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Communication

Assessment of the impact of the European CO_2 emissions trading scheme on the Portuguese chemical industry

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ABSTRACT

This paper describes an assessment of the impact of the enforcement of the European carbon dioxide (CO_2) emissions trading scheme on the Portuguese chemical industry, based on cost structure, CO_2 emissions, electricity consumption and allocated allowances data from a survey to four Portuguese representative units of the chemical industry sector, and considering scenarios that allow the estimation of increases on both direct and indirect production costs. These estimated cost increases were also compared with similar data from other European Industries, found in the references and with conclusions from simulation studies. Thus, it was possible to ascertain the impact of buying extra CO_2 emission permits, which could be considered as limited. It was also found that this impact is somewhat lower than the impacts for other industrial sectors.

1. Introduction

Climate change can be attributed to the greenhouse gas (GHG) effect, which is mainly due to the atmospheric gaseous emissions derived from human economic activities. Kyoto Protocol was signed in 1997, which originally aimed to attain, by 2012, a global emissions reduction of the six main GHG[1] of, at least, 5% less than the observed levels in 1990. As a result of the signature of the Kyoto Protocol, the European Union (EU) issued a global reduction aim of 8% of GHG levels, and Portugal, as a member of the EU, agreed to limit the increase of its atmospheric emissions to 27% regarding the 1990 levels. The EU abatement compromise was formalised in 2002 through the 2002/358/CE Directive, and later on, in 2003, by the European Directive 2003/87/EC, which created the European Union Trading Scheme (EU-ETS). The main objective of 2002/358/CE Directive was the promotion of emissions abatement measures having good cost-benefit ratio and also being economically efficient. In the first stage, only CO_2 and only some industrial sectors were considered. A future revision will probably include other GHG apart from CO_2, and will include other relevant sectors such as transportation, aluminium industry and chemical industry as well. European Directive 2003/87/EC requires that every member state has to establish a National Allocation Plan of emission allowances: (in the Portuguese case, Portuguese National Allocation Plan (PNALE)) which indicates, for each industrial sector, the maximum permitted emission amounts during the duration of the plan and even specifies penalties in case of non-compliance.

Competitiveness is a concept that may be defined in several ways. One way to measure an industry's competitiveness is through its production costs. In what way can GHG emission restrictions lead to competitiveness loss? What kind of impacts may be expectable if production costs increase due to the necessity of emission allowance purchase? Chemical industry is a global competing industry responsible for emission of several GHG, namely CO_2, which can result from industrial processes or power generation. Therefore, any emission allowance purchase would have an associated cost to be included in the production costs: a high CO_2 intensity and also a high production represent a higher number of emission permits that have to be purchased, resulting in higher production costs. Although the European Directive 2003/87/EC did not include the GHG emissions from the chemical industry, all emissions from this sector related with energy production in units having a thermal power higher than 20 MW, were included. The aim of this work is to assess the effect of emission allowances purchase on the chemical industry sector in Portugal, considering some pertinent scenarios, thus resulting in the economic impact of the cited European Directives in the Portuguese chemical industry. Also, this study comprised the need for any cost increase on

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[1] The six GHG considered in the Kyoto Protocol were carbon dioxide, methane, nitrogen oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride.

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manufactured chemicals and also assessed the eventual adoption of any technological innovation in this sector.

2. The basis for establishing the European emission trading scheme

In environmental policy there are two main types of regulation: instruments of command and control and instruments. The European emission trading scheme falls among the second category. Command and instruments are, nowadays, the dominant ones used for environmental regulation. The basic concept involved in this regulation is the specification, by the regulator, of the measures that polluting agents should adopt in order to solve the environmental problem. The regulator chooses the information needed in order to decide on the pollution control actions and notifies the polluting agents about the specific measures to be undertaken. These measures may also include penalties for non-compliance. These measures should not be mistaken with economic incentives which could also be adopted for pollution abatement. Although command and control instruments can be presented in several types, there are two distinctive features separating them from the economic instruments: the polluting agent is restricted in the choice of the means used to achieve the environmental goals and a lack of mechanisms to equalize marginal costs among all polluting agents. Economic instruments were derived from two different approaches: Pigouvian and Coase Theorem. Pigouvian approach is based on his works on the circumstances generating divergences between social and private costs (Pigou, 1920). If we consider an agent A, who is rendering a service to another agent B for which a payment is due, accidentally it also renders a service (or causes a damage) to other third agents, so that a payment from the benefited third agent, or a compensation for damages, is due, but it cannot be exactly quantified. The Coase Theorem (Coase, 1960) reflects the reciprocal nature of the problem associated with the effects of an activity of an agent on the welfare of other agents and uses the concept of property rights and its distribution. Considering two agents, A, a polluting agent and B, a pollution victim, a traditional overview of the problem tells us that A, being the problem originator should be held responsible. However, another overview, not so based on right and wrong, indicates us that agent B, the pollution victim, could be held responsible for not protecting himself against the pollution created by agent A. This means that, if B was not considered, the pollution generated by agent A would not be a problem. Coase Theorem reflects on the legitimacy of attributing property rights to one or the other agent. Coase concludes that, in the same conditions, to achieve an optimum level of global efficiency, there is no difference between being the polluter the owner of the property right to pollute or being the victim the owner of the right of not suffering the consequences of the pollution. It should be noted, however, that there is a considerable difference of having those property rights or not. As the right to pollute is a property right having a specific value, if the trading of that right is allowed, the objective of maintaining an optimum efficiency level should be attained independently of the agent who initially obtained the property rights.

The concept of emission trading scheme was popularized by Dales (1968) and later on formalized by Montgomery (1972), based on the Coase Theorem. It is based on the idea of creating a property rights system, or allowances, who grants, to who owns them, the right to emit a unit of a certain pollutant. These allowances may be considered as production inputs, such as any other raw materials or even energy, therefore having a market price and being traded as any other commodity. As the number of allowances is limited, implicitly or explicitly, its value is defined as a result of its availability. Montgomery (1972) showed that an emission trading scheme is liable to achieve the objective of attaining the required emissions reduction as it allows polluters a certain flexibility of options in choosing the best way to achieve this goal. Marginal costs, that is, costs related with the necessity to purchase additional allowances, have a tendency to equalize, which is a relevant issue for both the regulator, when deciding which environmental policy should be followed, especially and to the several operators active in the market, using different technologies and different capabilities, creating an "equal playing field", levelling-up cost factors and avoiding competition distortions. This is particularly important for energy intensive energy industries, such as the chemical industry.

3. The Portuguese National Allocation Plan and the emissions from the chemical industrial sector

Within the scope of the European Directive 2003/87/EC, the PNALE established an emissions cap for Portugal, which was then distributed among involved sectors, thus defining the maximum emission volume during the period for its application. The payment due for exceeding the emissions limit does not discharge the operator from the obligation to return a number of permits equivalent to the exceeded emission permits in the following year. The annual distribution of permits per sector for the first period (PNALE I) and for the second period (PNALE II) was done as presented in Table 1.

From PNALE I to PNALE II the net volume of emissions diminished. However, there was an increase of the emission allowances allocated to the combustion unit sector, which was mainly due to a redefinition of the combustion unit concept: PNALE I comprised all combustion units with a thermal power higher than 20 MW which supplied any energy product with utilization inside the plant or even outside (IA, 2004). For the period 2008–2012, the definition comprises some more units, namely the ones from the chemical industry sub-sector. This includes not only the units referred in PNALE I but also other emission sources such as carbon black producing units, steam-crackers and furnaces used in rockwool plants. However, for these plants, process emissions were excluded and only emissions

Table 1
Annual distribution of emission permits per sector according to PNALE I and PNALE II (Unit: tCO_2/year).

Sector	PNALE I	PNALE II	Diference (%)Difference (%)
Power plants	20,969,238	16,476,305	−21.4
Oil refineries	3,265,877	3,123,107	−4.4
Cogeneration plants	2,480,025	2,628,844	6.0
Combustion units	535,445	1.489,104	178.1
Ferrous metallurgy	308,784	336,376	8.9
Cement	7,135,493	7,044,795	−1.3
Glass making	681,153	701,586	3.0
Pulp and paper	362,841	361,848	−0.3
Ceramics	1,189,995	588,637	−50.5
Total	36,928,851	32,750,602	−11.3

Table 2
Weight of the chemical industry sub-sector within the cogeneration and combustion sectors for PNALE I and PNALE II (Unit: tCO_2/year).

Sector	Sub-sector	PNALE I	%Percent	PNALE II	%Percent
Cogeneration	Chemical	873,247	35	945,713	36
Combustion units	Chemical	225,061	42	1,173,762	79

derived from energy-producing units are included (IA, 2006). PNALE II considers an emissions increase for several facilities and also a provision for new investments. The weight of the chemical industry sub-sector, within the combustion units, increases from 42% in PNALE I to 79% in PNALE II, as shown in Table 2. The cogeneration sector weight becomes slightly stable.

4. The European chemical industry and the European Directive 2003/87/EC

It was feared, from some European industrial sectors, that the enforcement of the European Directive 2003/87/EC would result in a loss of competitiveness in the international market. The energy consumption is a major cost factor within the European chemical industry, accounting for 130 Mtep, which represents 3% of the world energy consumption and about 12% of the European Union (Botschek, 2006). The European chemical industry has increased its energy efficiency, thus reducing the energy consumption per production unit: in 2004 the energy consumption per production unit was 39% lower when compared to 1990. However, energy efficiency is somewhat limited, the higher the energy efficiency level, the more difficult to achieve additional reductions. In spite of that, since 1990, the production levels have been increasing continuously, while the energy consumption was kept constant, thus resulting in a significant decrease of the energetic intensity, as can be seen in Fig. 1.

From 1990 to 2004, the production of the European chemical industry increased 56%, whereas its energy consumption was kept stable and the GHG emissions decreased 20%. Therefore, the GHG emissions per unit of used energy were reduced at about 25%, and the GHG per produced unit was reduced at about 50% since 1990, as shown in Figs. 2 and 3.

In comparison, for example, with the US chemical industry, the European chemical industry obtained higher reductions on the intensity of GHG emissions per produced unit and is, therefore, more efficient nowadays. The US chemical industry reduced its emissions by 30% while the European industry reduced the same emissions by 50%, which can be seen in Fig. 4.

On its position on the European emission trading scheme, CEFIC (the European Chemical Industry Council), notes that the European chemical industry has been increasing continuously its energy efficiency and that emissions reduction should be made on a national voluntary basis. Also the emission reduction objectives should not be absolute, but, relative based on energy efficiency or on intensity of GHG emissions. The European chemical industry is

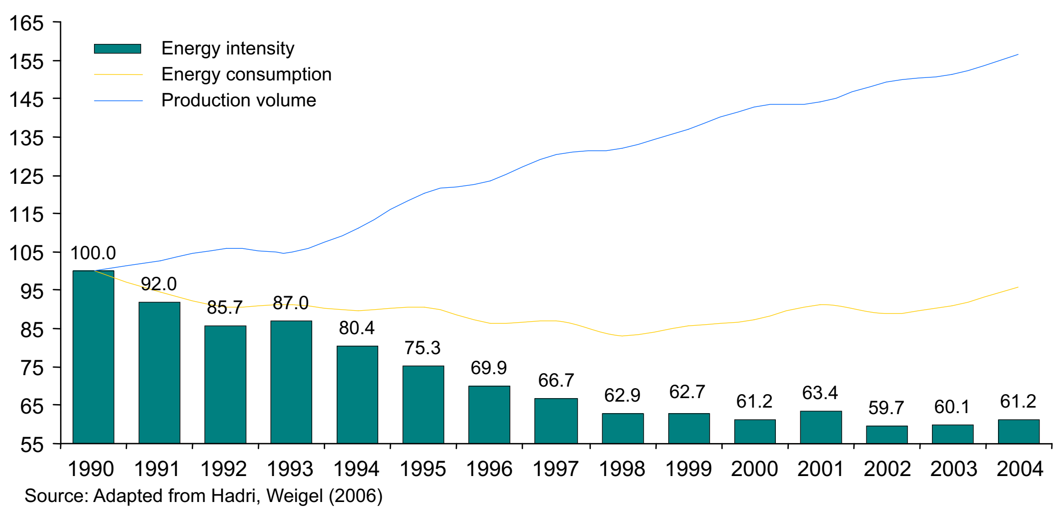

Fig. 1. Evolution of the energy intensity of the European chemical industry. (Hadri and Weigel, 2006).

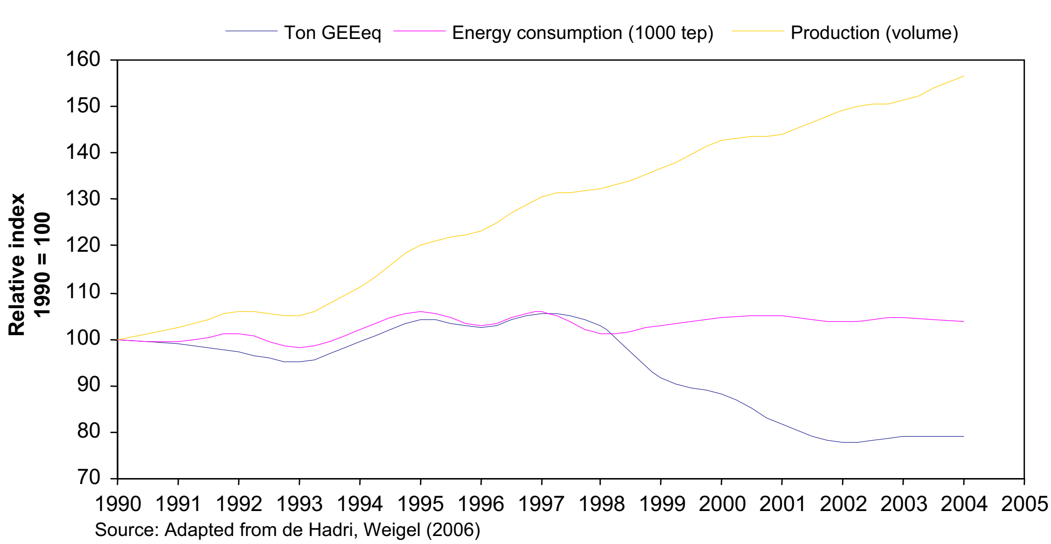

Fig. 2. Evolution of GHG emissions, energy consumption and production volume of the European chemical industry.

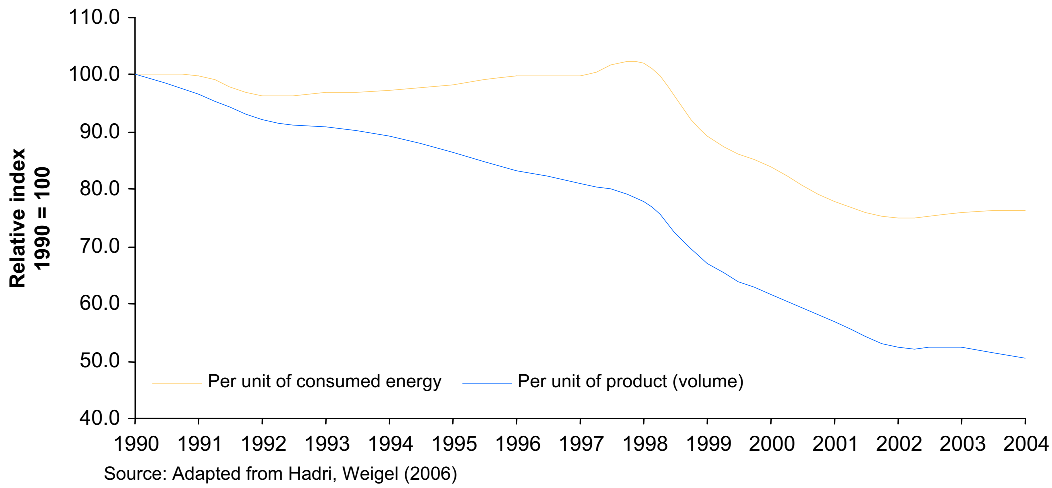

Fig. 3. Evolution of GHG emissions of the European chemical industry, per unit of produced energy and per volume of produced unit energy.

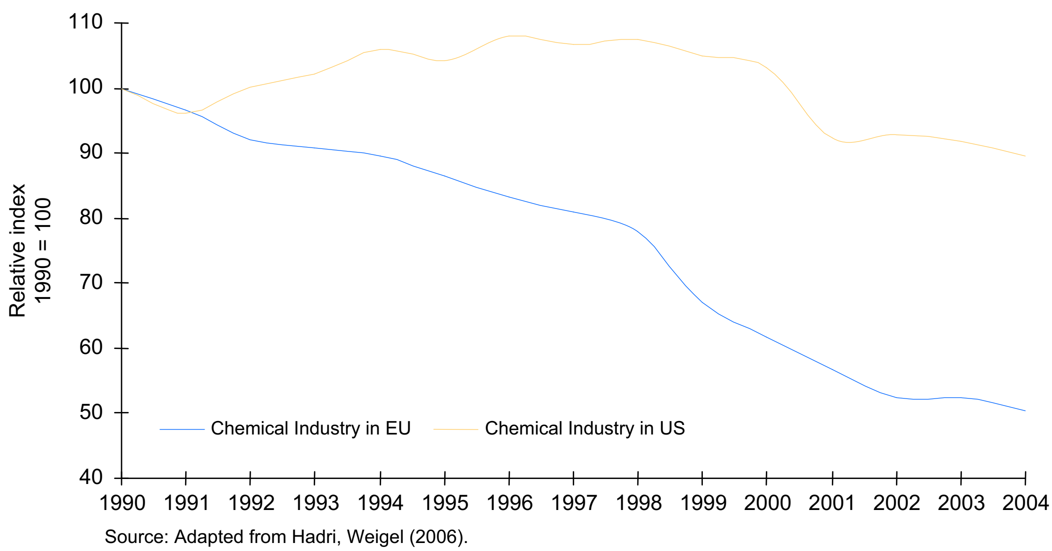

Fig. 4. Comparison between the GHG emissions intensity of the European and the US chemical industry per volume of production unit.

a global industry competing globally, where its competitiveness greatly relies on the energy costs, being an energy intensive industry (Ribeiro and Nunes, 2001). Thus, any measure resulting on an increase of energy costs, compared with the energy costs of other economic regions, like South and North America, Russia or Asia, will constitute a menace to its competitiveness. Exposure to the international competition, together with energy dependence, makes this sector particularly vulnerable to the regulations derived from Kyoto Protocol. Therefore, for companies operating at a global level, global initiatives such as the EU-ETS should lead to global solutions and also to reduce the uncertainty leading to any delay in the execution of new projects in the EU instead of encouraging production outside this economic block.

5. Methodology for this study

The potential impact of PNALE on the Portuguese chemical industry were assessed estimating unit cost increases on four significant Portuguese chemical companies with both combustion and cogeneration units, for several scenarios, according to the methodology by Reinaud (2005). Within this approach, direct costs are defined as the sum of the costs of emissions abatement plus the cost of purchase of emission allowances. These direct costs are related only to the marginal production, that is, the production volume with associated emissions not included by the number of allowances allocated by PNALE. These costs are dependent of the CO_2 intensity per produced unit and will be as much lower as the energy efficiency is higher. Indirect costs are related with electricity costs, which are costs derived from the power sector. Total costs are, thus, the sum of direct plus indirect costs. The tested scenarios considered the acquisition of 5%, 10%, 15% and 20% of total permits in the market, at prices of 5, 10, 15, 30 and 50 €/tCO_2. It should be noted, as a reference, that 40 and 100 €/tCO_2 are, respectively, the penalty to be paid for non-compliance, during PNALE I and PNALE II.

6. Estimation of EU-ETS impacts on the Portuguese chemical industry

The direct impacts of EU-ETS on the production costs of a company are related with any measure taken to reduce emissions or costs of purchasing emission allowances apart from those

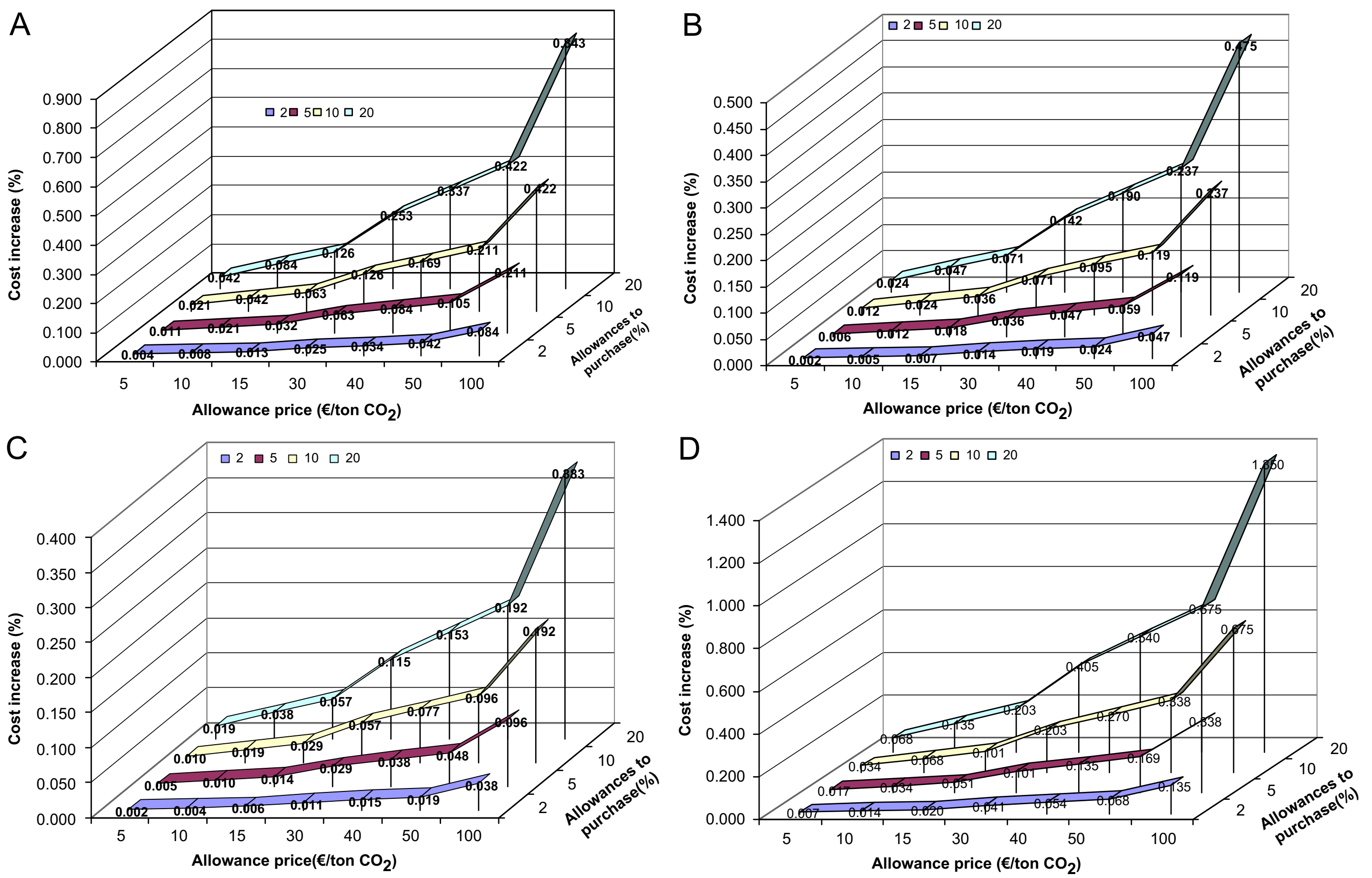

Fig. 5. Previewed increases on production costs for companies A, B, C and D.

Table 3
Increase of electricity costs on the EC.

Cost of emission permits (€/t CO_2)	0	5	10	15	30	50
Increase on electricity price (%)	0	5	11	16	32	53
Electricity price (€/MWh)	47.12	49.62	52.63	54.63	64.14	72.16

Source: Reinaud (2005).

initially allocated. The cost of emission abatement is, at the most, equal to the purchase cost of emission allowances. Therefore, an economic instrument such as this, allows that emission abatements are made until it is more advantageous to purchase emission allowances in the market instead of undertaking further additional reduction measures. This is one feature that is one of the main advantages of EU-ETS over control and command instruments, and that makes it more attractive in terms of achieving compliance for energy intensive industries such as the chemical industry. Thus, CO_2 intensity on the production will have a direct impact that shows mainly on the marginal production, that will be diminishing for total production as much as the number of emission permits freely emitted by the regulator increases. Fig. 5 shows the previewed increases on production costs for the four considered Portuguese enterprises as a consequence of adopting the previously mentioned scenarios.

The increase of electricity price is a consequence of the inclusion of the power generating industries in EU-ETS, according to the European Directive 2003/87/EC, which will transfer these costs to the consumers. Considering the same scenarios, the increases in electricity prices are shown in Table 3. Table 4 shows the total resulting costs, as the sum of indirect plus direct costs, and also a comparison with typical units from other industrial sectors on the EC. (Fig. 6)

7. Discussion of results

When compared with units from the steel making, cement and pulp and paper sectors, the studied companies show lower increases on total costs per ton of manufactured product than the other industrial sectors. Those are only of the same order of magnitude for the steel making industry by the EAF process, which is, from these industries, the less intensive in terms of CO_2 emissions. However, for these industries, comprise CO_2 process emissions while for the studied chemical industries only include CO_2 emissions derived from the power generation activity.

Based on these data, it can be said that EU-ETS has only a limited impact. With PNALE, operators only have to face costs if they have to purchase emission allowances in the market to cover for excedentary emissions, not yet previewed. This is also confirmed by the evolution of the price of emission permits on the spot market, which has been decreasing since EU-ETS has come into force, from 21.11 €/CO_2 in December 2005 to 0.07 €/tCO_2 in November 2007.

8. Conclusions

The performed simulation studies for other industrial sectors found in the literature (Oberndorfer et al., 2006) show that, assuming the compliance with the obligations derived from the Kyoto Protocol, EU-ETS appears to be the most cost-effective option. Also, it was shown that its impact on competitiveness is quite limited, which means that any competitiveness loss caused will be lower than any other caused by alternative regulation measures. EU-ETS could even have positive impacts on competitiveness (Oberndorfer et al., 2006). However, EU-ETS' main objective is not the stimulation of economic growth, but the reduction of CO_2 emissions at an acceptable cost in accordance with the Kyoto Protocol emission allowances, as they are allocated on a free basis, grandfathering, at the start-up of the programme will only be a cost if non-compliance exists. Only in this case, they will have effects on the competitiveness. Therefore, competitiveness losses are not a consequence of EU-ETS enforcement, but could result from restrictions posed by EU to GHG emissions within the scope of the Kyoto Protocol. It is now previewed that sectors included in EU-ETS will be more affected, in terms of competitiveness, than other sectors which are not included (Klepper and Peterson, 2004). In what concerns innovation, it is not yet clear that market mechanisms will result in stronger innovation levels than other environmental policy mechanisms. As a matter of fact, the fact that, at an early stage, allowances grandfathering cannot act as a stimulus for innovation. Energy utilization efficiency seems to be more important in industrial environments, due to economic reasons, but also due to the growing awareness regarding resource utilization and environmental conservation. In what concerns the Portuguese chemical industry, data were collected during this work (Tomás, 2008), showing that technological innovation, as a means to increase not only the energy efficiency of production processes, but also is a way to meet the need to reduce CO_2 emissions. The motivations behind of these innovations can be easily questionable if they are either economical or environmental. But, nevertheless, this finding reflects one of the key important aspects of a property rights trading scheme such as the EU-ETS, i.e., flexibility in choosing a mean to emission abatement, as postulated by Montgomery (1972). Of course, that these findings in the case of the Portuguese chemical industry could be easily inverted if the main motivation is environmental and emission allowance purchase costs become significantly lower that any abatement measure based on technological innovation. Any restrictions, in what concerns emissions, are also considered in the strategic evaluation of new investments. The cost increases observed for the tested scenarios were found to be, concerning the Portuguese chemical industry, non-relevant, when compared with companies belonging to other EU industrial sectors. It should be mentioned that the tested scenarios can be regarded as limit situations, both in terms of marginal production as in terms of total production, because PNALE allocated freely the total amount of emission allowances to the concerned industrial operators for the time being. Data from other EU countries' chemical industries, at the time this study was performed, was not readily and easily available, mostly due to the great diversity of chemical processes that existed within this industry. However, other countries' NAP would be dependent on how the country's emission cap is defined within the scope of the Kyoto Protocol. Therefore, for each country, the national chemical industry emission cap is in turn dependant on both the allowances volume allocated to that sector and how the allocation is made (total or partial grandfathering).

Table 4
Increase (%) over total marginal production costs for companies A, B, C and D and also for typical units from steel making (BOF and EAF processes), cement, pulp and paper.

	Cost increases (%)	Price of emission permits (€/t)			
		5	10	15	30
Company A	Indirect	0.09	0.20	0.29	0.59
	Direct	0.22	0.43	0.65	1.29
	Total	0.31	0.63	0.94	1.88
Company B	Indirect	0.07	0.16	0.24	0.48
	Direct	0.12	0.24	0.36	0.71
	Total	0.19	0.40	0.60	1.19
Company C	Indirect	0.38	0.83	1.21	2.42
	Direct	0.14	0.29	0.43	0.86
	Total	0.52	1.12	1.64	3.28
Company D	Indirect	0.39	0.86	1.25	2.49
	Direct	0.34	0.68	1.01	2.03
	Total	0.73	1.53	2.26	4.52
Steel (BOF[a])	Indirect	0.2	0.5	0.7	1.5
	Direct	4	7	11	22
	Total	4.2	7.5	11.7	23.5
Steel (EAF[b])	Indirect	0.4	0.8	1.3	2.5
	Direct	0	1	1	2
	Total	0.4	1.8	2.3	4.5
Cement	Indirect	0.7	1.5	2.2	4.5
	Direct	9	17	26	51
	Total	9.7	18.5	28.2	55.5
Pulp and paper	Indirect	0.5	1.1	1.6	3.3
	Direct	1	3	4	8
	Total	1.5	4.1	5.6	11.3

Source: Reinaud (2005), and data from companies A, B, C and D.

[a] BOF-Basic Oxygen Furnace.
[b] EAF-Electric Arc Furnace.

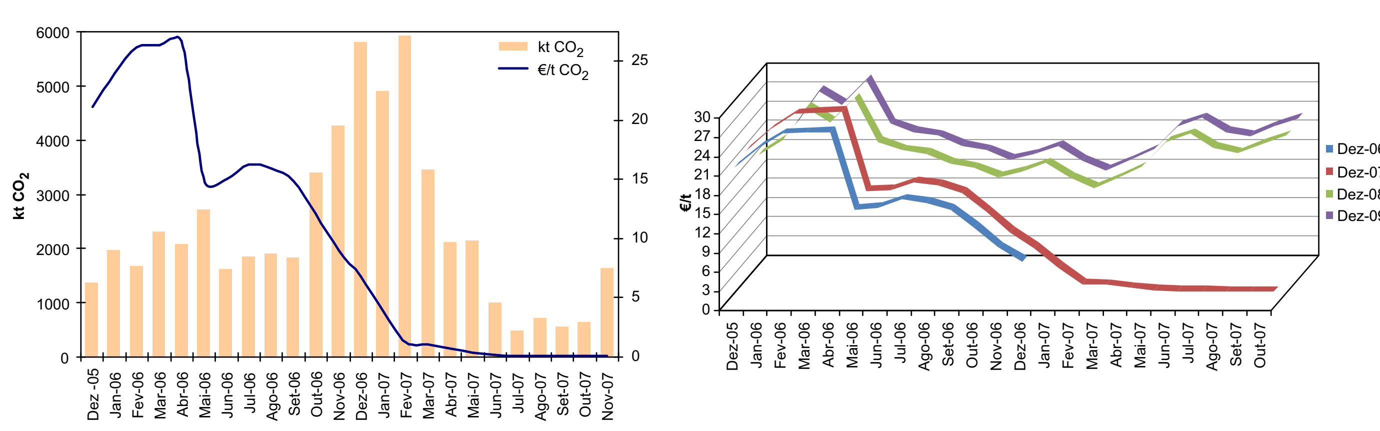

Fig. 6. Price evolution of permits on the spot market and evolution on the volume of permits from December 2005 to December 2007. (Powernext, 2007a,b).

If the compliance tendency is observed, the Portuguese chemical industry will not experience significant impacts as long as its emissions are comprised within PNALE. In case of non-compliance, and bearing in mind, the expected price evolution on the market of emission permits, the cost of allowance purchase will not result also in significant impacts as its price was (by the end of 2007) lower than 1 €/tCO_2, and this value is considerably lower than the one used here for the tested scenarios. Future markets have also shown a favourable evolution which is expected that they will not result in significant increased production costs for the period 2008–2012.

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