmental innovation. Environmental innovation is expressed as " all the changes in the product portfolio or production processes that tackle sustainability targets." some of these targets are: " eco-efficiency, reduction of emissions, waste management, recycling or any other activity that leaves minimum environmental footprint" [9].

1.1.3 Environmental marketing

At present, the concept of Sustainability has such importance that enterprises do not have any other choice but adjust their activities to sustainability principles and design their business model accordingly to attain a competitive advantage. Their business model focuses on future generations' consideration with transmitting, making, and communicating a product with sustainability-based value. They accomplish this aim via a marketing strategy that maintains profitability, ecology, and public interest. Sustainability marketing started with ecological concerns and converged on the long-term relationships regarding: "building and maintaining sustainable relationships with customers, the social and natural environment." What matters is making a sustainable value that responds to consumers'

demands while fulfilling all three sustainability policies in the consumption process [10].

1.2 The scope of the problem and a Research Gap

The problem arises when the ceramic tile companies do not communicate their sustainability activities effectively. The proper sustainability message to transfer is also a challenge for them. When communicating sustainability activities, companies need to set their communication objectives according to their priorities, interests, mission, and target group. The fundamental matter is to share the sustainability message efficiently with the audience to receive positive feedback. Companies employ a wide range of tools to transmit their sustainable activities [11].

Nevertheless, the effectiveness of those channels varies based on the characteristics of the company's activities and the company's priorities. So the questions of the research work are:

- How are sustainability activities currently marketed and communicated in the ceramic companies?
- What are the most effective channels to interact the proper sustainability message between the ceramic companies and the end-users?

The first research question aims to present how ceramic tile companies communicate their Sustainability Marketing activities. Further, this question will analyze how ceramic tile companies apply sustainability communication channels in their communication and marketing strategy to communicate their Sustainability Marketing activities to the end-users. Finally, the second question will investigate the most effective media to share the sustainability message with the end-users through qualitative research. Through these research questions, new knowledge about how sustainability marketing functions in the ceramic industry and how it influences marketing communications is achieved.

Furthermore, it can give ceramic tile companies a distinct method of addressing sustainability activities to create meaningful effects on the selection criteria of the end-users.

1.3 Objectives

This thesis investigates how ceramic tile companies communicate their sustainability activities through marketing channels to their end-users. The question of how Ceramic companies use sustainability marketing for marketing their sustainability activities and which communicational channels are most effective to promote sustainability criteria when selecting ceramic tiles is answered.

1.4 Structure of the work

This first chapter outlines the background and context of the research. Chapter two provides an in-depth theoretical study of the ceramic tiles in terms of; material, manufacturing process, the environmental effects of the process, and the strategies and functions to diminish these effects.

Moreover, the concept of sustainability, marketing, and communication of sustainability is studied in chapter two. Chapter three includes the research method and data collection. The analysis of the data and discussions upon it are presented in chapters four and five. Finally, the conclusion, suggestions, and further research arguments are presented in chapter six.

Chapter 2

Literature Review

2.1 Ceramic Materials

2.1.1 History

The word "Ceramic" is originated from the Greek word "Keramikos," meaning "for pottery," and is derived from the word "Cheros," meaning heat in an Indo-European language [12]. The first industry created by humankind during the Neolithic period, even before metals, was the industry of producing ceramics [13]. 24000 BC, the first artificial ceramic product as earthenware was made with a mixture of clay with water. It was then molded, dried, and cooked. It was 7000-5000 B.C when the cementitious material was used for flooring. It was a semi-plaster material used as a first covering layer in the walls' interiors, then decorated. In the copper ages, along with the kiln's invention to melt the copper, bricks that were only dried before were now cooked, thus having higher strength and much durability. In 3300 BC, the potter wheel was invented, and then earthenware pots came to exist. Since the beginning, ceramics have been products surrounding humankind and have been used in various areas and forms as natural or synthetic and traditional or modern. In 35000-30000 years ago, a natural ceramic called red ochre was used to cover the bodies of dead people. Subsequently, colored sands were mixed with water and were used to paint images and color bodies. However, earthenware was the first artificial ceramics in the form of female sculptures. The required temperature to fire these items was low to medium. Later, earthenware was used as food storage and for cooking. The low temperature used for firing earthenware led to a porous product that later, with the invention and use of kilns, got the higher quality and enabled ceramists to make higher-quality vessels. In addition to vessels and bricks, people started making clay tokens to record information and written language and trading. Through the clay tokens, pictographs were transformed into scripts.

The word "Tile" related to the French word "Tuile" originated from "Tegula," a Latin name used for a roof tile clay [12]. The use of ceramic tiles dates back to the oldest civilization when Egyptians decorated their houses with blue tiles in 4000 B.C, and Babylonian people hired glazed bricks for the Ishtar Door in Mesopotamia 5000 B.C [15].

In Europe, firstly, mosaics were used resembling the byzantine ones, creating drawings from pieces of stones. However, soon enough, under the ceramic Chinese influence accessible through

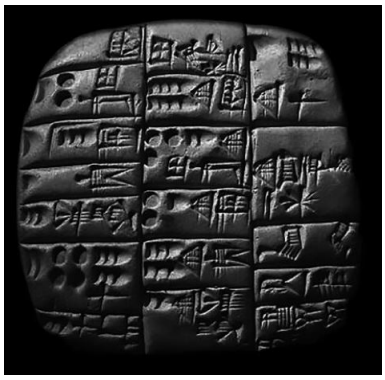

Figure 2.1: Clay tokens as cuneiform tablet [14]

the silk routes, the ceramic tiles with their glaze and drawings began being used. The Islamic Empire disseminated getting the benefit of by now the thicker tiles as inside and outside covering in Islamic architecture [15]. Moors introduced ceramic tiles into the Iberian Peninsula in the 13th and 14th centuries; however, after the 16th century, Portugal truly embraced ceramic tile art and made it one of its cultural expressions. They were done in a squared shape and used everywhere, from public places to private and religious ones, outside and inside walls [15].

Iznik, a tile belonging to the Ottoman Empire in Istanbul, Turkey, had a special glow due to quartz layers. Shades of red became iconic with floral motifs and Koran passages with Arabic calligraphy. They were applied in mosques to resonate with the sound of prayers, thus giving a feeling of amplitude [16].

Figure 2.2: Historical evolution of tiles through the course of years[15]

In the 17th century, a new class of Dutch tiles influenced by white and blue Chinese Ming porcelain became popular, called Delft, with central figures and elaborated ones on the four edges (image6) [15].

Manufacturing tiles on an industrial scale began in the twentieth century, and the automation of tile manufacturing was increased by the invention of tunnel kiln around 1910. There were two main

reasons for the tremendous advances and improvement of the ceramic tile industry after the second world war; more requests for building materials and the necessity for safer and healthier workplace scales for workers. These standards changed the system from manual labor work to a mechanical industry [17].

However, it was from mid 19th, almost the beginning of the 70s and 80s, due to the crucial energy crisis, that series of enormous changes and advances occurred in the ceramic tile industry [18]. Some of those changes established the base for the ongoing technologies. These changes were generally in three areas [19]:

- Treatment and the election of material to prepare via a wet or dry process
- Firing in which the prevalent double firing changed to single firing and rapid double firing thus less energy consumption become viable
- The forming procedure including the mills, presses, size of tiles, decorative techniques, and extrusion [17, 19]

2.1.2 What are ceramic materials?

Scientifically, ceramics are non-metallic, inorganic, and refractory materials. That is achieved via thermal processing of its mineral content, clays, or other minerals from earth crust, at a very high temperature during the manufacturing process or chemically processed powders [20]. The mineral substance of ceramic material transforms into a partially crystalline and partially vitreous structure after being subjected to the thermal process [21].

According to the American society of testing and material, the ceramic material is "an article having a glazed or unglazed body of the crystalline or partly crystalline structure, or of glass. The body is produced from essentially inorganic, non-metallic substance and either formed from a molten mass which solidifies on cooling or is developed and simultaneously or subsequently matured by the action of heat" [21]. Therefore, ceramic manufacturing is feasible for the amount of natural raw material in the earth's crust Fig.2.3. Regarding the periodic table of elements, the number of components associated with ceramic materials is limited. These elements are aluminum, silicon oxides, and Fe, Ca, Mg, K, Na, which are present in the chemical composition of the ceramic tile body, and Pb, Zn, Cr, Ni, Cr, V, Sn present in the formulation of ceramic glazes [21].

They are always composed of more than one element, namely a compound of metallic and non-metallic elements [13]; aluminum and oxygen (alumina)Al_2O_3 , silicon and carbon (silicon carbide), silicon and oxygen Si_2O_3 and silicon and nitrogen (silicon nitride) Si_3N_4 [20]. The atomic bonding makes ceramics stronger than metals but, on the other hand, is a limiting factor for plastic deformation because ceramics are fragile materials under tension forces. The atomic structure of these materials leads to the following properties [21]:

- Chemically inertness
- High wear strength

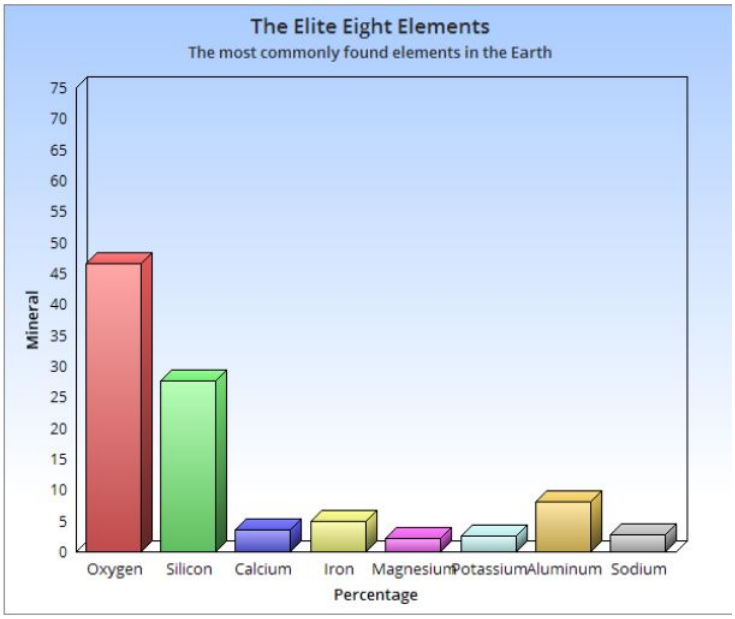

Figure 2.3: The most common elements in the earth's crust [21]

- High fusion temperature
- Insulators
- Low thermal conductivity
- High strength and brittleness
- Higher density than polymers and less density than metals
- Low ductility

2.1.3 Classification of ceramic materials

There are different criteria upon which ceramic materials are classified. They generally are assessed based on the chemical and mineralogical structure. In this regard, there are two main groups of ceramic materials [14, 20]:

- Traditional ceramics that are based on silicates and have an important place in buildings of early civilizations in the form of ceramic bricks, decorative tiles, and plasters. Traditional Ceramics include clay products, refractories, cement, and glass and are made with the material that is extracted from the earth's crust [14]
- Advanced or modern Ceramics that are developed more recently with synthetic materials with special physical features and a high amount of purity. These ceramics have better physical or mechanical properties than traditional ones and are found on non-silicate glasses, nitrides, carbides, borides, and pure oxides. They have a wide variety of applications, some of which are for cutting tools such as aluminum oxide, used for computer memories, Bio-ceramics used for artificial bones and teeth, Engineering Ceramics, Composites, High-temperature ceramics, Military applications, Ceramics in optics, Ceramics for electrical applications, and Magnetic ceramics

2.2 Ceramic tiles

There are generally two types of classifications for tiles [21, 19]:

- Commercial; from this point of view tiles are classified as Terracotta, Majolica, and Gres
- Technological; from the technological aspect in the manufacturing process, tiles are classified based on the body's raw material, the forming process, presence of glaze, number of firing, mechanical strength, and additional treatments after the firing process

2.2.1 Chemical composition of a traditional ceramic body

Regarding the required final ceramic product, the composition of materials for the traditional body in industrial manufacturing has various raw materials in different amounts. Ceramic products are made up of inorganic materials and are defined as any outcome of a process in which it is converted from a powdery state (it makes them porous materials) to a solid object by consolidating. They become partially crystalline and partially vitreous via different procedures and sintering, the composition of the body, and the conditions in which these procedures take place to determine the transformation and characteristics of the final product. Raw materials in the body of a ceramic product are arranged in two major classes [21]:

- Plastic materials; clayey materials
- Non-plastic materials; fluxing materials, Inert materials and additives

Plasticity means an attribution a material has by which it can be deformed under pressure and preserve form after the stress is omitted. Any clay is used in fine ceramic industries [22]. Non-plastic materials include quartz, limestone, dolomite, magnesite, talc, calcium phosphate, and feldspar [21].

The classification of elements specifying "Traditional Ceramic" body is limited, but according to the concept of "Standardised" tile body, it is comprised of [21, 22, 20]:

- Clayey materials consist of Al, Si, and a small percentage of Ca, Fe, and Ti and provide the required plasticity to achieve the desired shape
- Fluxing materials include K, Al, Si, and Na. They are present in the chemical composition of Feldspars, nepheline
- Additives
- Inert materials such as Silica, Talc, and Pyrophyllite

Plastic materials

Clays are the most critical elements among the elements of raw materials for the ceramic body. They are variable rocks consisting of various minerals with a silicate nature, such as Aluminum silicate and hydrates.

Different kinds of clay in ceramic body composition are classified as [21, 22]:

- Vitrifiable and plastic red firing clays
- kaoline-type, china-type clays
- Carbonitic clays
- Ball clays

Non-plastic materials

Alongside clays, there are supplementary materials whose mineralogical nature and particle size diffusion and their relative ratio define whether the firing body is red or white. The latter state and specification of the ceramic tile are significantly affected by the produced compounds in the firing stage. Some of the most important supplementary materials are [21, 22]:

- Feldspars and quartz
- Calcite and dolomite
- Silica

Regarding the raw material of the body, tiles are classified in three groups [21, 23, 24]:

- Red body ceramic tiles have a considerable amount of iron oxide in their chemical composition, giving them the red color and less percentage of complementary or supplementary materials. They are generally less expensive because of the ease of production and the relative price of raw material, Easier to cut, especially when tiling by yourself, Lighter than porcelain and heavier than a white body, and More porous than porcelain
- White body ceramic tiles are somewhere between the red body and porcelain body tiles. The lack of color in the body allows lighter glazes to pop, but the relative lack of hardness means they are only suitable for wall coverings. Key points about white body tiles include better color definition than red body especially with lighter glazes, More expensive than red body tiles; due to the more lightweight quality materials used in the production, sharper edges than red body tiles; due to the more refined grains of the clay used in the composition of raw material. In addition, white body ceramic tiles are often rectified, lighter than red or porcelain body ceramic tiles

- Porcelain tiles have less water absorption and more resistance to frost. They are dense and smooth. Compared to other ceramic tiles, porcelain tiles are more rigid, wear, and damage-resistant. Porcelain tiles are also heavier than other tiles, more expensive, harder wearing, and the least porous

Regarding the functionality of ceramic tiles, they are categorized as [21]:

- Wall tiles are produced via a single and double firing process. They have white or red body color based on the quantity and typology of the used clay. Previously they were produced in limited sizes such as 15x15 and 20x20 cm, but technological advancements increased the variety of sizes to 25x33, 33x45, and 40x60 cm. In addition, the quality and effects of glazes used on the surface of wall tiles give them a very high aesthetic aspect and technological performance
- Floor tiles are produced in square form with average sizes, and the recent trend for the surface effect has been stone-like or antique expression, a matt stained surface. Other special effects are applied on floor tiles via more complicated glazes like powder or grained glazes and different treatments after firing. However, glossy glazes are not preferable to be employed on the surface for the lack of abrasion resistance they have; if so, a layer of matt relief effect is applied

2.3 The manufacturing process of ceramic tiles

During and after the second world war, the variety of wall and floor tiles in the ceramic market was few. As for the wall tiles were porous and glazed tiles such as majolica for red body and calcareous for the white body, and for the floor tiles, there were unglazed products which were used for industrial and outdoor spaces [18, 19].

As discussed earlier, three major changes advanced the ceramic industry and resulted in the current technology. Depending on whether a tile is glazed or not and complexity of firing, if it is single,double or even third, the consecutive phases of the ceramic tile manufacturing process consists of the following stages [17]:

- Batching and preparation of raw material
- Mixing and grinding
- Spray drying
- Forming
- Drying
- Glazing
- Decoration
- Firing
- Quality control
- Sorting and Packaging

2.3.1 Batching and preparation of raw material

Tiles are made up of raw material that is available in the crust of mother earth. After the extraction of them from mines, they are transported to ceramic plants by trucks, railways or etc and then are stored depending on the stages of the particles processing and their state and specifications [17]. As powder state materials are stored in open stockpiles, warehouses, feeders, and silos, and the liquid states like slurry are stored in tanks.

Raw materials are checked for their uniformity to ensure their properties [18]. This need is met through preliminary homogenization and size reduction processes in quarrying operations [17]. The raw material is mixed along with water, cast, and pressed or extruded into shapes. The excessive and additional water is removed from the formula throughout subsequent stages [17].

2.3.2 Mixing and Grinding

Raw materials that are transferred to the factory are in rough forms thus they ought to be processed to obtain the desired particle size. In fact, the particle size and its distribution over the mixture of raw material have a decisive role in the type of technique that is employed for grinding. The grinding machines are mills composed of rotating vertically embodied rollers [19]. Grinding is an intricate step in ceramic manufacturing and its purpose is to create particles with an appropriate diameter and optimal distribution. The uniformity or homogeneous specification is optimal to accelerate chemical reactions while firing [17]. There are two types of grinding techniques and they are employed based on the specification of raw material [17]:

- Wet grinding
- Dry grinding

Wet grinding yields a more homogeneous output with a greater size reduction. It is used with natural mixes of clays and hard materials. It is also used when the impurities of clays need to be omitted from the bodies. Dry grinding is used in the cases of having a mixture with few materials like clays with similar physical specification and mineralogical structure [17].

Regardless of the type of employed technique, the grinding is consist of five main steps: crushing, percussion, impact, abrasion, and cutting. These steps are generally categorized into two main states; primary grinding in which extracted rough blocks are crushed into particles with 0.5 mm size and secondary (final) grinding by which particle size decreases to tens of micrometers and atomizing result in particles with the size of a few microns [19].

It is important to bear in mind that in order to gain the desired uniformity, physical and mineralogical heterogeneity is required. In this concern, there are some criteria that should be considered; Scattering of ingredients in the mixture of raw material must be thorough, the raw material should be pure and free from extra component. The degree and intensity of grinding vary for different mineralogical components [17]. It is essential for the forming process to have a mixture with a specified amount of

water and additives such as pigments. Various kinds of mixers are employed in the ceramic industry depending on the final product. In the ceramic tile industry stirred tanks are acquired to mix aqueous slurry, suspensions, and slips [17, 19].

2.3.3 Spray drying

Once the raw material is mixed in wet mill balls, the output is a slurry mixture of raw material with a water content that needs to be treated in order to obtain a specified amount of moisture, shape, and uniformity in particle's size. Spray atomizer drier or spray drier is where the treatments take place via an ongoing, automated flow. The aqueous suspension is transferred to tanks and then fed into a spray drier where atomizing happens. An atomizer is equipped with a pressure centrifuge nozzle, which breezes the slurry into the middle of a large tank that is fed with the stream of hot weather as slurry becomes air to burn. A chamber of shape and volume in drier cultivates the heat interchange between sprayed slip and hot weather stream. This automatic and ongoing process of atomizing and drying by hot weather yields atomized droplets of very uniform material with the specific content of water(basically 5.5-7%) [19] and homogeneous particle size distribution. In general, physical characteristics of slip such as density and viscosity play a way more important role in particle size distribution than the chemical composition of different ceramic bodies like porcelain tiles and single firing of both vitrified and porous ceramic bodies. This size is normally in the band of 100-600 microns in diameter whereas maximum size concentration in the range of 250-350 microns [17]. The produced very uniform powder has a high flow rate speeding up the further pressing process.

2.3.4 Forming

In order to form the body of the tile which is called biscuit, different methods are applied based on the type of the tile; whether it is a wall or floor ceramic tile or brick or roof tile. These methods are [19]:

- Semi-dry pressing
- Extrusion
- Slip-casting

When the clayey raw material has 5 to 7% of water or moisture content, a semi-dry pressing technique is applied [19]. The produced atomized dust in the spray dryer is loaded into a holding vat just behind the press machine. The vat releases the measured quantities of atomized dust into a tray which distributes the powder evenly in the mold. The shaping of tiles to give the desired geometry, compression of particles in order to attain the mechanical characteristics, and densifying of granules to remove any extra vacancy, take place in the pressing stage all of which, in addition to press power, have a considerable influence on compaction of granules. The moisture content of pressing dust is scattered fairly which confers plasticity via connecting the particles to each other [18]. Thus biscuits being produced by pressing get dry more easily and have a limited amount of firing and drying shrinkage.

In general, depending on the energy application, there are three types of pressing methods; hydraulic, mechanical, and isostatic, among which hydraulic press is employed in the manufacturing process of ceramic tiles. The energy consumption and necessary force or power of the machine depending on the size of the tiles, whether they are small and trim, medium or large size (e.g 30x60 cm, 60x60cm), standard sizes like 40x40cm or larger (e.g 120x180cm). The final product after the pressing step is expected to be without any defects in consequence of pressing such have had empty air pockets in the body, inaccuracy in the geometry, shape, or flatness. It is also desired to achieve a product with a homogeneous microstructure meeting some criteria as [17]:

- Having the preferable bending strength after being pressed necessary for the entire manufacturing process
- Achieving a biscuit which is vulnerable enough to release the gas that is produced because of the presence of carbonates in the firing or pre-firing stages
- The final produced tile must be typically porous, have specific mechanical properties like bending strength and firing shrinkage

In the extrusion process, clay composition is a paste with plasticity having 14 to 20% of moisture content. It is achieved by the homogeneous mixing of material with water. It is then pressed into a die, whereas, in the pressing method, clay material is the form of powder granules of clay content and is pressed into the mold. The variety of grain size and the percentage of water content in the composition of the material to be formed define whether the forming method is fully dry or semi-dry. There are other methods for forming the tile body, namely molding, which is applied for rustic affected tiles, borders, and some decorative tiles with unique surface shape [19]. In this technique, a die or mold with the final and defined geometry of biscuit and a cylindrical pressure is used to press the clay material through. This technique is primarily used in producing bricks and roof tiles and is less common for ceramic tiles. Because the tile is extruded through a cylinder, the final product needs to be separated. Thus this type of tile is called "spilt tile" [19].

Slip casting, on the other hand, is a traditional manual or mechanical process in which the liquid content of raw material is pressed into a plaster mold which absorbs the humidity and water content of the liquid raw material to the point that desirable consistency is achieved [19].

2.3.5 Drying

There are some considerably important requirements to be met by an appropriate tile body to attain the following processes like firing and glazing, such as including minimum water content as well as high bending strength. These requirements are achieved by the drying process which it's rate depends on various parameters [17]:

- Percentage of the content of non-plastic raw material in the case of having desirable and optimal finesse in particle sizes have a positive consequence on shrinkage
- The intensity of the pressure hired in the previous stage while forming; a higher amount of pressure causes less water distribution on the structure on the tile body

- Geometry and thickness of the tile has also direct relation with the speed of evaporation, bigger surfaces have a higher speed of evaporation
- The amount of moisture content where more moisture leads in higher shrinkage and plasticity

The drying process is the second energy consumer after firing. In this process, the water content is removed from the face of the shaped tile after the forming stage through evaporation. The heating air circulation is required in order to transfer the moisture from the substance to the surface and evaporate it from the surface of the tile, thus the hot air which is fed to the tile surface must be homogeneous to achieve optimal removal of water from it [25]. The temperature of the hot air flow has a very decisive role in the evaporation rate. Depending on the working conditions and air parameters such as volume, metric values, speed, and temperature, there are two types of driers [17]:

- Vertical driers
- Horizontal driers

In automated manufacturing of ceramic tile manufacturing systems, vertical driers are employed to obtain tiles with uniform temperature, minimum extra water content, and high bending strength. As the name states, these driers have a vertical structure. While tiles are automatically loaded and moved on rollers, fans and burners generate hot air circulation, thus evaporating the moisture and drying tiles by convection. Therefore, from the energy consumption point of view, these driers are used to minimize energy consumption [17].

On the other hand, horizontal driers have several rollers in a horizontal direction inside a tunnel in their framework, and the channel is insulated. The hot air, which is generated through recovering the radiated heat of the kiln, is fed in a similar way into rollers and causes evaporation and consequence drying of tiles [25, 17].

2.3.6 Glazing

The microstructure of glass-ceramic materials has particular technological aspects that accelerate the mechanical, chemical, and aesthetic properties of tiles when using them. Therefore, after the pressing stage is finished, tiles are generally subjected to glazing and decorating before cooking except for some terracotta tiles, rustic stoneware, and porcelain tiles [19].

Depending on the design of the tile, glazes might be applied in one or more layers through multiple firing cycles. In general, it is composed of vitreous material that cannot be solved when mixing with water. It is melted before use and then cooled suddenly in air or water to follow the crystallization process. The behavior of glaze and its effect on the surface does not depend only on the chemical composition of the glaze itself. It also depends on the body of the tile and the reaction between the body, glaze while being heated in the kiln.

Its thickness is between 75-500 microns and exists in various forms such as powder, granulate, aqueous, or non-aqueous and is applied to the surface of tiles. After exiting the glazing stage, it turns

to white and changes to transparent effects just as passing through the kiln. Glazing has aesthetic aspects and practical purpose, giving tiles bending strength, durability, and hygienic elements [17]. Similar to the raw material of the ceramic body, glazes are composed of inorganic materials which are applied to obtain specific effects, some of which are [26] :

- Glass former: silica
- Fluxes: zin, alkaline earth, boron
- Opacifier: zirconium, titanium
- Dyes: iron, chromium, cobalt

In general, glazes are formulated and categorized depending on various factors: the firing temperature, the presence of specific chemical material in the composition of glaze, kind of the method that is used to produce the glaze, the process by which glaze is employed on the tile surface, and desired optical effect of the finished product. Some of these effects are [26]:

- Matt or semi-matt
- Satin
- Transparent
- Shining
- Opaque
- Coloured

There are other criteria to be considered about the classification of glazes [26]:

- Fusibility meaning whether the glaze is less fusible, fusible, or hard
- Having an especial chemical element in the composition such as Lead
- The need for more firing or extra treatment; in this case, it can be single or double conventional firing, single or double fast-firing covering

Frits and other raw materials are ground in the ball mill. The percentage of moisture content is adjusted accordingly, then they are used in the suspension to prepare glaze. All the required characteristics related to viscosity and suspension are according to the method of applying glaze on tile surface [19].

2.3.7 Decoration

Once biscuits are subjected to glaze, the designed pattern is printed on the tile surface. It is essential to remove the moisture content of the tile body to guaranty its stability while the cooking process is happening in the kiln. When tiles come out of the kiln, they are homogeneous products, and they must be strong, having no defeats and physical lacks for the subsequent stages. Glazing prepares tiles for the next step that is decoration. The decoration is done via two main methods [17]:

- Screen printing
- Digital inkjet printing

Screen printing is a method with a much easier application technique when employing in glazing line, and its viability through which the printed colors on tile are visible [17]. This section is composed of the roller and printing. The design is done layer by layer in multiple printing cycles to achieve more possible details. The screens encompass unique masks, and ink is transmitted only through the openings of the pattern to transfer the design on the tile [19].

The recent signs of progress in the graphic area accelerated print screening techniques. They were once was used with glossy tiles but then were applicable with rustic tiles as well. The advantage of the method is the repeatability potential to obtain many products. There are three kinds of printers implementing this technique [17]:

- Flat; in this method, there is no direct contact with tile, and the scraper of the printer pushes down on the screen to transfer color via fabric, transferring pattern on the tile surface
- Rotary; this method has a stable printing speed, and unlike flat screen printing, tiles move non-stop, thus higher productivity is gained. In addition, a bigger diversity of designs are achievable through this method
- Roller; patterns of specified design is engraved on a silicon or polymer cylinder with a laser

When tiles get in direct contact with the surface of rollers, their moving speed is set equally; thus, synchronization of the components of the system occurs, and tiles get the pattern.

The second method of printing utilizes a very modern inject machine to apply the pattern to the tiles. This machine prints any design that is entered into the computer onto the tile surface. Protective layers, namely the top curtain of glaze, are sprayed on each tile which turns white shortly after it comes out of the spray tunnel and becomes transparent as it comes out of the kiln.

2.3.8 Firing

After the decoration and glazing step is done, the firing process takes place in the kiln. Firing is one of the critical stages in the manufacturing of ceramic tiles for controlling the moisture content of the body

and preserving and controlling iconic features of tiles such as mechanical strength and shrinkage and dimensional and thermal stability. It is also the first most energy consumer of the entire manufacturing of ceramic tiles. There are different kilns in the ceramic manufacturing industry; the most regular and common one is the very efficient roller kiln. The temperature inside the kiln reaches up to $1190°$. This heat solidifies the glaze and removes all the residual moisture within the tile body.

Moisture content in the ceramic body is released at temperatures between $100°$- $200°$ while the moisture content in the chemical composition of clay minerals is driven off at temperatures around $500°$-$650°$. In the firing process, raw material transforms into glassy and crystalline components to provide typical ceramic properties. The fed heat cause crystallization and expansion of atoms' presence in the microstructure of the tile body. The amount of growth is about the percentage of a vitreous component of raw material. The expansion of so-called shrinkage happens because of chemical reactions while firing [17]. Thus, the chemical composition of the tile body should be formulated in such a way that shows minimum possible expansion to avoid and prevent distortion while decorating.

Depending on the clay structure in the tile body, the required temperature for crystallization known as vitrification varies, but it usually starts with $900°$ ending up around $1100°$-$1200°$. Thus the body of tile in pre-firing stages must be solid and robust enough to tolerate pressures while molding and pressing are happening. It also needs to be able to stand the formation of bubbles, and subsequent defects that appear in the form of pin-holes [19]. The transformations that occur while firing include removing some components, the formation of other elements, melting fluxes, and glazes. The changes depend on factors that explain the main reasons for different product attributes in firing methods, such as thermal expansion, decrease in porosity, higher density, and other technological attributes. Some of these factors are [17]:

- Primary chemical composition of tile body
- Nature and essence of changes as well as results of reactions while firing
- The amount of temperature which is fed into the kiln

Firing is done by a single-layer roller kiln using fast-firing circles of about 45-60 minutes. The kiln is a long tunnel heated by gases heater through which each tile passes via a process called firing. Kiln has a relatively low yet vast chamber, and the flame is in indirect contact with the tiles. Temperature and heat are not fed into the kiln at once, but through some stages [27];

- Heating; depending on the temperature of the tile body and kiln, the heating feed rate is adjusted to the point that ceramic properties are obtained.
- Holding; the highest temperature is achieved and held based on the size of tiles and kiln.
- Cooling

In the first section of the kiln, the tile is dried at low temperatures to remove the moisture content from the body. If they are subjected to a very high temperature suddenly in the first place, the water will steam, and many of the tiles will explode. Once the tile is dried sufficiently, the temperature of the

kiln is raised to around $1100°$-$1200°$. This is when the tile is fired to decompose the clay composition and other minerals of the body. Then the last phase is the cooling stage which is at the end of the tunnel cooling down the tiles at a uniform rate before they come out of the kiln. This process is done to avoid cracking or holing on the tile because if not, hot tiles facing cold weather out of the kiln would break or crack due to thermal shock. After that, ceramic tiles can be fired one or more times based on the fired object, whether the tile is glazed or not [17, 19]:

- Single firing; it is applied o unglazed biscuits
- Double firing; is applied to cooked tile with an applied glaze over it.
- Third firing; if more details are required, the third firing happens with lower temperature.

While first firing is applied o unglazed biscuits to achieve the final characteristics of ceramic tiles, it helps solidify the body and obtain the bending strength and chemical preparations for the glazing stage. In this case, once the tile is dried and cooked, the glaze is subjected, and re-firing happens. More often, some extra drying treatments are undertaken after the glazing stage before the product is sent into the kiln [27]. The number of firing in the manufacturing process results in different types of tiles. Double and third firing is applied for additional surface treatments of decorative tiles.

2.3.9 Quality Control, Sorting, and Packaging

The ceramic tile manufacturing process ends up with quality control, sorting, and packaging. To ensure the quality of the finished product, it is inspected and verified for any imperfections, caliber, shade, and grade using manual labor and machines. This process is applied based on certain principles to affirm that tiles have acquired all the necessary physical and aesthetic features. These principles are defined from the commercial point of view. Thus they are not fixed and vary from company to company, but in general, there are two main criteria to distinguish the quality of the tile is checked and confirmed:

- Visual controls; recognizes the defects and classifies tiles based on their shade (color variations)
- Geometric assessments; classification regarding dimensional regularity, shape, and surface defects are done.

There are specific standards to classify and categorize ceramic tiles regarding final product details, such as ISO 13006 [17].

Once tiles are fired and undergo several quality control checks, they are sorted. It is done using equipment that carries out a visual inspection of the surface on the top-facing side of the tile using a machine with an artificial vision handled by an operator who inspects each tile's design and color tune. Later the sorter determines the size of the tiles. The information about each tile is used to sort and box the final product accordingly. Boxes are marked by quantity, shade, and caliber specifications and are placed on appropriate pallets. Products are packed utilizing automatic or semi-automatic

machines as well as manual work. Once boxing the product is done and placed on the pallet, boxes are shrunk by a plastic bound to prevent any damage and also accelerate displacement of pallets for the following stage, which is loading, and shipment [27].

2.4 Origin and evolution of the concept of Sustainability

Over the last decade, a high amount of depletion towards non-renewable energy resources, degradation of the land alongside producing non-biodegradable pollutants resulted in a great concern towards the environment; thus, consumers and producers get aware of environmentally friendly activities [28]. The term sustainability means the concept of "caring for the earth." It is a practice towards a lifestyle that maintains sustainability features and is explained as:" the satisfaction of the quality of life, keeping within the limits of the ecosystem's carrying capacity that supports us." It is a concept that benefits both ecosystem and people. It expands into three central pillars, which are intensely related to each other [29]:

- The environmental pillar which considers the ecological resources and how human activities influence it and human being lives
- The economic pillar requires awareness about the limitations and opportunities of economic growth and its effect on the environment and society. By acquiring a sustainable and proper strategy for using resources and reducing the use of non-renewable resources, sustainable employment, and income achieved for the people in society
- The societal pillar points out to the act that regardless of gender and social class, society requires knowledge about employing equality in the conditions of humans, including security, health, justice, and participation, to avoid inequalities and maintain social cohesion in terms of environmental and economic sustainability

Sustainable development deviates from relevant insights [30]. Various concepts associated with sustainability concept focus on a particular pillar of Sustainability, as:

- Societal marketing; focus on the social aspects of Sustainability by contemplating purchasers' demands, company's demands, and society's long-term profits while making marketing decisions [31]
- Green design; focus on the social and environmental aspects of Sustainability by designing products with specific deliberations: environmental risk management, functional well-being and safety, pollution prevention, product security, resource maintenance, and waste control [31]
- Resource management; concentrate on the environmental aspects of Sustainability by maintaining physical sources from their origin, within the multiple distribution and production stages, to last consumption, recycling, or reuse stage [32]
- Corporate social responsibility; focus on the social and economic aspects of Sustainability, and according to that, the organization has not only financial and legal commitments, but ethical and changeable duties [33]

- Green purchasing; focus on the social aspects of Sustainability by combining environmental concerns to the price and performance measures applied by businesses while making purchasing choices [34]
- Ethical trade; focus on the social and economic aspects of Sustainability and concerns with labor and employment situations and aims at implementing globally acknowledged criteria [35]
- Environmentally conscious manufacturing; focus on the social aspects of Sustainability by manufacturing products from the design to final delivery stages, and eventually to the end-of-life disposition with meeting all environmental criteria and terms [36]
- Ecologic marketing; focus on the social aspects of Sustainability by doing positive and negative characters of marketing activities on pollution, energy depletion, and nonenergy resource depletion [37]
- Reverse logistics; focus on the social aspects of Sustainability and believes that by recycling, reusing, and reducing the quantity of materials consumption, the companies are becoming environmentally apt [38]

2.4.1 Sustainability in industries and business

The most productive and practical tools to assess, monitor, and implement three sustainability criteria as sustainability indicators are those whose function is defined based on life cycle analysis methodologies. The life cycle of a product is all the stages a product goes through from cradle to gate, which includes: extraction of raw material, processing it, packaging, distribution, using, possible reusing, and recycling. Thus, life cycle thinking is an approach that analyzes and studies all the stages of a product's life cycle before designing and implementing [29].

Life cycle thinking has assessment tools related to sustainability pillars, some of which are:

- Environmental; LCA: life cycle assessment means diagnosing environmental impact
- Economic; LCC: life cycle costing. Every stage of the life cycle has internality costs: raw material extraction, personnel costs, energy, depreciation). LCC monitors and assesses internalities and externalities (economic costs of environmental impact concluded by LCA)
- Societal; S-LC: social life cycling is an advanced level of life cycle assessment and presents social aspects of LCA's results and quantifies social impacts on people who get affected by a life cycle of a product

Assessment of a product means studying and gathering all the data about a product, how it affects economically, environmentally, and socially. However, the main goal of life cycle assessment is to define and recognize '' from where to where'' to assess environmental effects of the product [29].

Sustainability and Circular economy

Academics and policymakers focus on the relationship between environment and industry by growing natural and social science research activities to make environmental innovation. Environmental innovation expresses as " all the changes in the product portfolio or production processes that tackle sustainability targets." some of these targets are: " eco-efficiency, reduction of emissions, waste management, recycling or any other activity that leaves minimum environmental footprint" [9]. One of the paradigms of Sustainability concerning a company's economic vision is following the concept of "circular economy" [29].

The circular economy focuses on two types of material flow [9]:

- Technical material that is revalued without integrating the biosphere
- Biological material that is revalued with entering the biosphere

Extra utilization of natural resources, changing them to products, and consuming them are the basis of the classic production model. Products are at the end of their lives, and most economic profit is gained by minimizing the production costs.

The circular economy monitors all the production processes of a product, including the design, production, consumption, and destination of the product when its life ends. While in the circular economy business model, the end-life form of a product transforms into raw material and nothing called waste exists. In this model, many consequences of recirculation take place by maintaining "stock" (which is enhancing the material and product to the maximum value and productivity) and increasing the concept of "flow" (which is selling the final product). Employing circularity in a business model of a company enriches their commitment towards the idea of Sustainability. Creating shared value for the rest of the society and increasing the competitiveness of the company [29]. The circular economy guarantees the high quality and value of a product through restorative and regenerative design strategies.

Figure.2.4 represents a circular model concept vs. a linear model:

The circular model follows some typical strategies. Some of these strategies are dematerialization of services and goods, avoidance of producing extra waste, extending the life cycle of a product, and life cycle thinking [9]. In addition, recovery, reuse, and recycling of material and introducing it unknown lifecycle for a product, create new markets, new and better job opportunities by reusing and sharing products and thus reaching the efficiency to use natural resources [7].

Sustainability and green procurement

When contractors, marketers, or buyers set some environmentally friendly requirements for their products, services, and contracts, they attain a process called green procurement. When this concept has been acquired, the products or services reduce the environmental damages. It is either obliged by

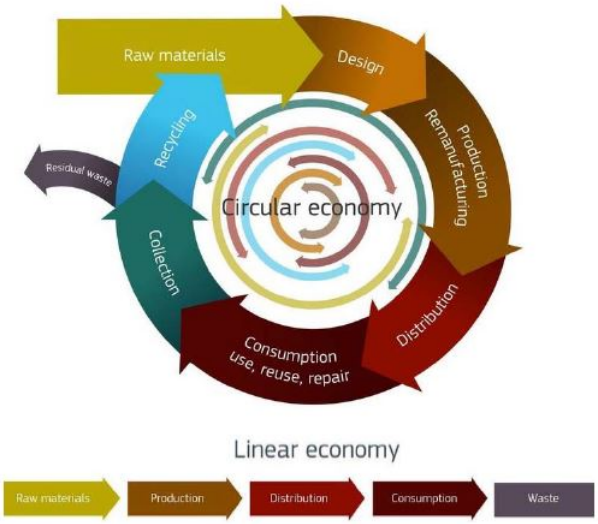

Figure 2.4: Schematic of circular economy vs linear economy [7]

the government and is called public green procurement or applied by the private sector for supply chains. Specific environmental requirements are necessary for green procurement, namely environmental communication systems such as ecolabels, certificates for buildings, and eco-management systems. In addition, suppliers ought to prove and show their adoption of environmentally sensitive activities through some accrediting certifications: Eco-management systems, Product ecolabels, and Sustainable building certificates [16].

Eco-management systems

EMS is one of the most eligible necessities for green procurement and is diagnosed for organizations. These certificates can be compulsory or voluntary by setting some awards. They are mainly in two categories [16]:

- The EMS is based on ISO 14000 standards, a set of rules and standards that the International Standardization Organization legalizes
- The European Community Eco-Management and Audit System (EMAS) is a certificate approved by the European level and maintained as a reference in many European countries
- ISO 14006 Ecodesign standard integrates environmental criteria into the design and development of products

Product eco-labels

Three types of product ecolabels defined by the ISO committee are [16]:

- Ecolabels or type 1 are certified ecolabels that indicate environmental performance in a product category. They are defined based on the life cycle assessment analysis. These labels are proper to communicate with the end-user and are positive in Green procurement.
- Environmental self-declarations or type 2 are labels used to communicate the environmental aspects and do not require third-party verification. They are proper media to communicate with the end-user
- Environmental product declarations or type 3 are used to present standardized life cycle information, which depends on life cycle assessment analysis. These labels are applied for communication between companies rather than with the end-users

Sustainable building certificates

Sustainable building certificates are practical to minimize environmental damage as well as social and economic. They include selection criteria for the building's land, building materials, construction, use, and demolition stage. Some of these certificates are:

- BREEAM stands for Building Research Establishment Environmental Assessment Method and evaluates impacts of a building in design, execution, and maintenance stages in 10 classes: energy, transport, building materials, water consumption, pollution, innovation, and environmental effect use of the land
- LEED stands for Leadership in Energy and Environmental Design (LEED); focuses on optimizing the ecological performance of building regarding some categories such as energy and water consumption, maintaining the materials and resources, indoor environmental situation, innovation, and design, and $CO2$ emissions
- VERDE represents VERDE tool, Spanish Green Building Board; is a Spanish environmental certificate that uses the life cycle assessment tool for different phases of the construction process
- SB TOOL, meaning sustainable building tool, is a software used in Green Building Challenge projects and implements criteria to evaluate buildings' level of Sustainability

2.5 The ceramic tile industry and contribution to Sustainability

2.5.1 Environmental impact of manufacturing ceramic tiles

The ceramic manufacturing process's environmental harm starts with the extraction of raw material, namely mining until the last step of the manufacturing process: packaging and distribution [4]. The main environmental profile of ceramic production consists of [8]:

- air emissions include the gas emissions of nitrogen oxides, sulfur oxides, inorganic fluorine, chlorine compounds, heavy metals, and carbon oxide

- waste of the process that includes various types of waste or broken parts of plaster molds that happen to produce during the manufacturing process and waste that is produced in the packaging stage
- CO_2 emissions and energy consumption; the energy for any stage of manufacturing of ceramic tiles is provided by natural gas, electricity, bio mas, biogas, and solid fuels
- processed wastewater that includes inorganic material, mineral component, heavy metals, and organic materials

During all these stages, different kinds of generated pollutants are hazardous to the entire ecosystem. The most significant pollution of this industry is air pollution, which affects eutrophication, acidification, depletion of the Ozon layer, global warming, and the livelihood of the people working inside ceramic factories and getting exposed to ultrafine particles generated by machines.

Figure2.5 shows the ceramic tile manufacturing process and the stages which generate the residues.

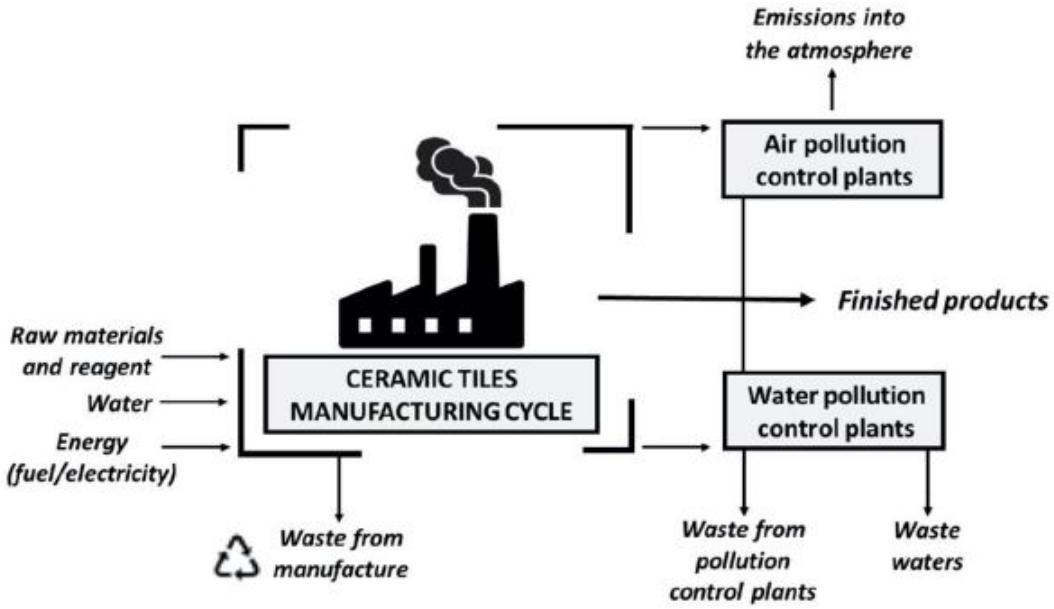

Figure 2.5: Materials, waste and the emissions flow in ceramic manufacturing plant [39]

The manufacturing process of ceramic tiles in EU countries and Turkey annually produced 1.4 million tons of dry solid waste in 2014, and this number is increasing accordingly regarding the amount of 5% yearly growth in the manufacturing of ceramic tiles. The central residues and scraps generated in the manufacturing process are as [3]:

- Green scrap forms 45% of the total amount of generated waste and are the type of residue that is not still fried. The green scraps include mainly broken biscuits, dust from the vacuum extraction system, unaccepted pieces from the sieving section of spray-dried powder. This residue consists of the oxides already present in the body composition of biscuits: silicon, a few amounts of calcium, sodium, magnesium, aluminum, and potassium.
- Glaze sludge is 4% of the total amount of generated waste. When the design or model of tile changes in separate production lines, glazing mills get cleaned accordingly; thus, the sludge is

generated, composed of glaze and cleaning material. Additionally, in the glazing stage, another type of residue is also developed while sieving the glaze. This residue is known as glaze sludge. Glaze sludge is composed of boron, zirconium, barium, and zinc.

- Fired scrap has the percentage of 41% of the total amount of generated waste and includes the fired tiles and the tiles which get rejected in the sorting phase because of defects, broken parts, or low quality
- Dust is 0.2% of the total amount of waste. This kind of dust is obtained from chemical reactions of $\mathrm{Ca}Co_3, \mathrm{Ca}OH_2$in the fillers of the kiln with acid compounds generated while the firing process is taking place. Some of these chemical compounds are fluorine, sulfur, and chlorine compounds. The installation of these filler bags is obligatory by environmental legislation to reduce and limit emissions (IPPC). This dust includes sulfur, chlorine, calcium, and fluorine in the form of gasses emissions.
- Polishing sludge is 8% of the total amount of waste. When polishing tiles, the abrasive particles of diamond and $\mathrm{Ca}Co_3$ is used in the cementitious or polymeric matrix. The waste is then generated due to the wear of polishing, cutting, and the pieces of fired product. This sludge also consists of the oxides already present in the body composition of biscuits: silicon, a few amounts of calcium, sodium, magnesium, aluminum, and potassium. It also includes chlorine because of the abrasive particles of $\mathrm{Si}C$ in the cementitious wheel used for grinding.
- Frit residue is 2% of the total amount of waste. The chemical composition of frit varies according to the type of glaze used in its composition. The change between the old and new frit takes at least 60 minutes. During this time, the medium frit is not used. Consequently, it produces frit waste, composed of boron, zirconium, barium, and zinc and frit residues

In addition to various kinds of residues and scraps generated during the manufacturing process, energy consumption is consumed in every stage of the production process is considerable. In this regard, the highest energy consumption is in the sintering process. It happens at a temperature of up to 2250 to 2350 Celsius. The sintering process uses electrical energy. Along with electricity, another primary type of energy consumed in the manufacturing process is natural gas [3, 4]. The consequent by-products of that energy result in a significant environmental impact. Nano and ultrafine particles are emitted into the environment, causing lounge problems to people working there. Besides nanoparticles, other dangerous materials are also released, such as gases, wastes, and chemicals known as human toxicity. Energy is in two forms: renewable and non-renewable. The energy used as 80% of raw material for producing tiles is non-renewable. The amount of energy and resource consumption for making every square meter of the ceramic tiles is as [4]:

- Electricity:1.94 kWh
- Fuel oil: 0.00951
- Natural gas: 22.66 kWh
- Water: 5.861
- Fuel gas: 185371 N
- Temperature: $550°C$
- Clays and Sands: 21.9 kg

Environmental impact aspect of life cycle assessments

The environmental impact aspect of LCA, for ceramic tiles according to ISO standards, is categorized as [40, 41] :

- Acidification potential and the phase of the most outstanding contribution is due to the emissions of acid compounds in the manufacturing process (54%)
- Eutrophication potential has the highest amount in the use stage (43%) when using detergents for cleaning the tiles
- Global warming potential reaches the maximum amount of (69%) in the manufacturing phase. It is one of the primary pollutant categories and depends on the manufacturing phases' internal and external factors. While the external factors are out of the manufacturing plant's control, such as the generated pollution, to produce energy in the region the plant exists. The Internal factors are namely:
  - Extraction and combustion of natural gas necessary for different stages in manufacturing process such as drying, firing, spray-drying and, distributing the product
  - Emitting CO_2 by combusting the fuel to generate electricity
- Ozone depletion potential; the most significant contribution is the manufacturing process (84%)
- Photochemical ozone formation potential and in the phase use phase it reaches the most outstanding contribution (65%) by using detergents for cleaning the tiles
- Depletion of abiotic resources gets the highest amount of (76%) in the manufacturing stage as the result of consumption of raw material and non-renewable energy
- Water consumption has the maximum amount in the use phase (62%) to clean the tiles

2.5.2 Practices towards Sustainability in Ceramic industry

We choose the building material focusing on aesthetic, economic, and technical factors. Still, an aware design needs to be more cautious and informed about the environmental impacts and design the buildings to reduce the negative footprint. Besides, the selection of building material must guarantee the health and safety of inhabitants.

Sustainable construction

The concept of sustainable construction gives importance and focuses on building a healthy environment. Ceramic tiles are popular and proper building materials with their unique attributes, as discussed earlier, and a wide variety of appliable spaces, the primary information in designing a building process. This concept of only focusing on reducing non-renewable energy and fossil fuel consumption does not satisfy environmental challenges. In recent years, sustainable construction has been a significant concern for constructors and deals with economic and ecological issues. This kind of

construction strategy focuses on selecting sustainable building materials that reduce the negative environmental impact in their life cycle. Sustainability and the reduction of the environmental impacts associated with the construction sector are considered throughout the building's lifecycle, from the extraction of the raw materials used in its construction to its demolition and waste processing materials. It is only possible to assess various building alternatives with the same functionality to reduce their environmental impact. This approach has to be a fundamental foundation in the transformation and innovation of the ceramic sector[41, 39].

Environmental profile of building materials

One of the crucial stages in developing a product's Sustainability is inquiring about its environmental profile during its lifecycle from a global viewpoint. A product is environmentally friendly when throughout its lifecycle and use of raw materials, during the consumption phase, and when disposing or recycling at the end of its useful life, it has a minimum environmental result [39]. There are strategies and methods to evaluate environmental impacts of the building materials such as Life cycle assessment analysis, the Sustainability of materials, marketing, eco-design, innovations [41].

Product development and life cycle approaches for ceramic Tiles

There is a high demand from ceramic tile consumers to have the product's environmental information. Thus, life cycle analysis is necessary for the ceramic tile industry because it is the most accepted and well-established method to evaluate the ecological impact. The Spanish ceramic tile sector is a pioneer in achieving the first Environmental Product Declarations (EPDs) by creating the product's lifecycle analysis. As studied earlier, according to ISO 14020, environmental declarations are the second type of ecolabels that explore the ecological impact of the product in its life cycle ASCER is the Spanish Association of Ceramic Tile and Floor Manufacturers developed a sectorial Product Environmental Declaration (DAP). The Environmental Product Declarations (DAP) are international and adjust to any specific country. The range of this DAP is from the cradle to the grave. The ceramic companies in Italy, Germany, North America, and Spain contribute to LCA and have their sectorial DAPs by providing all their inventory data. Despite becoming an indispensable element in promoting the competitiveness of companies or sectors faced with challenges from other countries and entering more environmentally aware international markets, the certification practice is currently optional [1].

Life cycle assessment as an environmental tool at the company level monitors the environmental footprint of a product, service, and process, takes place in different stages throughout the life cycle of the product [5]:

- Extraction of raw material
- Manufacturing
- Transport
- Use
- End of life

The analysis includes the input and output materials like fuel, water, energy, and raw material as the manufacturing phase's input and generated waste and emissions and its treatment as the output. The distribution stage encompasses the consumed fuel necessary for the transportation and its consequent emissions, managing the generated waste after the packaging stage, and any adhesive material such as mortar in the installation phase. The detergent and water consumption during the usage stage is counted for the ceramic tiles depending on the tiles' place, residential, commercial, or health centers. Moreover, the end-of-life stage is about the energy consumption for dismantling the tiles that are not significant. The generated waste in this stage is after the demolished building, including most of the tiles left in landfills. This pollutant's intensity reduces by substituting the sea transportation by road transportation in distances when there is any possibility. In general, LCA tools help us recognize the variables which have the most significant impact while in manufacturing ceramic tiles these are mainly [40, 41]:

- Weight of the tile affects the amount of material to transport, the energy consumption in the manufacturing process, CO_2carbon emissions and, the necessary raw material for the product. According to analysis, this factor needs to have a reduction up to 50% to minimize global warming and abiotic resource depletion
- Thermal energy is the most significant energy consumption by combustion of fossil fuels or gas. The process that consumes a high amount of thermal energy is: drying of the formed ceramic tile bodies (9%), and ceramic tile firing (55%), and spray drying of ceramic slurries (36%) The energy consumption during the manufacturing process can be more efficient to reduce the emissions by introducing the new drying and firing systems, replacing the spray-drying and, using renewable energies.
- Waste generation during and after manufacturing process

Waste management

Annually, the ceramic industry uses 65% of ceramic waste after recycling as raw material [3]. Figure2.6 illustrates the residues generated in every stage of the manufacturing process:

Almost all types of ceramic waste are homogenized and used in brief amounts, usually less than 5% in the composition of raw material for biscuits and glaze. However, as shown in Figure2.7, 90% of glaze sludge and 95% of frit residue and green scraps are recycled. This waste needs processing before introducing raw material composition, including milling the green scrap, introducing them in minor percentages, and melting it afterward, in high temperatures around 1500 Celsius. Contrary to green scrap, fried scrap is not recycled so often and is not used in the body composition of raw material, especially in red body tiles, because milling cost is high. In contrast, raw material for the red body does not have a high price. In the white body and porcelain tiles, some companies invest in recycling fried scraps up to 10% in some composition, while fired scraps leave color pigments that result in a color change of the body [3].

Regarding the polishing sludge, the cementitious abrasive tool leaves soluble salt in the composition of polishing sludge and does not make it possible to recycle. Additionally, the kiln filters' waste fluctuates the body suspension and stops recycling this waste in wet milling and spray drying.

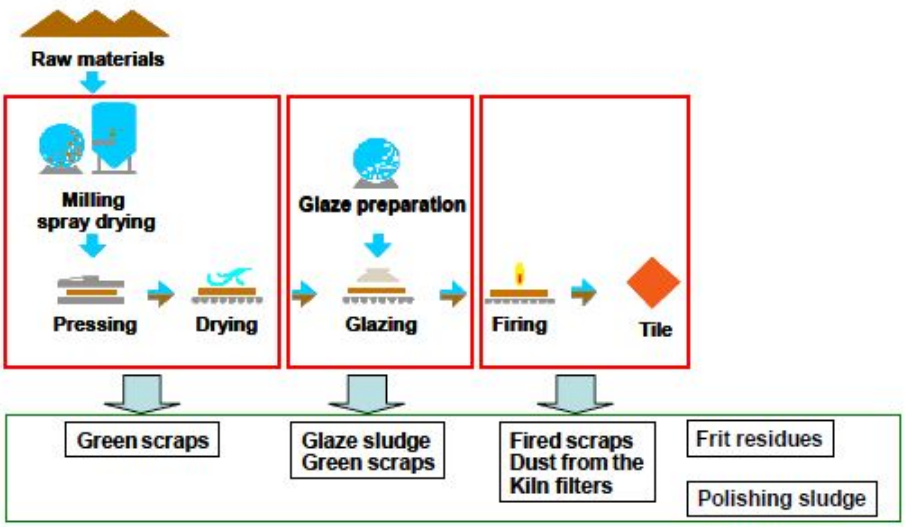

Figure 2.6: Schematic of the ceramic manufacturing process and residues generated in every stage [3]

Moreover, polishing sludge's chemical composition includes organic compounds and is combusted partially in the firing stage. Thus the recycling does not take place successfully. Besides, silicon carbide particles cause defects on tiles' surfaces. The rest of the waste from ceramic tile manufacturing is released to landfills. Various projects and attempts have been attempting to make the landfilled ceramic waste zero, making ceramic tiles for urban flooring that encompasses recycled waste in its composition up to 80% [3].

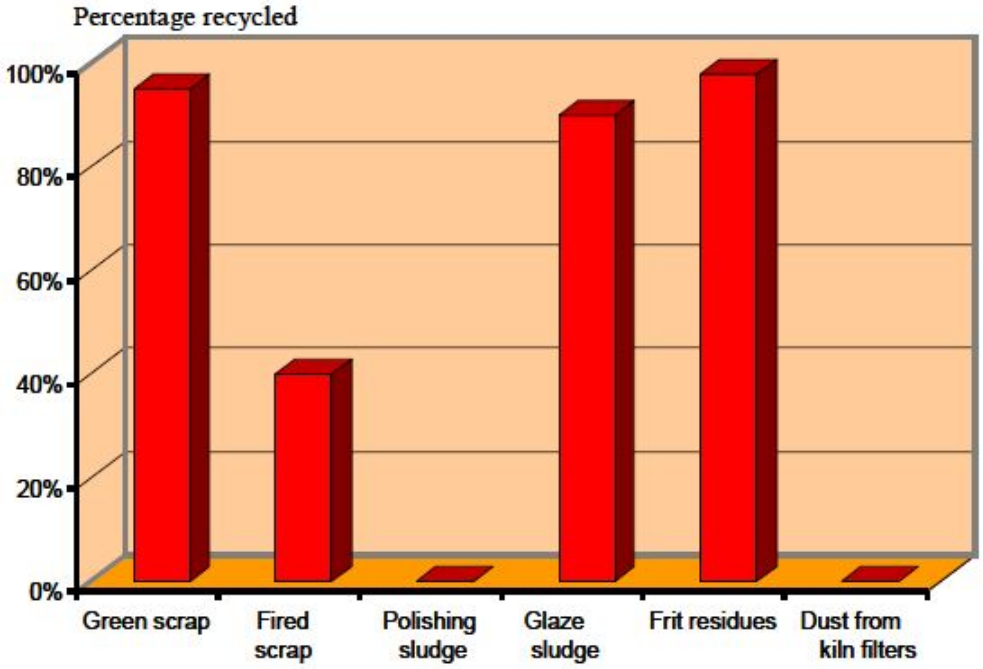

Figure 2.7: Recycling percentage of ceramic waste [3]

Besides the capacity and viability of waste to be recycled, recycling depends on society's envi-

ronmental behavior and ecological concerns. However, some obstacles are affecting the recycling rate of construction waste. One of the most significant obstacles is the financial implications needed to reuse and recycle the waste through systems that function through many industries. To overcome the obstacles, the government charges companies and enterprises with a special tax rate, designers have more information, and recycling processes get cheaper when they occur not through multiple but less complicated methods. Nowadays, recycling information is becoming increasingly available via more research work and investigations, recycling education programs, and legislation. Therefore, it is only possible for manufacturers to recycle their products more cautiously and responsibly and use recycled material as raw material for their products only when they have enough information and facilities. In that case, recycling waste from construction becomes more viable and affordable [42].

Eco design in Ceramic industry

Eco-design is expressed as:" the systematic integration of environmental impacts related to products. There always has been a concern about the environmental aspects of ceramic tile manufacturing. Thus, many innovations have been applied based on eco-design strategies that focus on optimizing the end-of-life systems [7, 8].

Ecodesign is a concept that draws significant concentration from environmental experts, supporting the systematic integration of ecological concerns in the expansion and design of ceramic products throughout their life cycle. There are many ceramic products with modifications that can be divided based on the applied eco-design strategies. Some examples of activities according to ecodesign strategies from Spain and Portugal are [8]:

- Reduction of material use is implemented by reducing the thickness of the product; tile manufacturing companies develop raw materials to reduce tile thickness from 12 mm to 4 mm
- Companies incorporate waste into the raw material to elect the material with low impact; companies recycle pre-consumer waste, reaching up to 90% recycled material by weight while maintaining the strength and versatility
- Tile manufacturing companies diminish kiln firing procedures by choosing environmentally sound production methods; designers alongside the ceramic manufacturers affect the manufacturing processes' environmental performance by designing products whose production requires fewer firing steps or lower temperatures
- There is a new trend called picking, a different kind of direct sales orders from the end consumer to the manufacturer, hence decreasing the transport consequences and reducing shipping actions
- to modify the packaging, companies have been attempting to minimize cardboard, shrink plastic and glue, and reduce strips in packaging

Ceramic industry and circular economy

After the European Commission adopted the circular model concept, the European Ceramic industry, namely Ceramic-Unie, highlighted the transition from linear to circular as a necessary procedure to obtain an economy with minimum carbon content. The durability of ceramic products leads to their resource efficiency, which means "using better" instead of "using less ." In the light of the long life span of ceramic tiles, up to 50 years, they get the competitive edge compared to alternative products. Durability and resource efficiency are critical factors for the circular economy model. Although we cannot recycle clay to 100%, fired clay can be reused, recovered, and recycled after the end-of-life because of its natural chemical composition. That is the reason they meet the essential requirement for the concept of "cradle-to-cradle."

The high durability of ceramic tiles contributes to the circular economy by optimizing selection criteria for raw material, product design, implementing strategies for resource efficiency, reusing the water in the same manufacturing process or other industries, reusing the residues such as broken ware and mass residues. In addition, some projects aim to eliminate raw material consumption by using 70% of the raw material out of recycled materials of urban and industrial waste. Furthermore, the ceramic industry has witnessed progressive attempts towards innovation and research to minimize raw material consumption and substitute energy resources and new technologies. One of those innovations is using digital inject printing in the product design area instead of rotary printing. In this system, ceramic ink is used instead of decorative ceramic paste. Therefore, it only consumes 20% of the conventional raw material. It also causes an enormous reduction in the number of broken parts and residues because it eliminates the tiles' mechanical load.

With all the ceramic industry's attempts to commit to the circular economy, there are some obstacles to implementing this concept [9, 29].

- Lack of precise definition of end-of-life waste and by-products as secondary raw materials.
- Authorities in some countries do not advocate the idea of consuming waste of other industries as a raw material for more processing
- Lack of harmonized and regular procedure for collection and treatment of the waste. Different countries have different strategies towards it
- Secondary raw material does not have a prolific European market. Manufacturers need a sensible price and high quality for replacing or corporating recycled material in the raw material mix. The recycled material should not get infected with demolition waste such as plastic, gypsum, mortar, or harmful materials of an industrial process such as slags and fluxes. Also, ceramic industries need to have a standard for secondary raw materials to be more confident in quality and consistency.
- Chemical and national legislations; in some countries, authorities restrict the consumption of secondary raw materials. There is no consistent position between countries to evaluate the industrial by-products. Besides, the chemical legislations classify some by-products and residues as dangerous. some of these by-products are indispensable for the ceramic industry, and labeling them as hazardous harm customer's trust

- Shipping of the waste between the source of the material and the manufacturing plant alongside the legislations of local authorities is an extra expense for industries, increasing the raw material's final price

2.6 Sustainability Marketing

The orientation of marketing

Marketing as a business term has various definitions. It explains as a framework that gives direction to an organization for thinking and choosing critical functions, besides equipping the organization with specific tools such as promotion, packaging, pricing, and distribution policies to respond to the customers' expectations [43]. According to the American association of marketing: " Marketing is the activity, set of institutions and processes for creating, communicating, delivering, and exchanging offerings that have values for customers, clients, partners, and society at large" [44, p. 2].

According to Kotler, conventional marketing stands for a " social and managerial process by which individuals and groups obtain what they need and want through creating and exchanging products and value with others." In his opinion, marketing is a business tool that helps companies progress their market performance through various pillars to promote their offerings and sales. The Marketing mix helps the business by opportunities that make significant progress in the competition. The marketing mix has four pillars [45]:

- Product; is any form of service or object that responses to customer needs
- Price; refers to the exchange value for customers to own a product
- Place; points out to channels for distributing through which selling and offering of the product takes place
- Promotion; various brands use different communicational tools and functions to give information to their stakeholders about their products

Figure 2.8: The four Ps: the marketing mix [45]

However, according to Kotler, a reformed and modern definition of marketing focuses mainly on digital technology and customer relationships as intra-company factors redefining the marketing mix model as people, processes, programs, and performances.

The Green Marketing

The phrase of green marketing appeared when environmentalists and global communities became more aware of the damage to the environment by the polluting activities of companies during the 1980s. Thus, they started putting pressure on industries to incorporate their concerns about the manufacturing and production process environment. These kinds of forces made a new sight of competitiveness in business, which shifted the natural environment's role from conventionally called external factor to an internal and central content for the marketing strategy of an industry and management view by integrating into the business plan of a company and redefining marketing strategy and decision making [46]. In this regard, some of the fundamental attributes of green marketing imply product, promote and packaging the product in line with environmental concerns [47].

Green marketing, also known as environmental marketing, aims to satisfy human needs through designing, pricing, and promoting a product that causes maximum positivity to the environment and minimizes the negative impact upon it. In recent years, these actions were announced to customers through the packaging of the product [28]. Consumers are usually confused with the term green marketing because, according to some people, it is all about environmentally friendly and responsible activities considering climate changes and global warming. In contrast, others perceive recycling as an essential nature of green marketing [47]. Also, there are different interpretations of green marketing according to studies that have been done upon respondents with various professional backgrounds;

Many marketers define green marketing as a strategy that focuses on environmentally sensitive consumers; environmentalists interpreted it as a business's ability to recognize and maintain environmental marketing strategies to stay at the market's head. On the other hand, most CEOs believe in reducing environmental damage, and businesses must integrate social responsibility into their marketing activities.

Green marketing was established in three main phases:

- First; on the 1980s, when marketers started promoting their green products, which had the minimum adverse environmental impact
- Second, in the 1990s, greenwashing happened, depicting customers with false ecological information about their purchasing green products. The offerings of green products were so confusing that customers spent less time overtaking the green concept into their decision-making criteria.
- The third stage happened by the beginning of the new century when environmental-based restrictions were set by Governments to manufacturers

The latest green marketing stage was concerning the most aware customers known as Millenials, who have a high customer loyalty about green products [48].

The difference between Green and traditional marketing lies in green marketing that is proactive, long-term oriented, value-based, and it is a core initiative that is the livelihood of human beings [47].

To gain the profit in the market, green marketing emphasis some core and important areas such as [47]:

- Green positioning
- Green price
- Green logistics
- Green promotions
- Appropriate management of waste

Strategies of green marketing and the effectiveness of sustainable marketing as a business strategy

Currently, companies are more and more interested in evaluating organizational performance based on environmental quality (the planet), social justice (people), and economic prosperity (profit). They tend to involve in green marketing tactics because of [49]:

- The increasing awareness of society thus consumers' concern about the three pillars of sustainability. For instance, Millennial consumers appear to have a high customer loyalty regarding green products [48]
- The higher cost of the energy and raw material
- The antipathy of consumers towards globalization, alerted by nongovernmental organizations' activities linking global business to ecological damages
- The significant impact of environmental considerations on company's financial performance, innovation benefits, and competitiveness

In this regard, organizations are investing in green activities, both internally and externally. Internally, companies are opting for substitutes for non-renewable inputs to reduce raw material needs and energy consumption. Externally, companies promote green core competencies in products and processes and assure long-term sustainability via the whole supply chain. Remarkably, considering the eco-friendly offerings developed, companies may change the materials used, the manufacturing or logistic procedures are taken, and evidence these issues in the offering positioning and its communication to the customer. As such, communication may highlight socioecological benefits rather than quality and price [49].

In this context, there are two opposite perspectives:

- The cost of employing green strategies are minimum, and any additional costs for the organization compensates by improved employee morale and productivity

- While the opposing perspective believes that employing socially responsible activities faces the financial disadvantage because of entailing additional costs.

One can ascertain the activities' effectiveness when examining concrete results, namely costs, benefits, and performance implications. There are two contradicting perspectives concerning the perception of the expenses from green activities and strategies. One view perceives the cost of employing green strategies as minimum compared to the benefits and states that any extra charges are compensated by higher employee morale and productivity. An opposite perspective considers that the employment of socially responsible activities represents a financial disadvantage, given the additional costs involved. Some critics say that if companies do not obtain higher profits, they will probably opt not to engage in green activities [46].

Nevertheless, eco-conscious companies are alert to the need to have a more comprehensive picture of the business, including environmental quality (the planet), social justice (people), and economic prosperity (profit). This leads them to define strategies that meet the triple-bottom-line performance, that is, the people, the planet, and the gain of the business [46]. Hence, the results of green marketing in business performance will be a combination of development and commercialization of green products, perceived as more valuable by some consumers, and priced higher than non-green products, as well as cost reduction via environmental programs [46]. Furthermore, complying with green marketing motivates organizations to produce products with a minimum adverse effect on the environment and a maximum impact on customer satisfaction for current and future purchases [47].

However, researchers state that efforts towards socially responsible activities may not meet the short-run welfare, but rather the satisfaction and maximization of the long-term profit. Thus, managers of companies must deal with stakeholders' short term pressure, maximize the organization's lasting market value and regulate their response to social pressure [49].

Green consumers and their behavior towards eco-labels

The green consumer defines as a consumer who is aware of environmental concerns and avoids buying any product that results in hazards towards any living organism, including unethical tests on humans and animals, or the environment during the manufacturing, using the phase of a product and consumes a high amount of non-renewable energy. There are three main pillars according to which customers affect a business to employ green strategies:

- Consumer's expectations of a business regarding environmentalism
- The amount of consumer's commitment to environmental issues
- The intensity of consumers' will to apply their effect and make marketers satisfy their needs, which is usually possible when consumers change their buying methods, showing when customers of a specific business are compassionate towards environmental issues, the firm applies green marketing a higher level.

The psychographic, demographic, and geographic behavioral variables are significant to specify the customer segment in the market. In this context, there are three various customer groups [10]:

- A small but highly informed group about socioecological issues which are willing to take steps toward it. They give importance to ecological and social characteristics of products when purchasing
- An informed group about socioecological plans which are willing to pay extra amount for the added value of sustainable development, but not resistant to take actions towards the quality of the products
- The third group, which most adopt sustainable products, known as socioecological passives, does not have awareness about ecological and social issues. Thus, they do not give value to the price and performance of sustainable products

The recent widening of green consumers has been aided by organizations' communication campaigns, increasing awareness about ecological issues, and facilitating access to environmental problems. As a result, green products' popularity raised and led companies to consider green activities not only to improve their performance but also as an opportunity to reach ahead in the competitive market [28].

In this context, specific labels called "Eco labels" for green products provide information about functions like quality measures such as product quality and value functions that include the reliability of a product. Eco-labeling of a product is a tool via which the gap between seller and buyer fills, and customers act more sensitive regarding green products when they know Eco labels. Companies improve their green market activities by promoting Eco-labels, thus manifesting their strategies towards sustainable marketing. Through this, they gain the loyalty and satisfaction of their green customers. At the same time, satisfaction and loyalty are significantly crucial in theory and practice. Customer loyalty is a willingness of a customer to buy the product of a particular firm again. A customer's loyalty to a specific brand or product states the solid and emotional performance [50].

The price and quality of a green product

As discussed earlier, developing a green product involves more expenses due to the supplementary costs oriented in research and development, recycling, and alternations in product design to avoid environmental damage. Thus many green products have higher prices than non-green products [47]. Green pricing is a significant monetary value paid by consumers, and in the light of developing innovative green products, companies ask for higher prices and gain higher profits [50]. In most cases, customers are vulnerable to premium prices for green products when ecological knowledge and information are provided. Organizations justify the most environmentally concerned client and consumer to be susceptible for paying a premium price for ecological products because they believe their knowledge and action influence their ecological behavior; thus, the environment [47, 50].

On the other hand, organizational buyers are not so definite in paying premium prices for recycled or green products when the product's quality is not the same such as paper [47, 50].

The Green Marketing leading into Sustainability Marketing

Unfortunately, when applying Kotler's marketing-mix model, greener products challenge the promotion and price aspect [10]. Additionally, some customers refuse to pay an extra price for green products. The 90's backlash of greenwashing still influences some other customers, so they do not engage in environmental campaigns. Thus, green marketing does not succeed in incorporating a sustainability plan [10]. When greener marketing and sustainable marketing expand with a more responsible management focus based on a strategy that sustainable economic development and stakeholder's expectations are satisfied, [10].

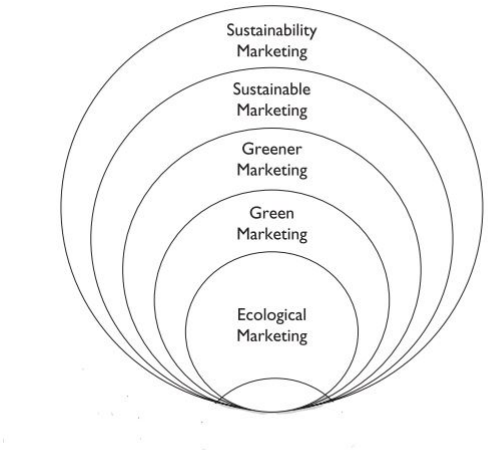

Figure 2.9: The evolution of marketing [48]

Sustainability marketing addresses the relationship between the three pillars of Sustainability. First, it is " the process of creating, communicating, and delivering value to customers in such a manner that both natural and human capital are preserved or enhanced throughout" [51, p. 3]. Sustainability marketing defines the standard purchasing behavior as buying sustainable products, and buying unsustainable products is considered abnormal, and the typical ordinary consumer refuses to buy unsustainable products. In this regard, the four P's marketing-mix model of Kotler changes to four C's in the sustainability marketing-mix model. The sustainability marketing mix focuses more on sustainable development and customer relationships, whereas the conventional marketing mix focuses on the seller's perspective. The four C's marketing-mix model consists of [11]:

- Customer solution; focuses on customers' satisfaction with their needs and wants while taking the social and environmental limits into account.
- Customer cost; not only cares about the product's price but also the environmental, social, and psychological value of a product in its life cycle.
- Communication; refers to interactive communication between the brand and the consumer by providing credibility and trust.
- Convenience; provides services to customers to meet their needs and expectations conveniently and easily.

The sustainability marketing mix model transforms marketing and Sustainability because these two concepts contrast each other. While marketing aims to maximize sales, Sustainability focuses on minimizing consumption in society [31]. Sustainability marketing also focuses on the long-term relationships regarding building and maintaining sustainable relationships with customers, the social and natural environment. What matters is making a sustainable value that responds to consumers' wants while implementing all three sustainability pillars in the consumption process. Contrary to green marketing, sustainable marketing does not aim to develop new products and substitution of products among consumers but focuses on developing sustainable solutions [52]. Consumers get motivated by sustainability marketing to choose sustainable products and services. Sustainability marketing reviews consumer needs, promoting sustainable answers to better customer value and serving the customer target group more efficiently. Alongside the social and ecological points of products, sustainability marketing's strategic settlement is the market segmentation, electing the particular target group and positioning the product in that specific market group.

Ecological product quality, social product quality, market segmentation, targeting, and positioning are five dimensions that define sustainability marketing. Pursuing an effective sustainability marketing strategy depends highly on [53]:

- Consumers
- Retailers
- Competitors
- Legislators
- Top management or owners
- Public exposure
- Industry membership

The customer is a critical hack for socioecological management and marketing. Their feedback to the company sustainable activities is by buying the products and avoiding them. Therefore, having more information about consumers' impact helps companies to promote a profitable marketing strategy [53]. Consumers are motivated and connected to spend on sustainable products if the communication and relational marketing tool is proper and influential. Besides, the advertisement with emotional content has a positive impact on consumer awareness [10]. Product positioning in regards to giving importance to the ecological and social issues depends on the target customer group [54]:

- Communication about products happens in a manner that gives superiority to socioecological benefits rather than quality and price; this approach corresponds to high sensitive customers who are sustainability pioneers
- Socioecological concerns have an essential part in positioning the product in a similar level of price and quality; this approach and the third approach targets consumers who are the medium size and big sustainability leaders, they know, and concerns about socioecological issues and are willing to pay the added value if they validate the quality as well
- Standards about Socioecological concerns are fundamental for the quality aspect of products

- When communicating and positioning the product, there is no room for socioecological concerns; this approach targets the consumers who are super sensitive about the price

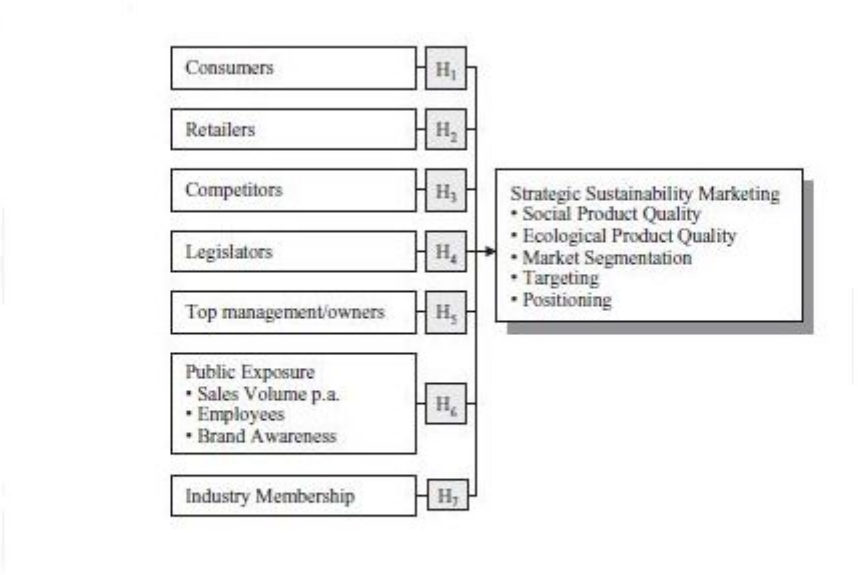

Figure 2.10: The key drivers for an active sustainability marketing strategy [53]

The pressure from customers in the market is more crucial than the pressure competitors push upon a company. However, regarding the increasing request and desire for sustainable products, competitors might satisfy consumers with more sustainable products as it is taking place in the food and fashion industry. Consequently, having more information about the impact of competitors will preserve an effective, sustainable marketing policy [53]. Retailers are another factor whose impact on the market is decisive because, for example, in the food industry, they regulate the availability and the amount of a sustainable product. In addition, they define the methods of promoting the products. Thus, it is essential to have enough information about retailers to relinquish the effective marketing strategy [34].

Companies can follow a practical sustainability marketing roadmap if they have more information about the effects legislators have. Researches show a direct relationship between legislators and the engagement of a company's marketing to socioecological issues. Legislators affect this engagement through various strategies [53]:

- defining labels and standards for the Sustainability of a product
- exciting consumers about the dilemmas or benefits of certain products
- establishing regulations for new products

Proceeding with an effective sustainability marketing strategy is greatly affected by the top management and owners of the companies' engagement in the sustainability issues. The leading man-

ager's opinion, beliefs, expectations, plans, and attitudes towards sustainability issues create a fundamental motivation for sustainability marketing. Proactive environmental management depends immensely on the ideas and perspectives of the top manager. To designate sufficient means for a company's environmental management, a company needs an ecological champion who is a senior member of the company and gives positive feedback to the environmental concerns [55].

The significant number of human and financial resources have a beneficial effect on a company's engagement in Eco-marketing activities. Thus, the more distinguished company's appearance becomes by high sales, brand awareness, and the number of employees, it helps the company pursue an active sustainability marketing strategy. The brand's consciousness and its dimensions or extent regarding the number of employees or the number of sales are two main beneficial sustainability marketing parameters that have a crucial role in presenting the companies' image. The company's size also helps to advertise it and has an indispensable place in marketing sustainable products as a corporate resource [56]. Membership of sub-industry, public appearance, and stakeholder's type explains the type and severity of strategic sustainability marketing [57].

2.7 Communication in sustainability marketing

Communication is a fundamental criterion for marketing to give consumers information about sustainability points of view for their lifestyle. Companies need to set their communication objectives according to their priorities, interests, mission, and target group when communicating sustainability activities. In transferring the message of Sustainability, senders try to inform, explain, persuade and form the peculiar message about the requirements and methods of managing sustainability practices via some vehicles known as channels. The fundamental matter is to communicate the message efficiently to the audience to receive positive feedback. Companies employ a wide range of tools to transmit their sustainable activities. The tools are in the six main categories [11]:

- Face-to-Face meetings in the form of interpersonal conversations, workshops and conferences, town meetings
- Audio vehicles like teleconferences, direct phone calls, radio talk shows, talk shows, and radio news
- Print such as press releases, brochures, books, flyers/fact sheets and pamphlets, direct mail, photos, reports, journal articles, advertisements, newspaper, magazine and
- Street actions
- Videos like films, documentaries, YouTube, internet streaming, video conferencing
- Electronic communication such as email, instant messaging, websites

Among all the vehicles, mobile and internet technology has a crucial role in people's consumption style. The growth of social networking is changing consumers' purchase behavior [58].

According to Kotler, communication was the fourth P pillar of the marketing mix model that links to the promotion of products and services [45]. Within sustainability marketing, the promotion pillar

transforms into a dialogue and an interactive relationship with customers. For example, convincing the consumers to change their shopping habits and instructing them about the durability and viability of sustainable products is possible through reminding, persuading, reassuring, and rewarding consumers to help them recall sustainability points of view in their lives [59]. Motivating and endorsing consumers happens through six types of communication appeals [11, 45, 10]:

- Financial; related to reducing value to pay for donations to causes or resource conversations
- Emotional; rises fear for the negative impact the consumer can have on the planet and affects the future generations. Thus it evokes the empowerment of the consumer upon choosing more sustainable products
- Zeitgeist; a set of activities via which consumer's social concerns link to environmental and social issues
- Comparative; is showing the superiority of a particular product endorsed by a celebrity, compared to a competing product
- Euphoria; highlighting the healthy effects of a product, leading to a sense of well-being
- Management; deployment of the company in a movement called green

Regarding the global sensitivity towards sustainability plan, which includes green manufacturing, social and economic justice, the concept of Corporate social responsibility gains importance. Corporate social responsibility is business engagement into sustainable economic growth in working with employees and their families, increasing life quality in society and local communities, and business growth and development. Enhancing corporate social responsibility in a firm's business strategy affects its corporate view, a critical purchase criterion for suppliers, investors, and consumers. But, unfortunately, corporate social responsibility metrics are difficult to describe because they don't have simple principles and technology measures [60].

In the sustainability marketing management process, communication is a vast and complex subject. It operates in two primary levels within the commercial marketing; partly, it works within the level of an entire company and their corporate communication strategy, and also there are communications at the sustainability solutions [61]. Implementing Sustainability and a sustainable strategic plan requires the relevant communicational forms of people's thoughts. Achieving legitimacy in sustainable development depends on societal communications. Also, societal communication can accelerate the complicatedness of Sustainability. Thus, the business acquires the internal and external environments of a firm for communication purposes. While the external communication is between service suppliers and customers, the internal communication happens with higher superiors, descendant juniors, and peers. The complexity of Sustainability is because of the doubtful goals it is seeking regarding interests and values. Sustainability communication generates a shared perception about the plans to achieve shared societal values and connects stakeholder groups effectively. Sustainability communication occurs in three main areas [60]:

- Communication about Sustainability; signifies how ideas and different knowledge regarding Sustainability are considered via face-to-face interpersonal or more general and mass communication forms. When the issues arise, framing, structuring, and deciding about the people who should take the actions are taken by focusing on sustainability.

- Communication of Sustainability; this type of communication is at the managerial level in which journalists, non-governmental organizations, scientists, and activists try to collect data for the sustainability issues in the society and affect decisions of the decision-makers and public.
- Communication for Sustainability; this concept concentrates on the regulating aspect of sustainable development. Thus, communication is not solely about presenting information associated with Sustainability and increasing knowledge for sustainability concerns but about generating societal conversion regarding sustainable development goals.

2.7.1 Sustainability communication and social media

The Age of Information brought forth new avenues of communication for companies worldwide (e.g., social media). Having additional visibility is a boon but also allows more scrutiny from the masses. To this end, companies had to adapt their communication with stakeholders, as the slightest mistake may damage their image and plunge stock value. Additional information, specifically company performance data, can now be inexpensively collected by any company. Creating metrics (e.g., Sustainability) to monitor company performance that can quickly turn into insights is now an ordinary reality in the market. Companies acquire social media to communicate internally and externally about their sustainable activities. Some of which are Facebook, Twitter, social networking, social bookmarking, and other blogs like wikis. Unlike traditional media, social media has a two-way interaction platform that allows organizations to transfer data to stakeholders and respond. Presence in social media enables green companies to react to business shifts regarding Sustainability and cultivate an innovative organizational culture. Thus, the engagement level of a company to environmental issues can be determined by how it prioritizes and values the innovations. There are many social media applications as a communication platform such as marketing, training of stakeholders about sustainability initiative of the parent company, information about working hours, information about jobs, as a link for philanthropic causes, economic, and environmental issues. The company's enthusiasm for conveying communication strategies and allocating resources for social media actions reveals its business culture and willingness to customer preferences and societal trends [62].

2.7.2 Sustainability a tool or reality?

Sustainability marketing is an ethical concern anymore; it is a competitive edge for stakeholders. Companies react differently from each other in response to this issue via two main criteria:

- Sustainable commitment
- Sustainable communication

In this regard, some questions arise, such as whether a company is genuinely acting responsibly, do they communicate their sustainable activities, or keep it secret? Do they look at Sustainability as a significant concern, or is it only a moral issue? Are they open to changing their activities and practicing more sustainable exercises if it is a serious concern? In this context, a metaphor called "light" is considered a scale parallel to the information about practicing sustainable activities that

companies provide. Four types of companies are defined according to their transparency, meaning, how much a company is practicing Sustainability and how much it is communicating sustainability [63]:

- Opaque
- Translucent
- Transparent
- Dark

Translucent companies; have a high commitment to Sustainability, they practice this concern, but they do not consider it a marketing opportunity! There is a natural action towards Sustainability but a lack of communication to publicize it! They do not get the idea of clients towards the practice they are doing. These companies are almost scared and conservative to publish it; hence, they are committed to environmental and ecological concerns. They do not unfold their activities because they believe it is unnecessary to disclose them or do not know about the importance and effect of a marketing strategy. Without communicating their activities through various marketing tools such as websites, translucent companies are in the following threats [63]:

- They might lose customers who are sensitive towards ecological issues, so translucent companies can seem as similar to any other company; thus, they lose clients
- They might not be attractive enough for investors
- They seem to be less active than opaque companies, so opaque companies entice more customers than translucent companies

For transparent companies, Sustainability is of high importance. Thus, its practices are actual, and communication with customers is in harmony with its commitment. Therefore, Sustainability becomes a competitive edge and benefit for stakeholders. They believe in the sentence: " seeing is believing." They practice sustainable activities not only because of their ethical nature but also its importance as a marketing advantage. They communicate what they do! They believe in Sustainability as a competitive edge through which they are getting more profit. Thus, Sustainability becomes not just a marketing tool but a milestone to reach. Eventually, all the company departments are involved in achieving this goal, being aware of their activities in both public and inside the company. It encourages them to participate in teamwork and brainstorm ideas and proposals. The principles for every stage of the process; such as:

- Production process implements in an environmentally friendly manner
- Pollution and CO_2 emissions in the result of transportation supervised to have a minimum negative ecological impact
- They choose suppliers considering their behavior and performance regarding the consideration for human rights as well as their green behavior

- Research and development department invests in sustainable technologies
- Human rights considering worker's rights and their safe environment when working are essential

The communication of transparent companies maintains through websites, product packaging, reports, articles, and marketing the Sustainability of the product [63].

Dark companies do not consider Sustainability as an important strategic issue. No information regarding Sustainability is published or communicated with stakeholders. Thus they have a minimum commitment towards this concept. These companies have a lack of knowledge and information about the importance of the subject of Sustainability. They have no business inertia; thus, dark companies are almost invisible or difficult to recognize in the environment of competition in the market. They need to gain more awareness and information about ecological friendly activities to improve their performance and achieve more advantages from an economic point of view. Otherwise, dark companies' product is not competitive because dark companies are not competitive. After all, they are not proper for the market. Besides, customers with higher awareness would be confused because dark companies do not communicate Sustainability. There is always a lack of data and information for clients. Hence, customers prefer to buy from other companies, and dark companies lose their customers and competition in the market [63].

Opaque companies use Sustainability as a marketing tool in an opportunistic manner! Communication is more in appearance than actual activities and what communicates is not consistent with what is committed. These companies are aware of how vital Sustainability is as a marketing tact! However, because there is no real triumph towards practices but only appearing knowledgeable and committed to Sustainability, they usually do not reveal the data and information applied by market and non-market external drivers where market external drivers are the application of clients, investors competitive pressure. Non-market external drivers are media, activists. Except for the exaggerated communication style and manipulation of necessary data for drivers, there is also a lack of communication among the opaque company's various departments. For example, research and development departments and innovation and investment have very different milestones than Sustainability and social concerns. Still, they pretend they have an intense problem with environmental and ecological issues when communicating. Their communication tool is the internet, websites, articles, and reports. Opaque companies can not survive in the long term if they keep up staying with the same strategy [63].

Some people believe, using Sustainability as a tool for marketing to gain more profit is not ethical. They might be correct because Sustainability is a marketing tool for companies to apply while genuinely respecting the environment and society's ethical and moral values. These principles, so to call, ethical values, must transmit to all the production processes, and the relevant information should pass to stakeholders, clients, and investors. Only then can clients and investors judge various companies and award or boy cut them based on their commitment to ethical functioning. In general, companies as a part of society have a crucial role in Sustainability because profit is their primary goal, but reaching it in an ethical and aware way with consciousness towards the environment and society is of high importance. Marketing of Sustainability, namely communicating it, is a way to gain profit from a business perspective because it attracts more potential investors and clients by marketing them more conscious about their choice [63].

Recommendations for enhancing effectiveness of sustainable development of companies

There are some hints for companies that prefer to improve their effectiveness in reacting to these critical developments [62]:

- Learn from observation; For a company under the spotlight for a sustainability challenge (it could be nice to add a specific example here), having no experience with sustainability communication can hurt its reputation. In preparation for such situations, careful examination of the competitors' public reports might provide much-sought answers.
- Go straight to the point; The stakeholders greatly value being specific when reporting a company's achievements, especially true in the sustainability domain.
- Do not pretend; It is not surprising that some companies have produced reports heavily biased towards areas that may improve their reputation and public image. Though in the sustainability domain, stakeholders are aware of best practices and may call out this behavior.
- Enhancing reputational risk; Any company interacting in social media should declare their official social media account and have a protocol to manage negative comments because social media is an interactive interface medium. The company's failures are shared boldly cause outsider stakeholders can reflect any positive or negative comments and information. Otherwise, there will be ambiguity among consumers.
- Respect internal stakeholders in the sustainability communications; Although implanting Sustainability within a corporate system is complex, involve employees in the sustainability message and integrate Sustainability in the strategic plan. Employees should have more information than stakeholders about the corporate social responsibility execution of the company.
- optimally acquire social media; The presence of a company in social media requires critical disciplines regarding the company's etiquette in responding to consumers, investors, or stakeholders. In addition, the company audiences in social media usually expect to be informed about the latest and fresh information. Also, it is recommended that a company limits its social media interaction to specific platforms and share the same information in their social media that they communicate outside of it.

2.8 Sustainability communications in ceramic industry

As discussed earlier, communication is a crucial foundation for companies to inform their clients, stakeholders, material providers and, authorities about their sustainability practices [53]. Consequently, ceramic manufacturers employ specific channels to transmit their sustainable activities. Here are some examples of how Italian and Spanish industries, as the environmental leaderships in the ceramic industry, are promoting their environmental and corporate social responsibility activities mainly through one of the following items:

- Providing information about environmental activities

- Published certificates
- Contribution to corporate social responsibility activities by cultural, scientific, and charity activities
- Sustainability reports

2.8.1 Websites as a platform to communicate sustainability-related activities

Regarding the adaptation of the most suitable channels to communicate the sustainability performances by companies, online tools and, especially, websites play an essential role. Companies show a lively and direct presence towards sustainability initiatives and information and interactions with their stakeholders. Furthermore, the corporate websites that provide more current information replace conventional communication media and annual reports. Thus, they are becoming a fundamental relational driver to the relationship between the company and its stakeholders and consumers [64]. The websites of ceramic industries generally present a section concerning sustainability, governance tools and,organizational models.The information include:

- Publishing general information about recycling of wastewater, recycling of raw waste, energy consumption, of non-extracted raw materials thanks to the recycling of raw waste, and CO2 avoided thanks to improved energy efficiency in their websites:
  `http://www.gruppoconcorde.it/en/sustainability/`
  `https://www.panariagroup.it/en/the-group/sustainability/`
- Publishing the green building and environmental certificates they are awarded such as CSTB (French Standards organization), BIELORUSSIA (Product quality seal equivalent to UNI but for Bielorus), PN(Product quality seal equivalent to UNI but for Poland), CCC(Chinese quality seal certifying the low radioactivity of materials), QB-UPEC(Product quality seal issued by CSTB (French Standards organization)), EMAS(Sassuolo) which is Eco-Management and Audit Scheme
  `http://www.irisceramica.com/certified-quality/`
- Sharing Videos of their production process and how they implement sustainability pillars in their process
  `https://www.youtube.com/watch?v=sbkCQ0ZbxQ4/`
- Sharing Catalogue of products with the most recycled material and environmentally friendly content
  `https://www.porcelanosa.com/trendbook/en/porcelanosa-new-collections-promote-recycling-and-su`

2.8.2 Corporate social responsibility activities

Contribution to corporate social When there is intense competitiveness, the company's image depends on economic and financial indicators, the quality of products, the new jobs created, and how the company contributes to the community's prosperity, the stakeholders, and the environment. Corporate social responsibility in the ceramic industry is met through programs to increase the life quality

standard within the area where the employees live and work and those in need within the environment. some of which are :

- Charity and Donation activities (Orphanage visit, blood donation, assistance for natural disaster area, planting activities)
  https://www.platinumceramics.com/our-company/csr-program/
- Projects of excellence in terms of quality classrooms, educational program and the professionalism of the staff employed
  http://www.gruppoconcorde.it/en/sustainability/
- Cultural events involving arts, and sports
- Corporating in research projects
  https://en.keraben.com/ver/269/keraben-grupo-promotes-the-european-research-project-destiny.html

2.8.3 Sustainability reports

The precision and clarity of the published sustainability data from the factories are increasingly demanded by consumers, legal analysis, developments in the market, and non-governmental organizations. Furthermore, a rising amount of financial tools and business companions require a precise analysis and vocalization of the company's sustainability actions. A sustainability report guides companies to inspire their stakeholders through sustainability risks and opportunities they cause, assessing their sustainable performance, and setting sustainability-related strategic plans. It includes non-financial data that covers environmental, governance and social concerns. Sustainability reporting communicates declarations of an organization's positive and negative effects on the environment, economy, and society [65]. Sustainability Reports that companies share usually includes some information proving their commitment to sustainability pillars, some of which are:

- Overall description of the company itself, its history and mission statements
- Details about how they implement sustainability pillars focusing on the environmental pillar, mostly considering water, energy consumption, raw material
- The minimum generation of waste
  https://www.irisceramicagroup.com/wp-content/uploads/2020/12/2020_sustainability_report_EN.pdf
- Their commitment to corporate social responsibility and the activities they do in this regard
- Their attempt towards designing ecologically and financially cost-effective products, like the concept of super ceramics that a company called Portobello is promoting in their report
  https://www.portobello.com.br/data/sustainability/Sustainability%20Report%202020%20Portobello.pdf
- Some economic statistics as well as employees

As discussed in previous chapters, communication in general and sustainability communication, in particular, is a two-sided transaction that benefits the ceramic industries and their stakeholders. Therefore, the ceramic companies whose strategic plan involves sustainability activities engage different channels to communicate their sustainability exercises depending on the extent of the information they share. In general, publishing sustainability information on the companies' websites introduces their products as high-value products and their openness to communicate with the consumers. On the other side, consumers increase their confidence in the company by receiving the information they reach for.

The published and documented information about a company's activities towards corporate social responsibility aligns with the consumers who engage and seek social causes. Either the consumer is an ordinary society member or a non-governmental organization, or an activist. In addition, the published videos, pictures, and documented corporate social responsibility activities improve the showcase image of the company and raise its reliability.

Sustainability reports and certificates assist the companies to have an insight into their current position in the sustainability path and where they need to focus on improving. Furthermore, it raises the company's sales and enhances its reputation. The certificates and reports with accurate data are practical tools for collaborations between related associations, non-governmental associations, and governmental associations. An architect, for example, that is obliged by his contract to incorporate a sustainably manufactured ceramic tile in his project, can reach out to the company and get his necessary documents.

Chapter 3

Research Method and data collection

In this thesis, three agents related to the ceramic tile industry were studied:

- Leading companies in the ceramic sector
- Two companies as the case study
- A focus group of end-users, namely architects, designers, and engineers who decide to embody the ceramic tiles in their projects

Thus the resources for collecting the required data for the research work were:

- Online data based on leading companies in the ceramic sector: This information, alongside the theoretical studies, was used as guidelines of the standard communicational practices.
- Interviews with Companies
- Information obtained from the results of the survey on the study group's attitude towards sustainability

3.1 Leading companies in the ceramic sector

This thesis seeks to answer the question " How are sustainability activities currently marketed and communicated in the ceramic companies?" and "What are the most effective channels to interact the proper sustainability message between the ceramic companies and the end-users?" The information from different resources is obtained to compare the practical communicational tools. Companies use these tools in practice compared with the theoretical communicational means noted in the previous chapter. Thus, websites of the famous and well-known companies are excellent references to gain some information about the current practices they are communicating as the standard framework. Therefore, the prominent companies' communication methods in their websites to choose the sustainably produced products are examples of the effective interaction between industries and their users when there is a question about how enterprises can influence their use. The leading companies' websites were also used to investigate the communicational means the companies use to

share technical details with architects, designers, and constructors. The referenced companies are described in Table 3.1.

Ceramic Companies		
Company Name	Country	Website
Iris Ceramica Group	Italy	https://www.irisceramicagroup.com
Keraben Groupo	Spain	https://www.kerabengrupo.com
Porcelanosa	Spain	https://www.porcelanosa.com
Gruppo Concorde	Italy	http://www.gruppoconcorde.it
Portobello	Brazil	https://www.portobello.com.br

Table 3.1: Information of the leading ceramic companies' websites

3.2 Two companies as the case study

This thesis has chosen a comparative case study scheme to frame the obtained data since various cases (several leading ceramic companies in the sector) are applied as a data reference. The case study strategy correlates sustainability communication from the theoretical point of view with the practices the professionals do within the industry. However, different companies combine diverse values and guidelines for sustainability marketing and communication, confirming the necessity of comparing the findings of various companies. Thus, various ceramic companies were conducted, but due to the confidentiality of the subject and the limitations of pandemic time, the number of companies to cooperate as the case study was limited. Hence, the population of the study is limited to two case studies.

Consequently, two case studies were confronted qualitatively within a comparative approach to analyze the similarities or differences. Furthermore, the sustainability communication methods of two case studies were compared with the strategies and practices of leading companies to identify the deficiencies. These companies have been interviewed through a semi-structured interview to provide data about their sustainability marketing activities and their use of various communication tools.

The companies are Mota Ceramic Solutions group (extraction of raw material to make ceramic body) and Tabriz Tile Group (the manufacturing company of ceramic tiles). Table 3.2. presents the samples and displays the successfully contacted companies, interviewed positions, and interview mode.

Ceramic Companies		
Company Name	Position	Mode of Interview
Mota Ceramic Solutions	CFO	Face-to-Face, emails
Mota Ceramic Solutions	Research and development	Face-to-Face, emails
Mota Ceramic Solutions	Commercial Manager	Face-to-Face, emails
Tabriz Tile Group	Research and development	Telephone Interview, emails
Tabriz Tile Group	Systems Management	Telephone Interview, emails

Table 3.2: Information of the case study companies

The interview questions and the general template are presented in appendix 1. The interview questions have been divided into four major categories:

- General questions about Sustainability activities have been asked, how Sustainability is developing and growing within the company.
- Questions were about the importance of the marketing department within the company and its role in the business plan.
- Questions were regarding different types of communication and their efficiency of influencing the consumers.
- Differentiating strategies the company adapts in the competitive market regarding sustainability activities.

Moreover, data has been supplemented through conducting online research of the two cases to complementing the data with their online representation and generating data that assist in answering the research questions.

3.3 Focus group

The survey titled " Sustainability communications in the ceramic industry" was conducted from November 2020 until July 2021.

The purpose of this survey was to investigate a focus study group of architects, designers, and constructors' opinions about sustainability issues in their professional area. The preference of sustainably produced ceramic tiles over other products and the importance of the company's communications with them on their decision-making criteria were studied in this survey.

The survey involved a total of 15 respondents, including 12 architects and designers and three engineers. 50% of the respondents were experienced in the sector for 10-20 years, and 30% had professional experience for more than 20 years. More than 50% of the architects worked in the municipalities of Lisbon, Porto, and Leiria. The engineers also worked for the state. The rest of the respondents were freelance architects and designers. Some face-to-face meetings and interviews followed to study the subject from the respondents' point of view in the first place. Then the survey was shared with them to fill out. The survey posed 15 questions:

- What are your profession, your age, and the country you are working in?
- How long have you been working in your professional area?
- How would you rate the focus on sustainability in your region?
- On a scale of 1 to 10, less critical and most important, how do you personally rate the interest in sustainability-conscious design?
- How much information do you have about green buildings?
- What are the most important environmental concerns for you?

- What are the most important principles or design criteria for choosing among materials, specifically ceramic tiles?
- Are there any legislations for architects or designers for selecting the building materials regarding the concept of sustainability?
- What media do you have to get informed about the sustainable practices of a company?
- How many events about sustainability in interior design and architecture and construction take place over a year?
- And is it held by related associations or the manufactures of materials?
- What environmental information about the building materials, namely ceramic tiles, is or should be provided by the product's producer to persuade you to buy their product?
- On a scale of 1 to 5, how much does the marketing of sustainability and communication upon it from the industry affect the designer to choose the product of that specific company?
- Is a company's communication towards sustainability sufficient and impressive enough to justify designers buying their specific product?
- In the case of extra information about sustainability practices, are companies cooperative and vulnerable to share and reveal the data?

Chapter 4

Analysis of the results

4.1 Leading companies in the ceramic sector

These companies had a specific section on their websites about sustainability. In that section, they share information about reducing their environmental footprints. Selected companies also publish certificates and sustainability reports. In addition, they promote and highlight their corporate social responsibility practices on their websites by sharing videos or photos of the events and all practices they participated in or invested in. They also share easily downloadable environmental certificates.

- Keraben Spain promotes their research and development activities on their websites. They introduce the projects they do regarding improving the treatment of wastewater, efficient systems that reduce the demand for natural gas, how to reduce the emissions from tile kilns, and ceramic tiles that save energy for buildings.
- Porcelanosa Group publishes its corporate social responsibility activities as sustainable architecture in the digital age, their involvement in the world ocean or forest day.
- Iris Ceramica has been one of the world leaders in producing ceramic and porcelain tiles for wall and floor coverings since 1961. On their website, they promote their ideology about sustainability and publish the links to download the documents of sustainability certificates and their annual sustainability reports. In their sustainability report, they provide comprehensive information about their environmental activities, corporate social responsibility projects, data about their economic conditions, design criteria, material choice measures, and complete data about their staff.
- Gruppo Concorde alongside the abovementioned items promote their corporate social responsibility activities. Furthermore, they cooperate in cultural activities with a multi-media museum that gathers valuable historical objects that embody the ceramic tradition in Sassuolo, merging past and present in a synthesis projected into the future.
- Portobello group shares their sustainability report by three distinct icons representing three pillars of sustainability on the sustainability section of their websites. By clicking on the icons, the related statistics and data are traceable.

4.2 Two companies as the case study

4.2.1 Case study: Mota Ceramic Solutions

The brand that assisted as a case study for this work is Mota Ceramic Solutions. With extensive multi-mineral reserves in Portugal, MCS has been extracting, processing, blending, and supplying quality controlled raw materials (Clays and Kaolines, Feldspars, QUARTZ, and ceramic paste) to the ceramics industry since the 1940s. The Group is committed to providing namely fit for purpose products, together with technical support services, to the ceramic industry worldwide. MCS group expertise in raw material supply and paste formulation for all sectors of ceramics means they:

- Develop specific products for current processes
- Improve the performance of current formulations
- Create new products for new technological processes
- Employ proven project management techniques to bring laboratory work to the pilot plant and then into large-scale production
- Their multi-mineral solutions incorporate their raw materials and knowledge gained from their industrial experience

Due to Mota's nature of production output, which is the extraction of raw material, they are constantly in the spotlight regarding sustainability issues. The interview took place at the Head Office in Aveiro, Portugal. The interview questions were first answered via face-to-face meeting and a consequent email to answer follow-up questions and develop more comprehensive detail about the issues.

In Mota Ceramic Solutions, they were very interested and cooperative in taking part in this research work. They invest more in sustainability activities and the research and development sector of the company. Thus, they agreed first to have the face-to-face interview held in the meeting room with a comprehensive presentation prepared by the CFOs, introducing the company, their activities, and their enthusiastic attempts in implementing sustainability pillars in their process. Later, the questions and doubts were asked, and weeks later, the subsequent questions were sent to have clear and more detailed answers.

Engagement in Sustainability approaches

General questions about Sustainability activities and how they are integrated into the company's operations were asked. When it comes to the sustainability activities that they perform, it was stated that Sustainability in a mining and mineral processing company starts with its definition - as an extractive industry, they are dealing with non-renewable resources - every tonne of material taken out of the ground does not 'grow' again. Thus MCS's definition of Sustainability is built on the premise that they focus on supplying the economic needs of the present without compromising the ability of

future generations to meet their own. In the context of their operations, this means minimizing the consumption of mineral resources while always looking for ways to maximize the number of recycled materials in their products, even if economically it is more expensive, and reduce water, energy (gas/electric) consumption per tonne of product produced. At the same time, they look to invest in technologies (solar panels) and digitalization to monitor performance. Moreover, the MCS had developed a comprehensive series of sustainability-related initiatives build around the EU 17 Sustainability Development Goals. Teach has been prepared with qualitative metrics, specifically in areas such as reducing their environmental 'footprint' (CO_2 production) while at the same time extending their social 'handprint' in the local communities where the Group operates.

The importance of the marketing department within the company as well as its role in the business plan

Their answer to the questions about the importance of the marketing department within the company and its role in the business plan was: MCS has appointed a full-time Sustainability Director since January 2021 to oversee this subject and coordinate and promote initiative across the various parts of the Group. The person works in close collaboration with the Health, Safety, and Environmental function and their Corporate Communication-Marketing function.

Different types of communication and their efficiency of influencing the consumers

When it comes to communication tools, they believe at present; there is an evident paradox and lack of understanding by the general public on the fundamental link between consumer demand, costs incurred, which need to be paid for (by someone) to support sustainable mineral extraction to supply a growing global market and drive for higher standards of living.

Furthermore, due to a solid anti-mining movement, corporate publicity and communication of all types are minimal. Therefore, they are having a challenge, including a lack of government clarity, support, and legislation that promotes the national interest and importance of Portugal's mining (sustainable) industry.Although sustainability communication is fundamental to address the severe issues, the mining industry players, including MCS, in Portugal have many legacy issues to address to improve its credibility. Until that time, MCS remains cautious in its external sustainability communication. Nevertheless, they use their website, corporate newsletters, industry magazines, and community activities to promote their image.

The potential for growth and differentiating strategies the company adopts in the competitive market regarding sustainability activities

Regarding the potential for sustainability-related growth, which differentiates strategies, the company adopts in the competitive market sustainability activities; MCS group states that they consider local support and relations with communities, Junta's and town halls in which MCS operate is actively pursued to maintain our social license to use (SLO) when positioning their products. They are also active with industry-related institutions such as APICER and IMA-Europe. However, as a B2B business, they

have little contact with end-users. Furthermore, they do not believe MCS's sustainability marketing communication strategy is unique about their particular communication strategy - it is still in its relative infancy. What is notable is the effort they are putting into quantifying, tracking, and taking ownership of their ESG sustainability responsibilities and stewardship of the country's mineral wealth entrusted to them. They take concepts of "Green Mining" and "Green Deal" seriously.

4.2.2 Case study: Tabriz Tile Group

Tabriz Tile Industrial Group was constructed in 24 km of Tabriz city in the northwest of Iran on a land with an area of 200,000 square meters and has started its activity in 1995. The initial capacity of this company is 1.5 million square meters per year in the production of various types. It was a wall tile that has been used since 1995 and with detailed technical studies on machines and the consumer market about the designs and dimensions that the end consumer pays attention to, renovation projects, and increasing capacity in the wall tile sector and creating an independent unit implemented a new floor tile section. Currently, the company is operating with an annual capacity of 3 million square meters of wall tiles and 5 million square meters of floor tiles.

Tabriz Tile Group has a modern and open-minded point of view, always very interested in following the latest technologies in the manufacturing process. They are working as an independent group with the name of Tabriz Tile Group and a joint venture with a Spanish ceramic company called Keraben Group. The joint brands are Kergres and Spinker. They invest more in sustainability activities and the research and development sector of the company. However, despite their actual implementation of sustainability pillars, they do not reflect it clearly on their websites, either their activities towards corporate social responsibility or their activities towards protecting the environment.

Due to the interviewer's job experience in the Tabriz Tile group for some years, it was agreed by the CEO to cooperate in this project. They decided first to have the telephone interview, and subsequently, questions were sent to the company's research department for more technical answers.

Engagement in Sustainability approaches

General questions about Sustainability activities and how they are integrated into the company's operations were asked. They answered that, through the systems' office, all the relations among internal sections are defined regarding evaluating risks and opportunities of the business. In addition, they implemented the organizational guidelines of PC-OM-04; when asking for more examples and how these guidelines were implemented, they did not provide an answer.

The importance of the marketing department within the company as well as its role in the business plan

Their answer to the questions about the importance of the marketing department within the company and its role in the business plan states the company's marketing department is specifically active

upon their business communication towards returning the waste to the production cycle and efficient energy consumption.

Different types of communication and their efficiency of influencing the consumers

When it comes to communication tools, they believe at present; through CRM group they focus on customer Services, Supervision upon critics and suggestions, Relationship between the sales management with the risks of the market, and Studying all the issues regarding safety in the work environment in all sections of the company. The most common communicational media they acquire are Online news, printed press, Ecological labels, advertising reports of distributors and stakeholders, and reports about openings of new showrooms.

The potential for growth and differentiating strategies the company adopts in the competitive market regarding sustainability activities

Regarding the potential for sustainability-related growth, which differentiates strategies, they stated that the company adopts in the competitive market sustainability activities as a new trend in their export and import considerations; the company's plans regarding risks and opportunities in the market, all sustainability pillars are considered in safety, quality, and sales. They present the related documents in the corporate sales report.

4.3 Focus group

A survey was designed and filled out by the end-users, namely architects, constructors, and interior designers in Portugal, Iran, Italy, and Greece. The reason for developing the survey was to focus on the specific decision-making end-user, namely architects and designers. In addition, the survey aimed to obtain a more profound and practical insight into the decisive criteria when selecting construction components. The survey aimed to investigate the influential factors to choose the sustainably produced ceramic tiles through the following factors:

- Personal enthusiasm and knowledge of the users
- The position of the manufacturers
- The importance of governmental legislation as a decisive influencer
- The necessity of sustainable building certificates
- The importance related associations
- The role of the manufactures' communication to influence their decision-making preferences

General information about age, country of work, and experience in the sector

The majority of the respondents were architects who had more than 40 years old, and they were working in Portugal with more than ten years of experience in the sector.

Personal knowledge, enthusiasm, and sensitivity towards sustainability and sustainable building materials

The responses about the importance and attention towards sustainability in their region pointed to the low interest in practice. However, the respondents considered they were very informed about the concept of sustainable and green building. Moreover, they stated the high value of sustainable design and implementing sustainability criteria when choosing construction materials, specifically ceramic tile. Still, when they were asked about any related projects, there were no clear answers.

The governmental legislation about sustainability certificates for the buildings

Although the architects were giving importance to choosing more sustainable materials and avoiding waste generation, there were not enough legislations and regulations for choosing sustainable building materials and getting sustainable building certificates. Thus, it highlighted the lack of governance or association-related obligations. In addition, most of the architects stated that there were less than five events, workshops, and training towards this concept held by related associations.

The effectiveness of a company's sustainability communication

When the respondents were asked how a company's communication can affect their choosing patterns, more than half of the respondents pointed to the direct relationship between its sustainability communications and its product choice.

They also stated that while they obtain most of the information about a company's sustainability actions and the product's sustainable production process through companies' websites, usually, the companies were not so helpful in revealing more detailed and extra information.

Chapter 5

Discussion

5.1 Leading companies in the ceramic sector

It is necessary to compare the communication of the case studies with the leading companies in the sector to achieve a comprehensive and clear insight into the deficiencies two case studies have regarding communicational strategies and methods; based on the mutual channel as electronic communication such as websites. The websites of the leading transparent companies illustrate that Sustainability is of high importance. Thus, its practices are fundamental, and communication with customers is following its commitment.

As noted earlier, Mota Ceramic Solutions Group faces obstacles regarding public opinion because they extract material, and the public does not appreciate this inevitable action. Thus, although they are cautious in promoting their sustainability-related activities, their main focus should be on changing or reforming the public opinion about them. By avoiding any harmful activities like loud explosions and leaving an empty query, and similar activities, they withdraw the negative news. Furthermore, they need to highlight any good and positive information towards their environmentally friendly activities in social media, in the press or news section of the website.

Comparing Tabriz Tile Group's website with the leading companies' websites illustrates their attention and the message they select to transfer to their viewers. They have a beautiful webpage focusing on elegant, trendy, and technically advanced products without any sustainability-related activities. Neither the corporate social responsibility activities mentioned in the interview nor the environmental activities in the manufacturing process are published and shared on their website.

5.2 Two companies as the case study

In this section, firstly, the two case studies are compared to each other. Then, theoretical studies in the previous chapters and the communicational methods of the leading companies in the sector are used as guidelines for the subsequent suggestions to case studies to improve their communications. The suggestions suits for all customer group but focusing on the study group of the survey.

General attitude towards sustainability

Regarding the Tabriz Tile Group, their answer towards the importance they devote to sustainability pillars and the question about if the company's marketing department has any effects on the business strategy are the core points about the company's approach towards sustainability. Unfortunately, most of the answers repeat a telegraphic and formal argument that they consider sustainability in all internal processes in manufacturing and external process on sales and export, without clarifying and giving examples. However, their approach to answering the factors influencing their sustainability marketing communication is considering sustainability as a trend in export and import.

Mota Ceramic Solutions is more comprehensive than Tabriz Tile Group when answering the questions. Their answer to integrating sustainability pillars into their operations clarifies their general idea about this concept. They state that the context of their process is minimizing the consumption of the mineral resources and looking for ways to maximize the number of recycled materials in their products even if using recycled material is more expensive than raw material. Furthermore, they reduce water and energy consumption per tonne of product.

Main concerns in sustainability strategies

Tabriz Tile group points out one crucial aspect of sustainability that seems to be one of their main focuses. They state that three pillars of sustainability in the industry, the present pressure in the society, the sanctions and economic consequences and loads, and the social conditions, regarding race, religion, and education, are considered in the training and education of employees and their families. Thus, not only do they highlight their production lines and manufacturing process, but they also the happiness and stability of their staff. Moreover, they emphasize educating their employees to bring knowledge to their company.

Mota's answer to the importance they consider for sustainability pillar is a point that differentiates it from Tabriz Tile Group, where Mota Ceramic Solutions developed a series of sustainability-related initiatives build around EU 17 Sustainability Development Goals. Therefore, this metric does not apply to the Tabriz Tile Group in Iran, a non-European country.

Another core factor about Mota Ceramic Solutions is having a sustainability director, even as young as January 2021. Still, that is a sign of the importance they consider sustainability.

The Sustainability communications and main objectives

The sustainability communications of Mota Ceramic Solutions group clearly explain how they are cautious in external communications, meaning the public will criticize them for promoting their sustainability actions. They believe in evident paradox and lack of understanding by the general public on the fundamental link between consumer demand, costs incurred, which need to be paid for (by someone) to support sustainable mineral extraction to supply a growing global market and drive for higher standards of living. They also complain about the lack of government clarity, support, and legislation that promotes the national interest and importance of Portugal's mining (sustainable) industry.

While Mota Ceramic Solutions Group targets positive publicity towards their activities to compensate for extracting minerals from the earth, Tabriz Tile Group seeks competition in the national and international market. However, Tabriz Tile Group either finds it unnecessary to disclose it or does not know its importance and effect as a marketing strategy.

Classification of the companies regarding their communications

As discussed in the previous chapters, companies react differently in response to the sustainability issues via two main criteria of the commitment to Sustainability and communication of Sustainability, categorized into four types of companies [63]:

- Opaque
- Translucent
- Transparent
- Dark

Likewise, Mota Ceramic Solutions Group, the participation of Tabriz Tile Group in research work as a case study, shows the value they consider for the concept of Sustainability. However, both case study companies act in the category of translucent companies. At the same time, they have a high commitment to Sustainability, they practice this concern, but they do not consider it a marketing opportunity! There is a natural action towards Sustainability but a lack of communication to publicize it! They do not get the idea of clients towards the practice they are doing. These companies are almost scared and conservative to promote it; hence, they are committed to environmental and ecological concerns. They do not unfold their activities because Mota Ceramic Solution Group is aware of the negative public opinion about the nature of its function.

Mota Ceramic Solutions is a company that takes the sustainability concept very seriously, but at the same time, they are still taking baby steps towards communicating it. Due to the bad image towards the mining industry, they do not use the argument of Sustainability as a marketing tool. Thus, the education of the public should start from somewhere else rather than the company.

Tabriz Tile looks at the concept of Sustainability as a new trend that they can acquire as a tool for competition in the market and exporting to markets abroad; they have lacked proper communication regarding their answers to the interview and the information they publish on their website.

5.3 Focus group

Regarding the survey results, as mentioned earlier, the focused study group were mainly architects above 40 years old with more than ten years of experience in the sector.

General knowledge and information about sustainability

The study group stated their high amount of knowledge towards sustainability issues. Still, they did not have a practical example of their declarations; their answers towards the most critical sustainability issue were generic, indicating the low amount of knowledge they had towards practical concepts of sustainability. Thus, it considered important to do a brief search about sustainability-related courses and subjects in Portugal's two leading public universities.Unfortunately, no sustainability courses in Architecture at the two leading public universities in Portugal were found [66, 67]. The curricula of architecture course in these universities includes:

- Drawing
- Geometry
- Structural systems
- Theoretical subjects related to space
- History of architecture in different eras
- Project
- Construction
- Materials
- Dissertation

How communication of the company affects the decision-making process

When they were asked about "What environmental information about the building materials, namely ceramic tiles, do they have," the answers were so vague. They also state waste generation as the most important environmental concern alongside clean water and climate changes; still, they said the most important principles or design criteria when choosing among materials, specifically ceramic tiles, was sustainability in general. However, they did not explain what aspect of sustainability was important, specifically about tiles.

Hence, while lack of theoretical information should connect with their education, the actual practices when embodying materials are due to a lack of know-how and technical knowledge. Therefore, it can be a proper sustainability message and information that needs to be revealed by ceramic companies to have robust communication with the focused study group.

Legislations towards building certificates and embodiment of sustainable products

The focused end-user group also referred to a lack of governmental obligations to make it compulsory for constructors and architects to contribute to sustainable building construction. Furthermore, they affirmed that there was no law on sustainable building certifications and selecting sustainable building materials. Finally, they mentioned the low amount of focus on sustainability in their region.

Chapter 6

Conclusion

This research aimed to identify :

- How are sustainability activities currently marketed and communicated in ceramic companies?
- What are the most effective channels to interact the proper sustainability message between the ceramic companies and the end-users?

In this regard, it was essential to have a theoretical study on the whole manufacturing process of ceramic tiles, the consequent environmental damage, and the compensative or prohibitive activities manufacturers and scholars do to reduce the harmful effects of this process. In addition, the concept of sustainability in general and in the ceramic industry, in particular, is also studied.

The study also covered the sustainability communicational tools, marketing principles, and the type of companies when it comes to communicating on sustainability. Finally, answering the research questions necessitated having a deeper insight into the subject by combining the theoretical background with the actual practices in the professional industry environment.

There were certain limitations to gaining helpful information during the work; either because of the Pandemic conditions or the confidentiality of the data, companies were not responsive to the calls and emails. Thus, after researching the leading companies in the ceramic sector, their websites and communicational methods were used as guidelines for proper communications upon sustainability in the ceramic industry.

So, two studies took place on the three agents of extraction of the raw material and preparation of the ceramic body, the manufacturing company that produces the ceramic tiles, and the end-users, which focuses on architects and designers in this study.

Two companies as the case study

The first study investigated the importance of sustainability in the strategic plan of two ceramic factories. First, face-to-face, phone interviews, and emails were applied to gain information about the relevant activities and communications about sustainability practices in the case study factories. Then

a qualitative and comparative analysis happened about the case study companies regarding the leading companies' communicational strategies and methods.

The results of the interviews revealed the apparent lack of communication in these case studies. Each company had its priorities when communicating its sustainability-related activities. While Mota Ceramic Solutions group was cautious because of the negative publicity of their actions, the Tabriz Tile group was satisfied with their modernized manufacturing process and the elegant products.

However, it seemed like they were not aware of the rising demand for sustainability marketing communications to survive and put a step ahead in the competitive market.

Focus group

The second study was held through a survey of a focused group of architects and designers, who are the professional decision-makers in choosing among building materials, namely ceramic tiles, for their projects.

The results of the survey and face-to-face interviews showed a high amount of personal interest in the subject of sustainability but a lack of practical and technical know-how to embody a sustainably produced ceramic tile in their projects alongside the aesthetic, economic and technical criteria. The results also illustrated the low interest and obligations towards implementing sustainability criteria in the decision-making process either by the architects or the agents who legalize the buildings.

It also results that alongside the events and training held by related associations, the communications of the ceramic companies strongly influence their preferences.

6.1 Recommendations

As both companies were open to participating in the research work as a case study, they are highly interested in the subject. Still, it is suggested to take critical actions towards their communicational strategies and tools.

Based on the conclusions, both case study companies are recommended to improve their overall communications about sustainability through :

Publish environment-related actions

Tabriz Tile Group is located in Iran where is facing a severe water shortage [68]. Alongside the other environmental issues, the water concern is a challenge for the group to consider in their actual sustainability practices and communicate the strategies and compensating actions they practice in their production process. Thus, it is suggested to put a distinct section about environmental problems in the global and local perspectives, in which they state their Sustainability related manufacturing

activities. Mota Ceramic Solutions Group, on the other hand, is already practicing compensation activities regarding environmental damage. However, it is suggested to highlight these activities with a louder voice in the public and social media, including their websites.

A short video of the company's sustainability practices, from the preparation of raw material to the distribution, is a means for transparent communication with clients. As the Porcelanosa group [69] does, a visual media that showcases the modern production lines and the manufacturing process gives an idea of the reality of sustainable activities within the company, including workers' work conditions, safety, and women's positions in the company.

Include sustainability indicators in products

Considering the rising global awareness towards Sustainability and its importance in the competitive market, the critical factor for Tabriz Tile Group to have a fringe for differentiation is to be engaged in the trendy concept of the market. Therefore, while they promote the design of the products, they can have an added information of technical and sustainably tracing information in their online catalogs. This item includes the recycled content of the raw material, the preserved energy while production, water save, information about the query the extraction of material took place.

Including traceable sustainability information in the online catalog of Tabriz Tile Group's Group can bridge end-users who are not in direct contact with the company and their media to reach out for information on their websites. Because in the public opinion, the engagement level of a company to environmental issues can be determined by how they publicize it.

Publish sustainability-related certificates

It is recommended that both companies publish their sustainability-related certificates for Tabriz Tile Group and Green Mining certificates for Mota Ceramic Solutions group to attract customers' trust when communicating sustainability activities. In addition, posting downloadable certificates on their websites makes their claims trustworthy for the most sensitive client, such as the focused study group of this work.

Promote Corporate Social Responsibility activities

Mota Ceramic Solution Group can gain public trust by participating in corporate social responsibility activities in mining areas or other regions. Hence, more investment in the education in the area, for instance, investing in local projects, plantations, charity activities, and many similar projects.

However, on one side, there is a challenge of facing misunderstanding and lack of comprehension of the public, and on the other side the lack of clarity of governmental laws. Without communicating their activities, Mota Group is in the threat of facing more obstacles regarding negative publicity from the public, ecological activists, and sensitive end-users who pay attention to the end product and the entire process from mining to its installation.

On the other hand, it is recommended that Tabriz Tile Group devotes a part of its website to their Corporate social responsibility activities that they already practice by the importance they give to the training of the employees. In addition, they can participate more in sustainability-related events taking place in their showrooms. Thus, while having a live show of their products, they communicate the sustainability message to the significant investors and constructors that prefer Tabriz Tile Group's products to others in the market.

6.2 Further Research

Further work is needed to deeply study the reasons, intentions, and constraints behind the lack of transparency, interest, and legitimacy towards implementing or communicating sustainability practices in the ceramic industry. According to the results of this thesis, future studies could also address:

- Cooperation between ceramic industries and Academia; the limitations during the research work while trying to obtain data from companies point out the significant gap between ceramic companies and Academia. Although ceramic companies have their research and development departments to do the research work, more sustainability-related projects in the sector benefit both parties. How do the ceramic companies collaborate with Academia as a part of their corporate social responsibility activities and benefit their research and development sectors while Academia trains the graduated engineers with professional industrial training? Therefore, more investigations are recommended for strengthening the cooperation between Academia and the ceramic industry.
- Cooperation between ceramic industries and associations of architects and designers; lack of technical knowledge and practical skills towards the concept of sustainability about ceramic tiles was one of the survey results and interview with the study group. It points out the necessity for the bridge between ceramic companies and associations of architects, designers, and engineers in the construction sector. The studies are necessary about building this bridge so that the companies share their latest sustainably designed and manufactured products with the professionals who decide to select the building materials. It is also suggested to study deeper on the interactions between associations and ceramic companies on influencing the co-design process of the products by the professionals who embody the ceramic tiles on their projects.
- Embodiment of sustainability-related courses in the curricula of the university courses;through this kind of education, students will have the essential knowledge about what they need to learn to contribute to sustainability in their field of study when implementing the knowledge in an actual professional environment. Embedded sustainability in the curriculum is a principle to motivate and approach commitment for more skillful and knowledgable sustainability actions from any graduated engineer or designer.
- Sustainability-related governmental policies;last but not least important is governmental legacies and policies' role in issuing sustainability-related legislation, which is a vast area for the research. For example, how can governmental laws oblige the constructors to incorporate sustainably produced ceramic tiles in the state buildings like hospitals, train stations, airports, schools, etc.?

Bibliography

[1] (Spanish Association of Ceramic Tile and Floor Manufacturers. *Tile of Spain*. URL: https://www.ascer.es/ (visited on 08/03/2021).

[2] Luca Baraldi. “World production and consumption of ceramic tiles”. In: *Ceramic world review* 113 (2015), pp. 48–61. URL: https://issuu.com/tiledizioni/docs/000_216_cwr_113.

[3] Francisco Javier García-Ten et al. “LIFE CERAM. Zero waste in ceramic tile manufacture”. In: *Key Engineering Materials* 663.March (2016), pp. 23–33. ISSN: 16629795. DOI: 10.4028/www.scientific.net/KEM.663.23.

[4] Aruna Sankar and Chithambar Ganesh. “The environmental impact caused by the ceramic industries and assessment methodologies”. In: *International Journal for Quality Research 13(2) 315–334* 13.2 (2018), pp. 315–334. DOI: 10.24874/IJQR13.02-05. URL: http://www.ijqr.net/paper.php?id=733.

[5] Davide Settembre Blundo et al. “Lifecycle-oriented design of ceramic tiles in sustainable supply chains (SSCs)”. In: *Asia Pacific Journal of Innovation and Entrepreneurship* 12.3 (2018), pp. 323–337. ISSN: 2398-7812. DOI: 10.1108/apjie-06-2018-0039.

[6] Marco Migliore, Cinzia Talamo, and Giancarlo Paganin. “Construction and Demolition Waste”. In: *Springer Tracts in Civil Engineering* October (2020), pp. 45–76. ISSN: 23662603. DOI: 10.1007/978-3-030-30318-1_2.

[7] Fabrício Sousa Simões Marisa A. Almeida. “Ceramic Industry contribution to a Circular Economy”. In: *Congress of Innovation on Sustainable Construction*. March. Coimbra, 2017. URL: https://www.researchgate.net/publication/315337655_Ceramic_Industry_contribution_to_a_Circular_Economy.

[8] Cristina Rocha. “Innovation and Ecodesign in Ceramic Industry”. In: *Challenges and Opportunities for Design Research, Education and Practice in the XXI Century, LeNS Conference, held in Bangalore, India, 29/09-01/10/2010*. 2010. URL: https://www.researchgate.net/publication/258808587.

[9] D Gabaldón-Estevan, E Criado, and E Monfort. “The green factor in European manufacturing: a case study of the Spanish ceramic tile industry”. In: *Journal of Cleaner Production* 70 (2014), pp. 242–250. DOI: 10.1016/j.jclepro.2014.02.018. URL: http://hdl.handle.net/10234/126187.

[10] Kean Peattie. *Sustainability Marketing: A Global Perspective, 2nd Edition*. 2012, pp. 1–23. ISBN: 978-1-119-96619-7. URL: https://www.wiley.com/en-us/Sustainability+Marketing%3A+A+Global+Perspective%2C+2nd+Edition-p-9781119966197.

[11] Ruth Rettie, Kevin Burchell, and Debra Riley. “Normalising green behaviours: A new approach to sustainability marketing”. In: *Journal of Marketing Management* 28.3-4 (2012), pp. 420–444. ISSN: 0267257X. DOI: 10.1080/0267257X.2012.658840.

[12] DECORCERA. *The long history and evolution of ceramic tiles*. URL: https://decorcera.com/the-long-history-of-ceramic-tiles.html (visited on 08/03/2020).

[13] J.P.Veiga M.O.Figueiredo, T.Ferreira de Silva. “Ancient glazed ceramic tiles”. In: *International Seminar "Conservation of glazed ceramic tiles", National Laboratory for Civil Engineering, Lisbon* 40.6 (2009), p. 10. ISSN: 0021891X. DOI: 10.1007/s10800-010-0086-x. URL: http://repositorio.lneg.pt/handle/10400.9/539.

[14] A. O. Surendranathan. *An Introduction to Ceramics and Refractories*. 2014. ISBN: 9781482220452. DOI: 10.1201/b17811.

[15] Lurca. *Ceramic tile history*. URL: https://www.lurca.com.br/gb/ceramic-tiles-history/#:$%5Csim$:text=The%20history%20of%20ceramic%20tiles,tile%20bricks%20(image%201).&text=During%20the%20Ottoman%20Empire%20became,city%20near%20Istanbul%20called%20Iznik. (visited on 08/03/2020).

[16] K.P. MANI. “The Tile Industry in Kerala - an Overview”. PhD thesis. Cochin University of Science and Technology, 1973, pp. 30–69. URL: https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.879.4892&rep=rep1&type=pdf.

[17] Editrice la Mandragora s.r.l Imola Italy. *Applied ceramic technology*. Vol. 1-2. 2002. ISBN: 9788578110796. DOI: 10.1017/CBO9781107415324.004. arXiv: arXiv:1011.1669v3. URL: https://documents.pub/document/sacmi-vol-1-inglese-ii-edizione.html.

[18] Michele Dondi, Mariarosa Raimondo, and Chiara Zanelli. *Clays and bodies for ceramic tiles: Reappraisal and technological classification*. Tech. rep. 2014, pp. 91–109. DOI: 10.1016/j.clay.2014.01.013. URL: http://dx.doi.org/10.1016/j.clay.2014.01.013.

[19] Institut De Promocio Ceramica. *Ceramic tiles commercial and technical classifications*. Tech. rep., pp. 1–23. URL: http://www3.ipc.org.es/guia_colocacion/mediateca.html.

[20] Greg Geiger. *Introduction To Ceramics*. Tech. rep. American Ceramic Society. URL: https://ceramics.org/.

[21] Sacmi. *Identification of ceramic raw materials*. ISBN: 8888108483. URL: https://pt1lib.org/book/6109579/f5fa3c?id=6109579&secret=f5fa3c.

[22] Marta Valaskova. “Clays, clay minerals and cordierite ceramics - A review”. In: *Ceramics - Silikaty* 50.4 (2015), pp. 331–340. ISSN: 18045847.

[23] Ian Wilson. *Applied Clay Mineralogy. Occurrences, processing and application of kaolins, bentonite, palygorskitesepiolite, and common clays*. Vol. 55. 6. 2007, pp. 644–645. ISBN: 9780444517012. DOI: 10.1007/bf03406033.

[24] M. Dondi. “Technological and compositional requirements of clay materials for ceramic tiles”. In: *2001. A Clay Odyssey* January 2003 (2003), pp. 23–30. DOI: 10.1016/b978-044450945-1/50092-0.

[25] Solanki Kaushik and S R Shah. “Analysis of Drying Process in Ceramic Tiles Industries”. In: *International Journal of Advance Research and Innovative Ideas in Education* 2.3 (2016), pp. 2395–4396. URL: http://docplayer.net/28013285-Analysis-of-drying-process-in-ceramic-tiles-industries.html.

[26] R. Casasola, J. Ma Rincón, and M. Romero. *Glass-ceramic glazes for ceramic tiles: A review*. Tech. rep. 2. 2012, pp. 553–582. DOI: 10.1007/s10853-011-5981-y. URL: https://core.ac.uk/download/pdf/36085576.pdf.

[27] European Commission. *Reference Document on Best Available Techniques in the Ceramic Manufacturing Industry*. Tech. rep. August. Council Directive 96/61/EC (IPPC Directive), 2007. URL: https://eippcb.jrc.ec.europa.eu/reference/ceramic-manufacturing-industry.

[28] Jacob Cherian and Jolly Jacob. "Green marketing: A study of consumers' attitude towards environment friendly products". In: *Asian Social Science* 8.12 (2012), pp. 117–126. ISSN: 19112017. DOI: 10.5539/ass.v8n12p117.

[29] Fernando E. Garcia-Muiña et al. "The paradigms of Industry 4.0 and circular economy as enabling drivers for the competitiveness of businesses and territories: The case of an Italian ceramic tiles manufacturing company". In: *Applied Sciences (Switzerland)* 7.12 (2018). ISSN: 20760760. DOI: 10.3390/socsci7120255. URL: https://www.mdpi.com/2076-0760/7/12/255.

[30] Melanie Fritz. "Sustainability in the agri-food industry: a literature review and overview of current trends". In: *8th International Conference on Chain Network Management in Agribusiness the Food Industry*. Institute for Food and Resource Economics, University of Bonn. Wageningen, 2008. URL: https://www.researchgate.net/publication/273627391_Sustainability_in_the_agri-food_industry_a_literature_review_and_overview_of_current_trends.

[31] "Marketing and sustainability". In: *Marketing Intelligence & Planning* 26.2 (2008), pp. 123–130. ISSN: 02634503. DOI: 10.1108/02634500810860584.

[32] Òscar Jordà, Moritz Schularick, and Alan M. Taylor. "Financial crises, credit booms, and external imbalances: 140 years of lessons". In: *IMF Economic Review* 59.2 (2011), pp. 340–378. ISSN: 20414161. DOI: 10.1057/imfer.2011.8.

[33] Archie B. Carroll. "A three-dimensional conceptual model of corporate performance". In: *Corporate Social Responsibility* January 1979 (2017), pp. 37–45. ISSN: 0363-7425. DOI: 10.5465/amr.1979.4498296.

[34] John. Cary, Michael J. Polonsky, and Suku. Bhaskaran. *Green marketing and EMS*. Tech. rep. Melbourne: Rural Industries Research and Development Corporation, 2004, p. 44.

[35] Alex Hughes. "Corporate strategy and the management of ethical trade: The case of the UK food and clothing retailers". In: *Environment and Planning A* 37.7 (2005), pp. 1145–1163. ISSN: 0308518X. DOI: 10.1068/a3753.

[36] Joseph Sarkis. "Manufacturing strategy and environmental consciousness". In: *Technovation* 15.2 (1995), pp. 79–97. ISSN: 01664972. DOI: 10.1016/0166-4972(95)96612-W.

[37] Ruxandra Irina Popescu et al. "Ecological marketing –strategic option for business development in bucharest". In: *Economic Computation and Economic Cybernetics Studies and Research* 51.2 (2017), pp. 67–83. ISSN: 18423264.

[38] Marisa P De Brito and Rommert Dekker. *Reverse Logistics-a framework*. Tech. rep. Rotterdam: Erasmus University Rotterdam, 2002. URL: https://www.researchgate.net/publication/46434127.

[39] Giacomo Boschi et al. "Sustainability in Italian ceramic tile production: Evaluation of the environmental impact". In: *Applied Sciences (Switzerland)* 10.24 (2020), pp. 1–15. ISSN: 20763417. DOI: 10.3390/app10249063. URL: www.mdpi.com/journal/applsci.

[40] Eliseo Monfort Gimeno. *What role do ceramic tiles play in green procurement and sustainable building?* Tech. rep. Castellón: Universitat Jaume I. URL: http://repositori.uji.es/xmlui/handle/10234/126187.

[41] Anita Terjek and Annamária Dudás. “Sustainability and Environmental Awareness in the Ceramic Industry”. In: *European Journal of Engineering Research and Science* 5.8 (2020), pp. 970–979. DOI: 10.24018/ejers.2020.5.8.2027.

[42] Issam Srour, Wai Kiong Chong, and Fan Zhang. “Sustainable recycling approach: An understanding of designers’ and contractors’ recycling responsibilities throughout the life cycle of buildings in two US cities”. In: *Sustainable Development* 20.5 (2012), pp. 350–360. ISSN: 09680802. DOI: 10.1002/sd.493.

[43] Christian Grönroos. *Service Management and Marketing*. Vol. 15. 2007, pp. 3–31. ISBN: 0470028629. DOI: 10.1108/EUM0000000004874.

[44] Gregory T. Gundlach and William L. Wilkie. “The American marketing association’s new definition of marketing: Perspective and commentary on the 2007 revision”. In: *Journal of Public Policy and Marketing* 28.2 (2009), pp. 259–264. ISSN: 15477207. DOI: 10.1509/jppm.28.2.259.

[45] J. G. Smith and Fred. E. Clark. *Principles of Marketing.* Vol. 38. 151. 1928, p. 450. ISBN: 9780273684565. DOI: 10.2307/2224326.

[46] Fred Langerak, Ed Peelen, and Mark Der Van Veen. “Exploratory results on the antecedents and consequences of green marketing”. In: *International Journal of Market Research* 40.4 (1998), pp. 323–335. ISSN: 14707853. DOI: 10.1177/147078539804000404. URL: https://www.researchgate.net/publication/254767696_Exploratory_Results_on_the_Antecedents_and_Consequences_of_Green_Marketing.

[47] Dinuk Arseculeratne and Rashad Yazdanifard. “How Green Marketing Can Create a Sustainable Competitive Advantage for a Business”. In: *International Business Research* 7.1 (2013), pp. 130–137. ISSN: 1913-9004. DOI: 10.5539/ibr.v7n1p130.

[48] V. Kumar, Zillur Rahman, and A. A. Kazmi. “Sustainability Marketing Strategy: An Analysis of Recent Literature”. In: *Global Business Review* 14.4 (2013), pp. 601–625. ISSN: 09721509. DOI: 10.1177/0972150913501598.

[49] J. Joseph Cronin et al. “Green marketing strategies: An examination of stakeholders and the opportunities they present”. In: *Journal of the Academy of Marketing Science* 39.1 (2011), pp. 158–174. ISSN: 00920703. DOI: 10.1007/s11747-010-0227-0. URL: https://link.springer.com/article/10.1007/s11747-010-0227-0.

[50] Cees J. Gelderman et al. “Green marketing as an environmental practice: The impact on green satisfaction and green loyalty in a business-to-business context”. In: *Business Strategy and the Environment* December 2020 (2021), pp. 1–16. ISSN: 10990836. DOI: 10.1002/bse.2732.

[51] Diane M. Martin and John W. Schouten. “The answer is sustainable marketing, when the question is: What can we do?” In: *Recherche et Applications en Marketing (English Edition)* 29.3 (2014), pp. 107–109. ISSN: 2051-5707. DOI: 10.1177/2051570714540497.

[52] Vinod Kumar et al. “Evolution of Sustainability as Marketing Strategy: Beginning of New Era”. In: *Procedia - Social and Behavioral Sciences* 37 (2012), pp. 482–489. ISSN: 18770428. DOI: 10.1016/j.sbspro.2012.03.313. URL: http://dx.doi.org/10.1016/j.sbspro.2012.03.313.

[53] Irene Henriques and Perry Sadorsky. “The determinants of an environmentally responsive firm: An empirical approach”. In: *Journal of Environmental Economics and Management* 30.3 (1996), pp. 381–395. ISSN: 00950696. DOI: 10.1006/jeem.1996.0026.

[54] Frank Martin Belz and Birte Schmidt-Riediger. “Marketing strategies in the age of sustainable development: Evidence from the food industry”. In: *Business Strategy and the Environment* 19.7 (2010), pp. 401–416. ISSN: 09644733. DOI: 10.1002/bse.649.

[55] Michael A Berry and Dennis A Randinelli. “Proactive Corporate Environmental Management”. In: *Acedemy of Management Executive* 12.2 (1998), pp. 38–50.

[56] Kimberly Ann Elliott, Richard B. (Richard Barry) Freeman, and London School of Economics and Political Science. Centre for Economic Performance. *White hats or Don Quixotes? : human rights vigilantes in the global economy*. Centre for Economic Performance, London School of Economics and Political Science, 2004. ISBN: 0753017644. URL: https://www.researchgate.net/publication/5001135_White_Hats_or_Don_Quixotes_Human_Rights_Vigilantes_in_the_Global_Economy.

[57] Henning Madsen and John P Ulhøi. “Stakeholder Pressures, Environmental Impact and Managerial Initiatives of SMEs: A Longitudinal Study”. In: *The Journal of Transdisciplinary Environmental Studies* 14.1 (2015), pp. 1602–2297. URL: http://www.journal-tes.dk/.

[58] Jeffrey Barber. “Communicating Sustainable Production and Consumption Challenges and Strategies”. In: *GRF Shanghai Conference 2014*. 2014. URL: https://www.researchgate.net/publication/272787222.

[59] Chris Rose. *Research Into Motivating Prospectors, Settlers and Pioneers To Change Behaviours That Affect Climate Emissions*. Tech. rep. URL: http://campaignstrategy.org/articles/behaviourchange_climate.pdf.

[60] Ruhet Genç. “The Importance of Communication in Sustainability & Sustainable Strategies”. In: *Procedia Manufacturing* 8.October 2016 (2017), pp. 511–516. ISSN: 23519789. DOI: 10.1016/j.promfg.2017.02.065. URL: http://dx.doi.org/10.1016/j.promfg.2017.02.065.

[61] Ken Peattie and Frank-Martin Belz. “Sustainability marketing — An innovative conception of marketing”. In: *Marketing Review St. Gallen* 27.5 (2010), pp. 8–15. ISSN: 1865-6544. DOI: 10.1007/s11621-010-0085-7.

[62] Anne H. Reilly and Katherine A. Hynan. “Corporate communication, sustainability, and social media: It’s not easy (really) being green”. In: *Business Horizons* 57.6 (2014), pp. 747–758. ISSN: 00076813. DOI: 10.1016/j.bushor.2014.07.008. URL: http://dx.doi.org/10.1016/j.bushor.2014.07.008.

[63] Fabrizio Baldassarre and Raffaele Campo. “Sustainability as a marketing tool: To be or to appear to be?” In: *Business Horizons* 59.4 (2016), pp. 421–429. ISSN: 00076813. DOI: 10.1016/j.bushor.2016.03.005. URL: http://dx.doi.org/10.1016/j.bushor.2016.03.005.

[64] Alfonso Siano et al. “Communicating sustainability: An operational model for evaluating corporate websites”. In: *Sustainability (Switzerland)* 8.9 (2016). ISSN: 20711050. DOI: 10.3390/su8090950.

[65] Cheryl Khor. *Sustainability Reporting Strategy Creating impact through transparency*. Tech. rep. URL: https://en-rules.hkex.com.hk/node/1892.

[66] Architecture. *University of Lisbon*. URL: https://www.fa.ulisboa.pt/index.php/pt/cursos/mestradointegrado/arquitetura/especializacao-em-arquitetura (visited on 04/09/2021).

[67] Faculdade de Arquitetura Ar. *University of Porto*. URL: https://sigarra.up.pt/faup/pt/cur_geral.cur_planos_estudos_view?pv_plano_id=586&pv_ano_lectivo=2021&pv_tipo_cur_sigla=MI&pv_origem=CUR (visited on 04/09/2021).

[68] Kaveh Madani, Amir AghaKouchak, and Ali Mirchi. “Iran’s Socio-economic Drought: Challenges of a Water-Bankrupt Nation”. In: *Iranian Studies* 49.6 (2016), pp. 997–1016. ISSN: 14754819. DOI: 10.1080/00210862.2016.1259286. URL: http://dx.doi.org/10.1080/00210862.2016.1259286.

Appendices

Appendix 1

6.2.1 Interview Template

Interview with Tabriz Tile Group

1. How is Sustainability integrated into the context of the operations of the company? Tabriz Tile group implements the sustainability pillars considering the risks and opportunities in the area of health in the workplace and ecological footprints all of which are presented in the guidelines of PC-OM-04.

2. How much importance does the company give to sustainability pillars? (Social, Economic, Environmental) Does the company has any goals or milestones to achieve Sustainability?

If yes, how are these goals related to the business plan of the company?

The triple bottom line, including social, environmental, and economic pillars, are defined and implemented in the external and internal strategies of the company annually. They are also considered in the short and long-term milestones of the company. The company focuses on reducing environmental risks, expenses, introducing new products, establishing the culture of proper consumption, accepting and following the work agreements and disciplines identified in PC-OM-12 organizational guidelines.

3. Is there any sector responsible for pursuing implementing this concept inside the company among different sectors and correlate them with each other in the same direction to achieve the sustainability goals?

Yes, through the systems' office, all the relations among internal sections are defined regarding evaluating risks and opportunities of the business.

4. Does the marketing department affect the company's business model and priorities regarding the concept of Sustainability?

According to CRM, yes, the company's marketing department is specifically active upon their business communication towards returning the waste to the production cycle and efficient energy consumption.

5. What are Sustainability Marketing/communication activities currently performed?

Through CRM group: -Customer Services - Supervision upon critics and suggestions - Relationship between the sales management with the risks of the market -Studying all the issues regarding safety in work environment in all sections of the company

6. Which types of communication are (Online news, print media, clothing labels, CSR reports, in-store advertisements) efficient, and which ones are less usable? Communication media is ac-

quired such as Online news, printed media, Ecological labels, advertising reports of distributors and stakeholders, and reports about openings of new showrooms

7. Which external and internal factors influence the sustainability marketing strategies of the company? What are the challenges for the communication of Sustainability? What factors prohibit the development?

Three pillars of sustainability, including ecological, environmental, and social in this industry (Ceramic tiles), the present pressures in the society, and the social conditions (regarding race, religion, and education), are considered in the education of employees their families.

8. Do the company target socio-ecological active consumer groups and integrate socio-ecological criteria into the product positioning?

According to milestones of Tabriz Tile industrial group as an eco-friendly complex, it is highly committed to the environmental issues and implements the concern on their purchase, sales, distribution and, packaging process

9. Does the company see growth potential for Sustainability Marketing/communication in the future? Will the role of sustainability communication become more important?

Yes. Regarding The sustainability as a new trend, the company follows the principles in their export and import considerations

10. How would the company describe its differentiation strategy when it comes to Sustainability Marketing compared to competitors? What makes its communication strategy special?

The company's strategies regarding risks and opportunities in the market, all sustainability pillars are considered in safety, quality, and sales. The related documents are present in corporate sales reports, and the company is vulnerable to present those reports.

Interview with Mota Ceramic Solutions Group

1. How is Sustainability integrated into the context of the operations of the company?

Sustainability in a mining and mineral processing company starts with its definition - as an extractive industry we are dealing with non-renewable resources - every tonne of material taken out of the ground doesn't 'grow' again. Thus MCS's definition of Sustainability is built on the premise that we focus on supplying the economic needs of the present without compromising the ability of future generations to meet their own. In the context of our operations, this means minimising the consumption of mineral resources whilst always looking for ways to maximise the amount of re-cycled materials in our products, even if economically it is more expensive, and reduce water, energy (gas/electric) consumption per tonne of product produced. At the same time we look invest in technologies (solar panels) and digitalisation to monitor performance.

2. How much importance does the company give to sustainability pillars? (Social, Economic, Environmental) Does the company has any goals or milestones to achieve Sustainability?

If yes, how are these goals related to the business plan of the company?

Yes, MCS has developed a wide series of sustainability related initiatives build around the EU 17 Sustainability Development Goals. Teach have been prepared with qualitative metrics, specifically in areas such as reducing our environmental 'footprint' (CO2 production) whilst at the same time extending our social 'handprint' in the local communities where the Group operates.

3. Is there any sector responsible for pursuing implementing this concept inside the company among different sectors and correlate them with each other in the same direction to achieve the sustainability goals?

Yes, MCS has appointed a full time Sustainability Director since January 2021 to oversee this subject and coordinate and promote initiative across the various parts of the Group. The person works in close collaboration with our Health/Safety and Environmental function as well as our Corporate Communication/Marketing function.

4. Does the marketing department affect the company's business model and priorities regarding the concept of Sustainability?

Yes, see (3)

5. What are Sustainability Marketing/communication activities currently performed?

At present, due to a strong 'anti-mining' movement, particularly this year prior to local elections; corporate publicity and communication of all types, is at a minimum.

6. Which types of communication are (Online news, print media, clothing labels, CSR reports, in-store advertisements) efficient, and which ones are less usable?

Normally we use our website, corporate newsletters, industry magazines and community activities to promote our image.

7. Which external and internal factors influence the sustainability marketing strategies of the company? What are the challenges for the communication of Sustainability? What factors prohibit the development?

In addition to the response in (5) the challenge includes a lack of government clarity, support and legislation that promotes the national interest and importance of the mining (sustainable) industry in Portugal. There is a clear paradox, and lack of understanding, by the general public on the fundamental link between consumer demand, costs incurred, which need to be paid for (by someone) to support sustainable mineral extraction to supply a global growing demand and drive for higher standards of living.

8. Do the company target socio-ecological active consumer groups and integrate socio-ecological criteria into the product positioning?

Yes, local support and relations with communities, Junta's and townhalls in which MCS operate is actively pursued to maintain our social license to operate (SLO). We are also active with industry related institutions such as APICER and IMA-Europe. However, as a B2B business we have little contact with end users.

9. Does the company see growth potential for Sustainability Marketing/communication in the future? Will the role of sustainability communication become more important?

Yes, sustainability communication is fundamental to address the serious issues touched in in (7). Nevertheless, the mining industry players, including MCS, in Portugal have many legacy issues to address in order to improve its credibility. Until that time, MCS remains cautious in its external sustainability communication.

10. How would the company describe its differentiation strategy when it comes to Sustainability Marketing compared to competitors? What makes its communication strategy special?

In addition to the comments in (9), I do not believe MCS's sustainability Marketing communication strategy per se is special - it is still in its relative infancy. What I believe is special is the effort we are putting into quantifying, tracking and taking ownership for our ESG sustainability responsibilities and stewardship of the countries mineral wealth entrusted to us. We take seriously conceprts of 'Green Mining' and 'Green Deal'.

Appendix 2

6.2.2 Survey template

1. What are your profession, your age, and the country you are working in?

2. How long have you been working in your professional area?

3. How would you rate the focus on sustainability in your region?

4. On a scale of 1 to 10, less critical and most important, how do you personally rate the interest in sustainability-conscious design?

5. How much information do you have about green buildings?

6. What are the most important environmental concerns for you?

7. What are the most important principles or design criteria for choosing among materials, specifically ceramic tiles?

8. Are there any legislations for architects or designers for selecting the building materials regarding the concept of sustainability?

9. What media do you have to get informed about the sustainable practices of a company?

10. How many events about sustainability in interior design and architecture and construction take place over a year?

11. And is it held by related associations or the manufactures of materials?

12. What environmental information about the building materials, namely ceramic tiles, is or should be provided by the product's producer to persuade you to buy their product?

13. On a scale of 1 to 5, how much does the marketing of sustainability and communication upon it from the industry affect the designer to choose the product of that specific company?

14. Is a company's communication towards sustainability sufficient and impressive enough to justify designers buying their specific product?

15. In the case of extra information about sustainability practices, are companies cooperative and vulnerable to share and reveal the data?