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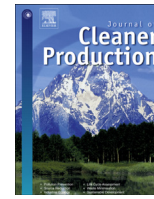

Unwanted effects of European Union environmental policy to promote a post-carbon industry. The case of energy in the European ceramic tile sector

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A B S T R A C T

Global warming combined with low carbon transition plans is threatening the future of high energy consumption industry sectors in the European Union (EU). The need to respond to environmental challenges is demonstrated by support for international level energy policies and legal requirements, such as the Kyoto Protocol which the EU supports, and increased EU-level environmental legislation and energy policies. The effect of these initiatives is gradually transforming industrial activities in the EU. However, since not all countries have adopted these policies, evaluation of their net effect needs to take account also of side-effects such as delocalization of industry activity and the legal environmental frameworks in the countries where companies have chosen to relocate. This paper analyses EU energy policy and its impact on a particular energy intensive industry, the European ceramic tile sector. The discussion in this paper is not about the purpose of EU legislation, but about its effects on a specific industry. The effect of policy on industry is not a new topic, but the question of the unwanted effects of environmental and energy policy on European industry is becoming more relevant as the struggle to achieve a post-carbon Europe increases. In focussing on a specific set of EU legislation on a particular industry this article adds to the debate by showing the negative effects of policy mechanisms. The need for a scientific evaluation of the systemic changes required for a transition to a resource-efficient, green and competitive low-carbon economy outlined in the 7th Environment Action Programme is highlighted. It is suggested that the EU should periodically re-evaluate its Emissions Trading Scheme legislation to include specific actions and a follow up system which would prevent the best performing environmental companies from delocalizing or shutting down.

1. Introduction

There is growing concern about the unsustainability of the production model in the so-called developed countries, given the diminishing capacity of the environment to assimilate the impacts of economic activity in a non-traumatic way (Huisingh et al., 2015; Lockie et al., 2013; Rockstrom et al., 2009). The situation is being exacerbated by the rapid growth of other economies especially Brazil, Russia, India and China (BRIC countries) and the consequent greater demand for energy and raw materials to feed that growth (Pao and Tsai, 2010, 2011a,b). At the same time, there is increased public awareness of the diminishing capacity of the environment to assimilate the impacts of human activity, and continuous demands for environmental sustainability (European Commission, 2014; Hajer, 1995; Rogers et al., 2008). At the institutional level, this concern is reflected in support for energy policies and international legal requirements such as the Kyoto Protocol (Böhringer et al., 2009a,b; Jordan and Lenschow, 2000). Also, academic attention has been directed towards energy and sustainability policies and their effect on industry (López-Gamero et al., 2010; Vera and Langlois, 2007; Weber and Rohracher, 2012). Debate in the EU over the sustainability of 'traditional' industries (Dewald and Achternbosch, 2015), such as the ceramic tile industry (Gabaldón-Estevan et al., 2014), is being fuelled by the major transformations induced by the process of globalization and the

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economic crisis. This article contributes to this debate by analysing EU environmental and energy policy and its impact on the EU ceramic tile sector.

Global warming and low carbon transition (COM, 2011b, 112 final; Directive 2012/27/EU) are posing huge challenges for high energy consuming manufacturing industry subsectors in the EU, especially those, such as the ceramic tile industry, which have relatively low productivity (Koroneos and Dompros, 2007) and are competing in international markets. The EU's commitment to leading a response to these environmental challenges, has resulted in a high level of legislative activity related to environmental (Directive 2010/75/EU; Directive 2011/91/EU) and, especially, energy policy (Directive 2004/8/EC; COM, 2011a, 109 final). The effect of those initiatives is gradually transforming industrial activity within the EU. The new scenario, characterized by increased pressure imposed by environmental regulation (carbon dioxide – CO_2 Emissions Trading Scheme – ETS (Directive, 2009/29/EC; Commission Decision of 24 December 2009), use of Best Available Techniques – BAT, etc.), favours non-EU competitors – whose production often does not meet EU environmental standards – which benefit from lower energy prices and, in some cases, have better access to raw materials. This is encouraging the relocation of production to places with conditions with less favourable environment, social and labour regulations.

Since the studies by Rubik and Scholl (2002) and Helby (2002), European environmental legislation has grown in complexity and scope (Oikonomou and Jepma, 2008). However, recent research on the effect of EU policy on environmental protection is not conclusive. Afionis and Stringer's (2012) work on biofuel regulation, shows that EU regulations prioritize competitiveness and economic growth over environmental protection, while Gouldson et al. (2015) and Boeters and Koornneef (2011) suggest that, sometimes, the impact of EU environmental regulation is overestimated. Jänicke (2012) highlights the relevance of the policy dimension for understanding how response to and interactions between the technical innovation system, influence acceleration or deceleration of virtuous or vicious diffusion process cycles. Westner and Madlener (2012) show that the EU's ETS affects the attractiveness of EU countries for investment in large-scale, combined heat and power plants. Maes et al. (2015) claim that the EU's Renewable Energy Directive sustainability guidelines need to be developed further and de Miranda and Kruglianskas (2015) stress the need for reflexivity in environmental regulations.

In addition to prioritizing energy efficiency in all energy domains, EU environmental policy is aimed at achieving a 20% reduction (on 1990 values) in greenhouse gas (GHG) emissions by 2020 and a reduction in renewable energy sources deployment (to 20% of gross final energy consumption in 2020). The costs of compliance with this policy are estimated to be between 0.4% and 0.6% of EU Gross Domestic Product (GDP) in 2020 (Capros et al., 2011). However, implementing the changes required to meet the EU Directives targeting specific sustainable energy development objectives can have contradictory impacts (Streimikiene and Šivickas, 2008).

Some studies provide evidence of ‘carbon leakage’, while others minimize or ignore its occurrence (Barker et al., 2007). Some suggest ‘the potential for the global leakage rate to exceed 100%; i.e. a policy to reduce carbon emissions in the industrialized countries actually increases global carbon emissions’ (Babiker, 2005: 441). Chen's (2009) study of US regional GHG policy suggests that leakage and spillovers could be a concern. Kallbekken et al. (2007) affirm that, potentially, the clean development mechanism in the Kyoto protocol, could reduce carbon leakage significantly, while Kuik and Hofkes (2010) suggest that border adjustments to prevent free-riding and carbon leakage might be more effective at reducing carbon leakage rates in some industries (iron and steel) than others (minerals, cement).

Since the level of environmental and energy policies varies, it is necessary to assess the net effect of these initiatives. This includes taking account of the side effects of relocating industrial activity such as the legal environmental frameworks in these locations. This paper provides an analysis of EU energy policy and its impact on the European ceramic tile sector. It is organized as follows: Section 2 describes the theoretical framework; Section 3 discusses the main characteristics of the European ceramic tile manufacturing process along its value chain (Section 3.1) and the recent evolution of its market share and production (Section 3.2). It presents the available data on energy consumption in the ceramic tile industry (Section 3.3), summarizes the legislation most relevant to that sector (Section 3.4) and analyses the impact of EU energy policy on the sector (Section 3.5). Section 4 concludes by summarizing the main contributions of this paper.

2. Theoretical framework

This analysis adopts a systems perspective on the impact of supra-national (EU level) legislation on the performance of an EU industry sector. There are various approaches to the study of innovation systems in evolutionary economics, which use various units of analysis. First, national innovation systems (Freeman and Soete, 1987; Lundvall, 1992; Nelson, 1993), followed by regional innovation systems, related to specific areas within large territories (Cooke, 1996; Cooke and Morgan, 1993). Technological systems focus mainly on the networks of agents in the generation, diffusion and utilization of technologies (Callon, 1992; Carlsson and Stankiewicz, 1995; Hughes, 1984) and sectoral systems refer to innovations in industries across political borders (Breschi and Malerba, 1997; Malerba, 2002). Finally, district systems combine innovation system and industrial district approaches (Gabaldón-Estevan et al., 2012) and emphasize the relevance of territory for both the industrial district form and other elements of the innovation system.

From a systems perspective, legal and institutional frameworks are central to the definition of firm strategies since they affect the productive, scientific and technological environments (see Fig. 1). Similarly, socio-technical regimes can be understood as historical routines and optimization processes, which are institutionalized and materialize and are aligned with multiple dimensions such as industry structures, technology and infrastructure, knowledge base, users and markets, culture, and policy and political power

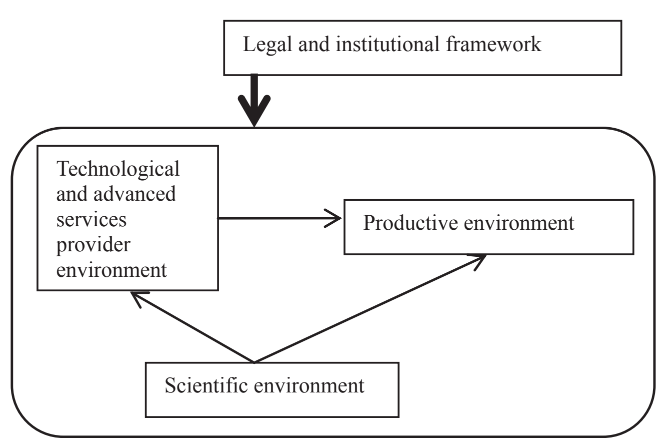

Fig. 1. Schematic illustration of the main elements in an innovation system. (Adapted from Fernández et al., 1996).

(Geels, 2002; Smith and Raven, 2012). This last refers to policy targets and priorities, administrative rules, power relations, etc., which influence the direction of search since ‘new regulations, and changes to markets or competitors, are all factors that affect the activities in sectors, in terms of the way they perform their activities, or the range of activities they perform’ (Gabaldón-Estevan and Hekkert, 2013: 152).

The analysis involves three steps: (1) describing the main characteristics of the European ceramic tile manufacturing process along its value chain with specific emphasis on the energy intensity of each stage; (2) analysing thermal and electrical energy consumption in the ceramic tile industry; and (3) evaluating the impact of EU energy policy on the European ceramic tile sector.

Secondary data were collected from various sources including specialist sectoral publications and statistics. Data drawn from EUR-Lex, the EU legislation database on EU level environmental policy were used to map the policy measures that influence the development of the ceramic tile industry.

3. Analysing the evidence

Section 3 has five sub-sections. Section 3.1 discusses the main characteristics of the European ceramic tile manufacturing process along its value chain and Section 3.2 presents the European ceramic tile industry market share and production. Section 3.3 presents the available data on energy consumption in the ceramic tile sector and Section 3.4 summarizes the legislation most relevant to the ceramic tile industry, and its impact on the industry. Section 3.5 investigates the impact of EU energy policy on the sector.

3.1. The European ceramic tile manufacturing process

The stages in the ceramic tile manufacturing process vary according to the functionality required of the manufactured product. The main ceramic tile production stages are:

(1) raw materials preparation. Appropriate raw materials are selected and proportioned to achieve the desired product characteristics. Their quality (i.e. impurities content) determines their suitability for tile production and the product's final cost, which, to an extent, is dependent on the distance between mine and plant. Use of local raw materials is maximized to reduce manufacturing costs, but some raw materials have to be imported from other regions or countries, including non-EU countries (e.g., white clays imported mostly from Ukraine, and feldspars imported from Turkey). In the pressing stage, the raw materials mix is subjected to wet or dry milling. Wet milling is the most frequent preparation method in Europe, owing to the properties of the granules obtained by spraying; however, from an energy point of view, dry milling is more efficient. Wet milling accounts for 30% of the thermal energy consumed in ceramic tile production;

(2) ceramic tile forming. Ceramic tile bodies are generally formed by pressing, using hydraulic presses which consume electric energy;

(3) drying. The formed tile bodies are subjected to a drying cycle to reduce the moisture content, which varies according to the type of forming process. This stage accounts for around 10% of total thermal energy consumed;

(4) glazing and decorating. After drying, the ceramic tiles are usually glazed and decorated. The process consists of the application of various glaze layers depending on the mechanical or aesthetic properties desired, followed by decoration which is done by digital inkjet;

(5) firing. In this final production stage, the ceramic tiles are subjected to a thermal cycle at temperatures ranging from 1100 °C to 1200 °C, depending on the product. This stage accounts for more than 50% of total thermal energy consumption in the manufacturing process.

A single firing process means the tile body and glaze are fired simultaneously. Double firing refers to when the tile body is fired before being decorated, and then fired for a second time to fix the glaze. The most common ceramic tile manufacturing process in Europe is single firing (see Fig. 2).

3.2. The European ceramic tile industry — market share and production

Wall and floor ceramic tiles constitute the biggest sector (measured by turnover) in the European ceramic tile industry, with total sales in 2013 estimated at around €9 billion. A third of ceramic tile production is exported outside of the EU, resulting in a largely positive trade balance, with exports representing four times EU imports of ceramic tiles in value.[1]

The European ceramic tile industry has been the world leader for design and innovation and continues to set the trend for new designs and functionalities. Ceramic tiles cover a wide range of product categories which satisfy technical and aesthetic needs related to both traditional and modern indoor and outdoor environments. Ceramic tiles have many functional characteristics including better hygiene and greater safety. Their resistance to exposure to light and to chemical attacks, and their ease of maintenance makes ceramic tiles important for the sustainability of buildings.

European ceramic tile production increased continuously from 1980 to 2006, reaching a maximum annual production of around 1500 million m^2. The global financial crisis caused this value to decrease in 2009 to 1079 million m^2 (Giacomini, 2010). However, since then, European ceramic tile production has slowly increased to reach 1.186 million m^2 in 2013, due mainly to increased exports (Stock, 2014).

At the same time, world ceramic tile production has increased continuously since 2006 and, after 2008, the European ceramic tile industry lost relative weight in the world ceramic tile industry. For example, the percentage of European tile manufacturing in world production decreased from 16.6% in 2008 to 10% in 2013. Fig. 3 shows the evolution of European and world ceramic tile production, and the percentage production in Europe since 2008.

Italy and Spain are the biggest ceramic tile producers in the EU, accounting for some 66% of production; however, Poland, Portugal, Germany, France, Bulgaria, the UK, Romania, the Netherlands, Czech Republic and Hungary are also significant producers. Fig. 4 shows the evolution of Spanish and Italian ceramic tile production from 1981.

3.3. Energy use and consumption in the European ceramic tile industry

The ceramic tile industry consumes considerable amounts of energy along its value chain. The main energy consuming phases are mining, transport of raw materials to the processing plants, the manufacturing process, and storage and delivery of the ceramic tiles once packaged. The energy involved in the use and end of life phases is negligible (Benveniste et al., 2010). Transport of raw materials to the plants, and the product to markets — the two ends

[1] www.cerameunie.eu.

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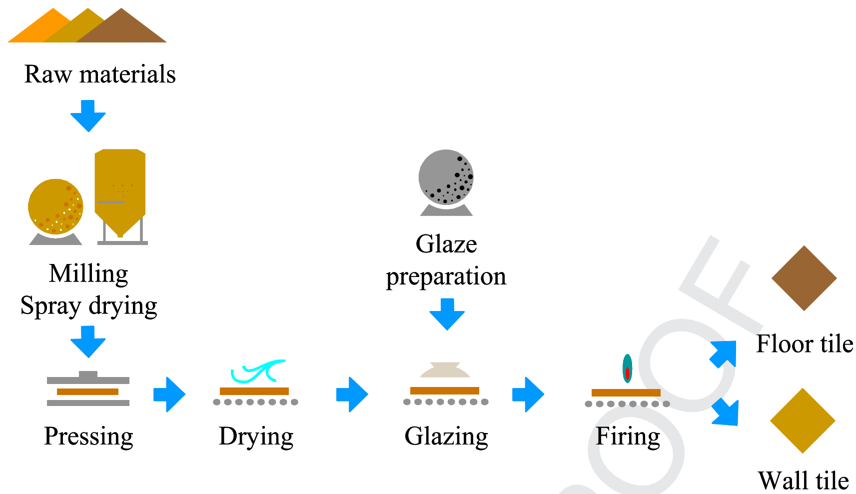

Fig. 2. Schematic illustration of the single-fired ceramic tile manufacturing process (own elaboration).

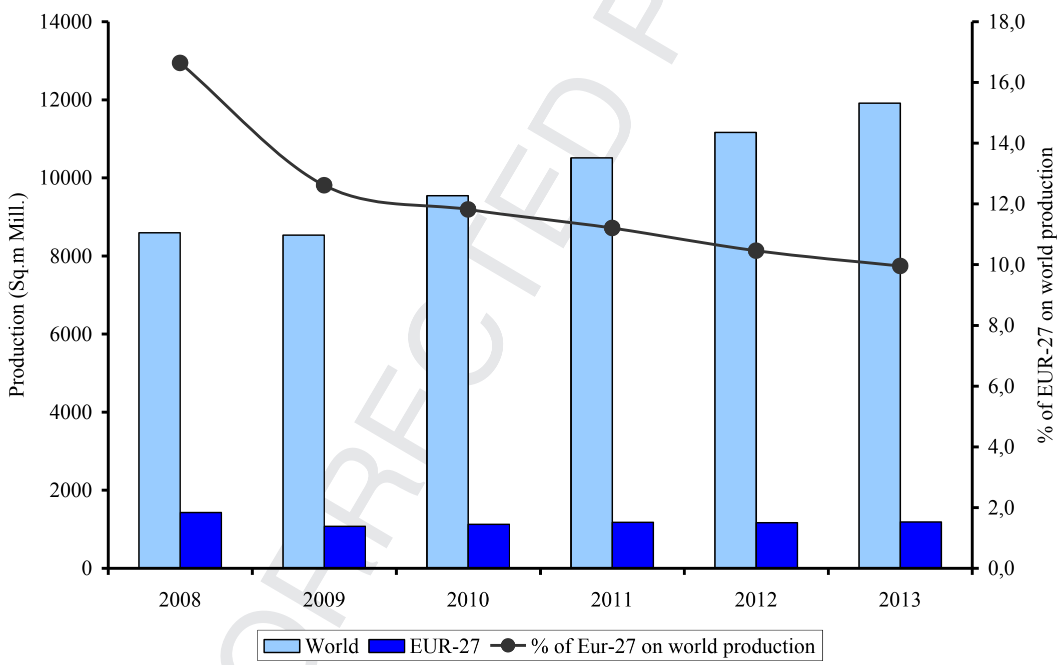

Fig. 3. EU 27 and world tile production in the period 2008–2013.
(Based on Giacomini (2010) and Stock (2014)).

of the production chain – are by truck (small and medium distances) and ship (longer distances). The manufacturing process is an intensive thermal energy consumer (around 28 kWh/m^2) (Monfort et al., 2010a,b). Since the 1980s, European ceramic tile plants have been fuelled mainly by natural gas. In some countries, such as Spain, the majority of spray-dried powder producers have installed cogeneration units (producing heat and electric energy simultaneously), which has increased their total energy efficiency for this stage to between 85% and 90%. The use of cogeneration systems in EU ceramic tile companies is linked strongly to national energy policies, which explains the significant differences among EU countries in the degree of implementation of this highly efficient technology.

In those ceramic tile industries that rely on cogeneration units, part of the electricity produced is used in the manufacturing process, and the thermal energy from the combustion gases in the cogeneration unit is recovered for use in the spray dryer. This increases energy efficiency based on reduced primary energy consumption. In plants with no cogeneration system the heat needed for the manufacturing process is produced by fossil fuel combustion or electricity supplied by the general grid. However, it should be noted that conventional thermal power stations are typically less energy efficient overall (some 35–55% depending on the technology used) because combustion gases are released into the atmosphere with no energy recovery.

Electric energy is required also for transportation (conveyor belts, robots, etc.), presses, fans, etc. In the case of cogeneration systems, the net electricity balance is positive. According to some studies (Monfort et al., 2010a,b, 2014; Nassetti et al., 1998; Timellini and Blasco Fuentes, 1993), the majority of European ceramic tile

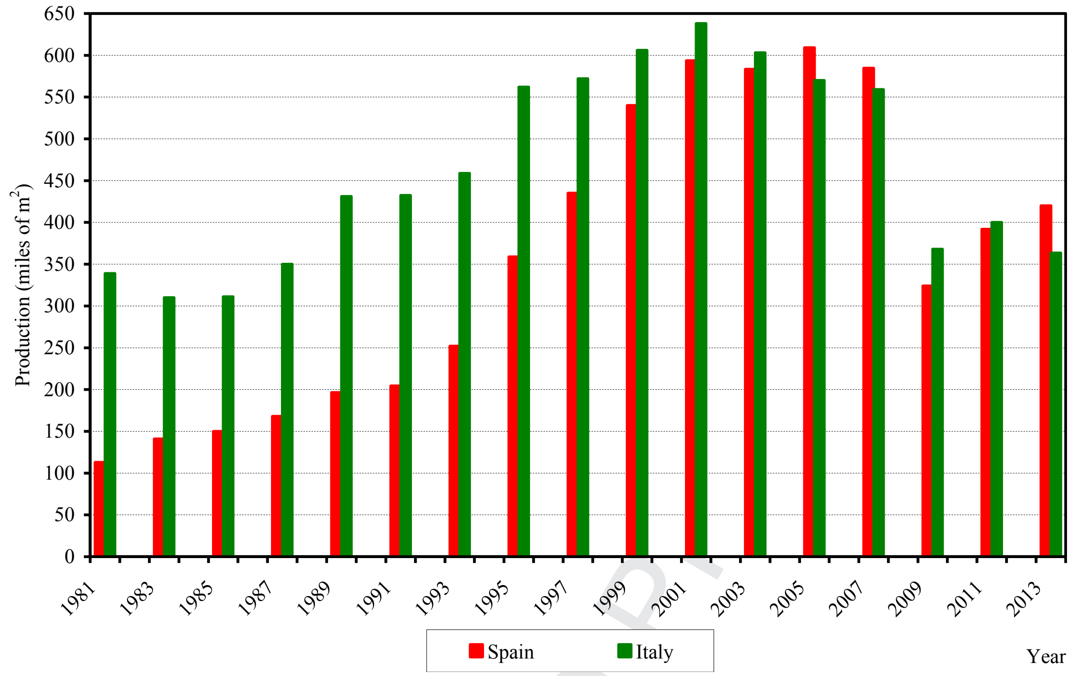

Fig. 4. Evolution of ceramic tile production in Spain and Italy in the period 1981–2013 (own elaboration from Cofindustria Ceramica, 2010; Stock, 2014).

companies use the BAT in terms of energy efficiency. Thus, although there are some additional saving measures that could be implemented, in the absence of any breakthrough developments, further significant reductions in energy consumption are not envisaged (Gabaldón-Estevan et al., 2014). The trend in energy costs, and increasing concern in the EU over CO_2 emissions may become major hurdles for European ceramic tile companies in the short term.

Fig. 5 shows the evolution of thermal energy consumption in Spanish manufacturing since 1985. Between 1985 and 1990, companies dramatically reduced their consumption of thermal energy through the adoption of new technologies (single firing, roller kilns, cogeneration systems, etc.) and use of natural gas instead of heavy oil or gasoil. Since this innovative period, consumption of thermal energy has remained fairly stable with no major changes to energy efficiency. The slight reduction observed after 2010 is likely explained by some minor improvements related to energy recovery systems, and implementation of larger kilns. Although the values shown are for Spain, they can be considered representative of the European ceramic tile industry, and are close

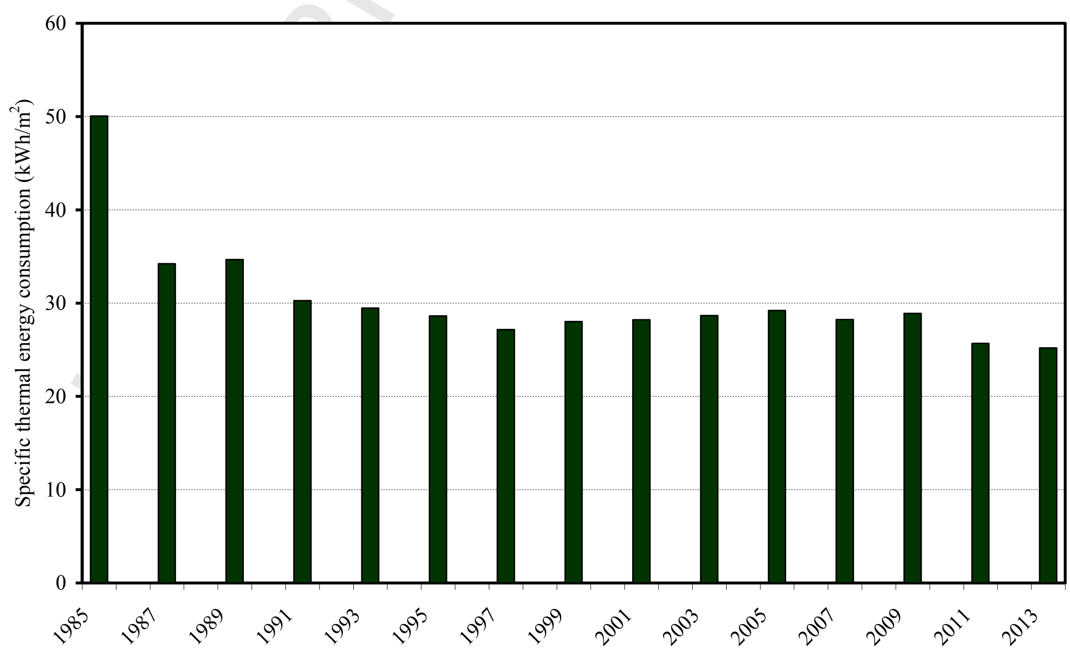

Fig. 5. Evolution of specific thermal energy consumption in the ceramic tile manufacturing process in Spain in the period 1985–2013 (Monfort et al., 2014).

to Italian data (Nassetti et al., 1998; Timellini and Blasco Fuentes, 1993).

CO_2 emissions have followed a similar trend (see Fig. 6) with most CO_2 emissions from the combustion process (90%). The remaining 10% corresponds to decomposition of the carbonates used for the body composition of earthenware (wall) tiles; hence the floor/wall tile production ratio has a minor effect on total CO_2 emissions.

Regarding electric energy consumption in the manufacturing process, the most recent studies indicate average values of around 3.2 kWh/m^2 (Monfort et al., 2010a,b), much lower than thermal energy consumption (26 kWh/m^2). Electric energy is involved in the materials handling (conveyor belts, robots, etc.) and forming (hydraulic presses) stages, the water and gas cleaning systems (pumps, fans, etc.), driers and kilns (fans, control units), etc. Nevertheless, in Spain, where cogeneration systems have been implemented in the last 20 years, the net electricity balance at cluster level is positive (Monfort et al., 2010a,b).

3.4. *EU environmental and energy policy*

This section summarizes the legislation most relevant to the ceramic tile industry, listed below along with its impacts on the industry:

- Directive 2004/8/EC of the European Parliament and of the Council of 11 February 2004, on the promotion of cogeneration based on a useful heat demand in the internal energy market;
- Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 2003/87/EC to improve and extend the GHG emissions allowance trading scheme of the Community;
- Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control);
- COM (2011a) 109 final Communication from the Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions of 8 March 2011 – Energy Efficiency Plan 2011;
- COM (2011b) 112 final. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A roadmap for moving to a competitive low carbon economy in 2050;
- Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency;
- Commission Decision of 24 December 2009 determining, pursuant to Directive 2003/87/EC of the European Parliament and of the Council, a list of sectors and subsectors which are deemed as exposed to significant risk of carbon leakage;
- COM (2014) 21 final. Communication from the commission to the European parliament, the council, the European economic and social committee and the committee of the regions. Energy prices and costs in Europe.

Among these documents, the EU's roadmap, published by the European Commission in 2011, to achieve a low-carbon economy (COM (2011b) 112 final) should be highlighted. This document specifies the emissions reduction targets set by the EU for industrial sectors, establishing a reduction in CO_2 emissions of between 83% and 87% by 2050.

3.5. *The impact of EU energy policy on the European ceramic tile sector*

For more than 30 years, the European ceramic tile industry has been working to reduce energy consumption and CO_2 emissions through the adoption of innovative technologies and the implementation of energy saving actions. However, meeting the EU 2050 targets will require another technology revolution and implementation of breakthrough technologies.

The most recent European policy, such as the ETS, is challenging European energy intensive industries. Although the ETS is considered positive for promoting research, investment and activities (energy audits, energy consumptions control, implementation of energy saving actions, etc.) focused on reducing CO_2 emissions, there are some aspects of it that require refinement to avoid unaffordable costs and consequent relocation of

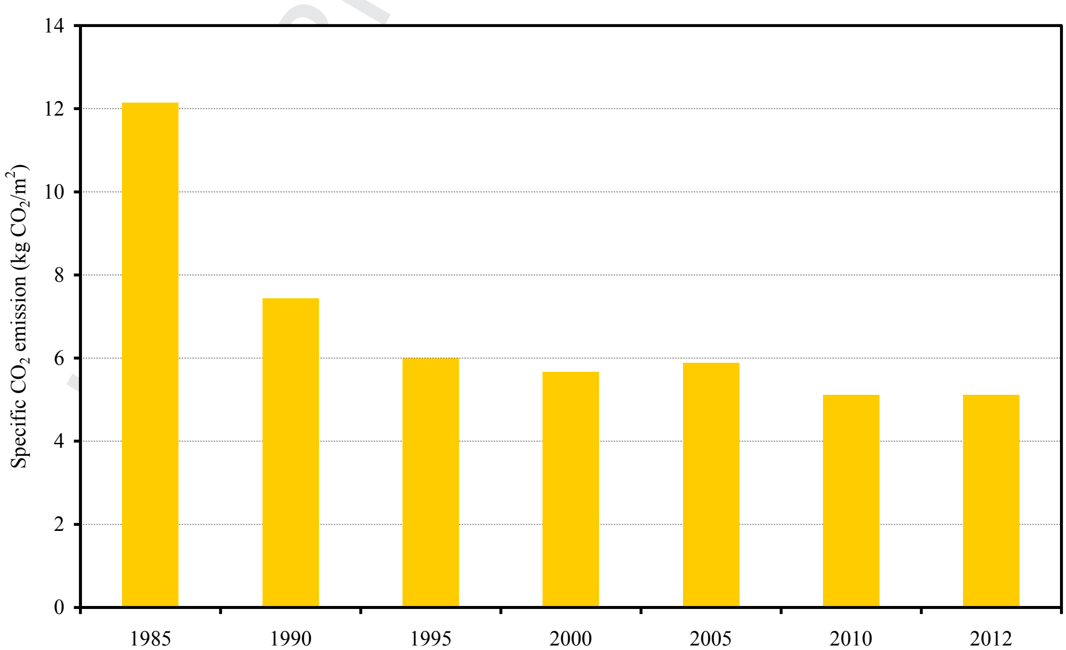

Fig. 6. Evolution of the specific CO_2 emission in Spain in the period 1985–2012 (Monfort et al., 2014).

ceramics factories to areas with less stringent environmental regulation.

Almost all European ceramic tile manufacturers are affected by the ETS (Directive 2009/29/EC). To counter the risks of relocation of manufacturing industries outside the EU for reasons of cost and climate policies, and loss of employment in Europe, the European Commission has established criteria to determine whether an industry manufacturing sector is at risk of carbon leakage, based on the economic impact of the application of the ETS on production costs and the sector's trade intensity (imports and exports) with countries outside the EU.

The European ceramic tile industry is one of the sectors at risk of carbon leakage (Commission Decision of 24 December 2009) and receives some free emissions allowances. In the new EU ETS (from 2013) the allocation of free allowances is based on the most efficient industries, rather than on historical data (former EU ETS). There is a maximum number of free allowances for each industry sector which must be shared among all the relevant companies, with the result that the best performers may not receive all the free allowances requested (Ceramic Industry Manifesto 2014–2019).

The list of countries exposed to a carbon leakage will be revised every five years. The number of free allowances is reduced annually, so the situation for ceramics companies is becoming increasingly difficult and the threat of competition from outside the EU is growing due to the direct (allowances available to buy) and indirect (management system and audits) costs of ETS implementation.

Fig. 7 shows the prices of EU Allowances (EUA) from the beginning of the new ETS period (2013–2020) and shows that the value has been growing since April 2013, from €3/t to more than €8/t in 2015.

In this new scenario, European companies are being forced to reduce their CO_2 emissions in the medium and long-term. The EU 2011 roadmap offers guidance for moving to a low-carbon economy in 2050. This document provides objectives related to reducing CO_2 emissions in all industry sectors including ceramics, with the aim of achieving a reduction of 83–87% by 2050. The European ceramic industry responded in 2012 by publishing its roadmap to 2050 (Cerame-Unie, 2012). This suggests that in the short-term, BAT should be adopted by all manufacturing countries although this will not be sufficient to achieve the ambitious European objectives, which will require the development of breakthrough technologies and new energy sources.

Based on life cycle assessment study estimates (Monfort et al., 2013, 2014), to achieve a more than 50% reduction in CO_2 emissions in the manufacturing process will require low-carbon and cheaper electricity production systems to allow the use of electric driers and kilns (resistances, microwaves, plasma, etc.) with minimum CO_2 emissions. Alternative fuels, such as biomass or biogas, would decrease emissions, but less significantly. In addition to CO_2 emissions reduction costs linked to EU policies, energy prices need to be considered. Energy costs are estimated to be two to four times higher in Europe than in competing countries. Since energy costs represents around 30% of manufacturing costs in the ceramic tile sector, policies affecting energy costs are a crucial factor in the survival of the European industry (Ceramic Industry Manifesto, 2014–2019).

Table 1 presents average natural gas and electricity prices related to the European ceramic tile industry; in 2010–2012, they increased by 27% for natural gas, and 21% for electricity.

Breakthrough innovations and renewable sources of energy are linked to institutional and financial support for research. Therefore, EU research policies play a central role in the future of energy-intensive industries. Since the mid-1980s, European companies have been world innovators in machinery and materials for the ceramic sector. However, it is becoming more difficult to benefit from European and domestic research programmes because they tend to favour research in advanced materials and leading sectors (biomedicine, pharmacy, etc.), and there is a shortage of funding for the traditional sectors (Gabaldón-Estevan et al., 2014; Tello and Weerdmeester, 2013).

[2] http://www.sendeco2.com/, retrieved 18 September, 2015.

4. Conclusions

The European ceramic tile industry has adopted innovative technologies and implemented energy saving actions to reduce its energy consumption and CO_2 emissions, and is using the BAT. However, new regulation and environmental policies are requiring more innovation and are resulting in the relocation of ceramics factories outside the EU, to areas with less strict environmental policies.

The new ETS Directive has had an impact on almost all European ceramic tile manufacturers. Its overall effect should be to promote research, investment and other activities directed to reducing CO_2 emissions. However, it does not provide a fair mid-term solution for companies that have continuously updated their industrial facilities. The free allowances received by the sector, which is exposed to the risk of carbon leakage, are based on the most efficient industries rather than on historical data. Also, the number of allowances is not sufficient for all the companies in the sector and even the best energy performers may not receive the full number requested. The scheme is to be revised every five years, and the number of free allowances is reduced annually, meaning the situation for ceramics companies will worsen, as will their competitiveness with manufacturers outside the EU due to the direct costs (buying allowances) and the indirect costs (management system and audits) of implementing the ETS.

To survive this new scenario, which includes reducing CO_2 emissions by between 83% and 87% by 2050, European companies must begin reducing their CO_2 emissions in the medium term. However, this will need another technological revolution. For instance, to reduce CO_2 emissions by more than 50%, will require decarbonization and cheaper electricity production in Europe to allow the use of electric driers and kilns with minimum CO_2 emissions. Use of biomass or biogas as fuels will not produce sufficient emissions reductions to meet the 2050 target.

Another pressure on the competitiveness of energy-intensive industries is the price of energy which is affected indirectly by EU policies. Energy costs, which represent around a third of ceramic tile manufacturing costs, are two to four times higher in the EU than in competing countries; therefore, policies affecting energy costs will be crucial for the survival of the European industry.

Finally, as the systems perspective predicts, the implementation of breakthrough technologies, including the use of renewable sources of energy, is linked to institutional and financial support for research activities. EU research policies will play a central role in the future of energy-intensive industries. Many European and domestic research programmes are focused on advanced materials and new sectors (biomedicine, pharmacy, etc.), resulting in an increasing shortage of funds to support the so-called traditional sectors. Only a more comprehensive research financing scheme that includes research support for these traditional sectors – described by Jacobsson et al. (2009) as the innovation/industrialization challenge – will help ceramic tile and other European industry sectors to continue to lead the transition to a low-carbon economy.

To summarize, the question of the unwanted effects of environmental and energy policy on European industry is becoming

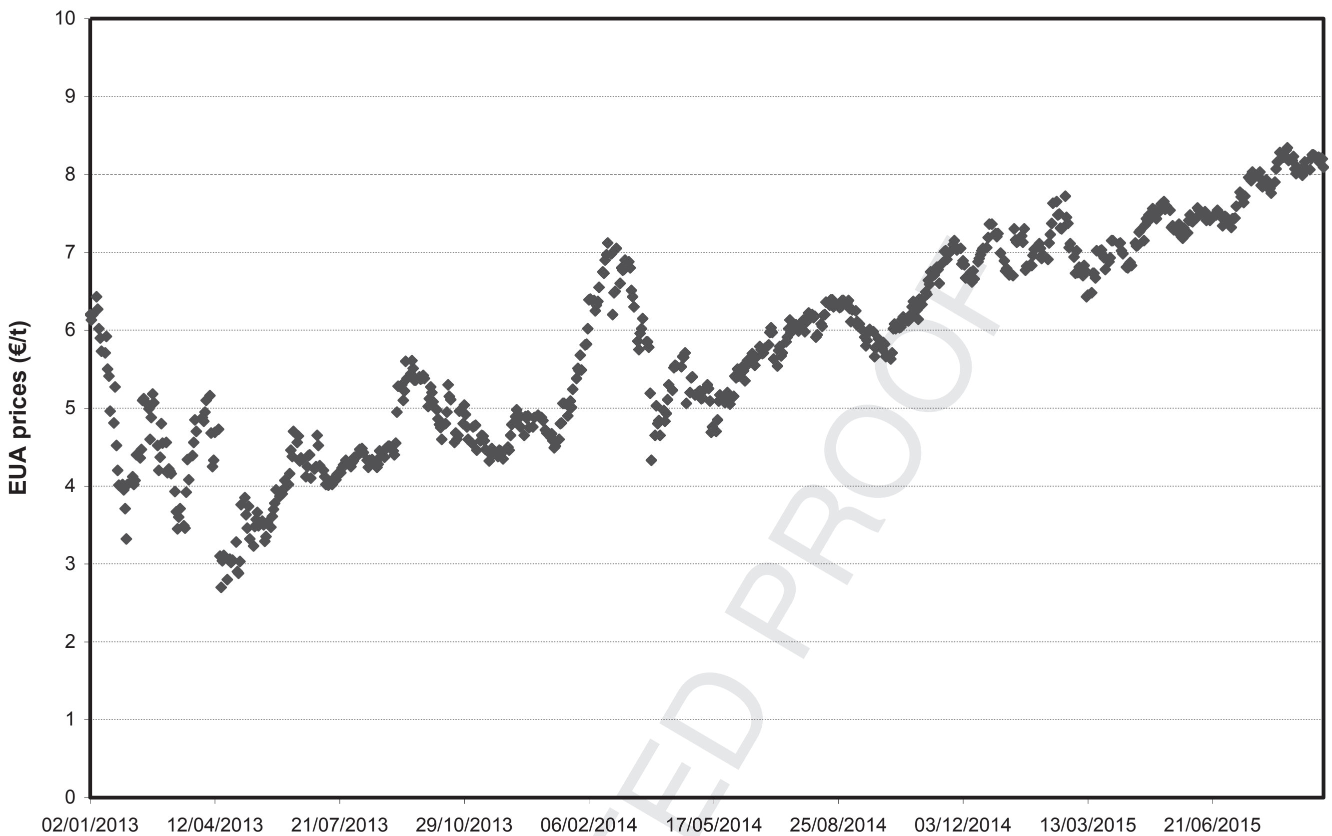

Fig. 7. Evolution of the EUA prices[2] in the period January 2013 to September 2015.

Table 1
Average energy prices for the European ceramic tile industry in the period 2010–2012 (COM (2014) 21 Final).

Energy source	2010	2011	2012	% Change 2010–2012
Natural gas price (€/MWh)	25.0	26.2	31.7	26.8
Electricity price (€/MWh)	80.8	88.8	97.6	20.8

especially important in the struggle to achieve a post-carbon Europe. This paper has focused on a specific set of EU legislation related to one particular industry and shows how policy mechanisms can operate to produce negative effects. This study highlights the need for a scientific evaluation of the systemic changes required for a transition to a resource-efficient, green and competitive low-carbon economy described in the 7th Environment Action Programme. By studying the effect of EU policy on the ceramic tile industry this work highlights the challenges faced by the ceramic tile industry regarding energy consumption and CO_2 emissions. Replication of our analysis for other industries would provide a clearer picture, and contribute to the assessment of public-sector interventions. Overall, it is concluded that the EU should periodically re-evaluate its legislation concerning the ETS Directive in order to refine/include specific actions, and implement a follow up system to prevent the unwanted effects of environmental and energy policy such as relocation or shutting down of the companies with the best environmental performance.

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