

The role of environmental policies in the eco-innovation process: evidences from the European Union Emission Trading Scheme

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Abstract

This paper discusses the innovative potential and outcomes of a specific policy instrument, the European Union Emission trading Scheme (EU ETS). EU ETS is the cornerstone of the European climate policy and it was introduced in 2005 with Directive 2003/87. It can be considered the biggest example of an emissions permit scheme compared to previous experiences.

The focus is set on the design of the scheme and on cap-stringency. EU ETS design aspects have been scrutinized with respect to their influence on the development and introduction of low-carbon technologies following the indications of the theory on tradable permits and the lessons learnt from past experiences. A micro-level analysis of the innovative and non-innovative response to the EU ETS is realized through a case study concerning the Italian paper industry, which is one of the energy-intensive sectors included in EU ETS. The Italian paper industry has been chosen as sample to analyse the effects of the application of EU ETS and to identify the patterns of the compliance strategies adopted by operators.

The analysis of the general performance of the scheme and of the response strategies adopted in the paper industry provides a comprehensive picture of EU ETS potentials for the development and diffusion of environmental innovations in the field of low-carbon technologies and on the factors influencing this process during Phase I.

Keywords: Emission trading, EU ETS, eco-innovation, paper industry

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1. The relationship between emissions trading schemes and innovation: an overview of theory and empirical evidences

The topic of the linking between environmental policies and innovation has been extensively discussed in theory and it has been the object of several empirical efforts. The relevance of this topic increases with the emergence of global environmental problems that require a technological answer and with the development of progressively more demanding and ambitious regulations, especially in the field of climate-energy. Technology advancements are considered a key factor necessary for the attainment of the ambitious target set at European level imposing the reduction of 20% of carbon emissions by 2020.

In this paper it is adopted a broad definition of innovation in low-carbon technological solutions, that refers to the production, assimilation or exploitation of a product, production process, service or management or business method that it is novel to the firm and which results, throughout its life cycle, in reduction in the carbon-intensity of the installation where it is introduced².

The environmental economics literature has dedicated much attention discussing the incentives for the adoption and development of environment-friendly technologies provided by different policy instruments. The debate was dominated by the opposition between command-and-control approach to regulation versus economic and market driven approach, the first being considered inferior compared to the second. The debate on that issue originated by the works of Downing and White (1986) and Milliman and Prince (1989). Further analysis in the same direction have been provided by Malueg (1989), Fisher *et al.* (2003)³.

Emissions trading⁴ pertains to the group of policy instruments classified as market-based instruments (MBIs) or economic instruments (EIs) which can be defined as regulations that encourage firm's behavior through market signals rather than through explicit directives regarding pollution control levels or methods (Stavins; 2002). Conversely, command and control (CaC) regulations set uniform standards for firms, that can be technology or performance based⁵. The idea of using transferable discharge permits to allocate the pollution control burden among sources was developed forty years ago by Dales and the first rigorous proof that such systems could become a cost-effective policy instrument was provided by Montgomery⁶.

In general, the mainstream neoclassical literature attributes to MBIs the property of static efficiency, saving information costs, the possibility of a double dividend (in case of taxes), self enforcement and of promoting innovation better than CaC instruments. The main arguments in favor of market based instruments as for their effects on innovation's decision fall into the following points (see OECD; 2005 p. 8): (a) due to the presence of an opportunity cost associated with any level of emissions, market-based instruments offer potential greater returns to innovators, (b) MBIs are less prescriptive, resulting in a greater space across which innovations can be applied, (c) incentives are continuous and are not dependent upon ratcheting of regulatory

² This definition is adapted from the one about eco-innovation elaborated by the European MEI projects. Information and reports of the MEI project are accessible at: <http://www.merit.unu.edu/MEI/>

³ For a review of this body of literature see Kemp (1997), Jaffe et al. (2000) and Kemp and Pontoglio (2008).

⁴ There are three different types of emissions trading programs: reduction credit, averaging, and cap-and-trade programs. For a complete description of these three basic types see Ellerman et al. (2003).

⁵ Technology-based standards specify the method that firms must use in order to comply with regulation, performance-based standards instead set a uniform control target to be achieved.

⁶ A consistent body of literature has followed, see contributions in Tietenberg (2001).

stringency. Emissions trading is an instrument whose core lies in the creation of a market attributing a price for a determined environmental externality. If a scheme can rely on a proper design, the market price will act as an incentive to develop or adopt innovative solutions able to reduce this externality as much as possible, even beyond the level required by law. The existence of a market for a pollutant allows the actors to internalize the cost related to the environmental negative effects of their activities and to factor carbon-reduction strategies into daily business. The price signal is spread also to suppliers and technology providers.

Despite these claims supporting emissions trading systems, recent reviews of the theoretical literature ranking environmental instruments according to their potential innovative spillovers showed mixed results (see Kemp and Pontoglio; 2008, Vollebergh; 2007, Taylor; 2007, Requate, 2005). To this purpose Requate (2005) states that “there is little we know empirically to which extent market based instruments perform”, firstly because “there is hardly any chance to make experiments and empirical comparison of instrument under similar condition, secondly, several countries regulate the same externality by several instruments”. Criticism about emissions trading emerged also in the analysis realized by Driesen (2003). Driesen asserts that the supposed superiority of emission trading schemes presented by the traditional literature in environmental economics is biased because the overall analysis is concentrated only on the group of emitters, “who have an incentive to make extra reductions [...] so that they can sell credits” and make profit from that, thus realizing extra reductions if compared to an equivalent policy based on traditional regulation”. But in Driesen’s view this point leaves half of the actors (the ones who comply to the existing regulation by buying permits on the market) out of the picture, thus suffering from relativism.

In addition, ex-post empirical analysis on the effects of environmental policy instruments on innovation revealed that the nature of the instrument (market-based or cap-and-control) is just one of the features of the policy setting describing an environmental policy, the other main identifying issues are: stringency, timing, enforcement, combination of instruments and other design issues (Kemp and Pontoglio; 2008).

As for the applications of emission trading schemes, they are mostly confined to US experiences. In Europe, before EU ETS coming into force, national emissions trading schemes have been implemented in the UK and in Denmark to regulate carbon emission in the power generation sector, but to the knowledge of the author these experiences haven’t been subjected to an ex-post evaluation of their impact on innovation. To these experiments we should add intra-firm schemes implemented by BP and Shell in the ‘90s.

Taylor (2007) realized a systematic analysis of the main US cap-and-trade systems in the field of air pollution based on previous and more in-depth analysis of the same author. The policies analyzed were (a) the national SO₂ trading scheme introduced with the Clean Air Act Amendments of 1990, also called “Title IV”; (b) the NO_x Budget Trading Program (NBP), a seasonal and regional scheme for NO_x emissions implemented in 1999 and (c) RECLAIM, the Regional Clean Air Incentives Market in force from 1994 in south California for NO_x and SO₂ emissions. Taylor demonstrated that under Title IV and NBP the main innovations realized by emission sources consisted in the adoption of end-of-pipe solutions (primarily post-combustion devices) or in fuel-switching. As for RECLAIM, due to an initial over-allocation of allowances it was not necessary for operators to reduce their emissions. Regulation of industrial SO₂

emissions in the US in the period from 1995 to 1990 was made using both CAC instruments and MBIs (Clean Air Act). The analysis from Taylor et al. (2005) and Taylor (2007) using patent data reveal that the Clean Air Act lead to less innovative activities compared to previous regulation, and this effect has been considered in strict connection with lower-than-expected prices of allowances. According with Taylor (2007), cap-and-trade programs face an “invention problem” since they do not provide an incentive for the development of R&D. However, this flaw could be avoided improving the instrument’s design (for instance modifying the cap at regular intervals in order to sustain scarcity on the market).

In another evaluation of US experiences focusing on their innovative spillovers realized by Gagelmann and Frondel (2005) it is pointed out that the innovation effects of the past experiences in the use of emissions trading have proved to be limited due to the presence of non constraining target (especially for the RECLAIM program) and to developments realized outside of the created emissions market.

As a conclusion of this although incomplete review, what is true is that the existing empirical literature is not sending the clear message that emissions trading experiences spurred innovation, partially because of the limited number of studies (OECD; 2005), of the limited scope of the experienced reviewed, and of the contextual deficiencies of some of the systems analyzed (*i.e.*: inadequacy of the target, external shocks). However, a lack of empirical evidence cannot simply be interpreted as a lack of evidence itself. The analysis of the technological impact of a policy instrument is a complex activity, facing problems of measurability and composite interrelation and correlation of phenomena. Some effects (or lack of expected effects) cannot directly be attributed to the choice of the policy instrument, instead could depend to its specific design. The evidence emerging from many empirical studies is that more aspects pertaining to the policy setting and going beyond the nature of the policy instrument should be investigated.

Within this context, the analysis of EU ETS during its first application Phase (2005-2007) can be considered a relevant test to understand better how tradable permits schemes perform.

2. EU ETS and innovation: an assessment of the elements influencing its innovative potential in Phase I

EU ETS is the cornerstone of the European climate policy, defined by the European Climate Change Program that sets up measures and interventions necessary to respect the Kyoto target. More ambitious and long-term reduction targets have been fixed with the “Energy-Climate package” of March 2007⁷.

The installations covered by EU ETS are approximately 10.800 (EEA; 2008) in four energy-intensive sectors: energy activities (power, heat and steam generators, oil refineries and coke ovens), the production and processing of ferrous metal (iron and steel) and minerals (cement, glass and ceramics) and pulp and paper. The initial application phases were two, the first starting on January 2005 and covering the period 2005-2007 and the second overlapping with the first Kyoto commitment period of 2008-2012. Following the “Climate-Energy package”, that set a reduction target of green-house gases emission of 20% to be reached by 2020, the Commission released a proposal that is currently under discussion extending EU ETS to subsequent 5 years phases and introducing significant modifications (European Commission; 2008).

⁷ See documents accessible at: http://ec.europa.eu/energy/energy_policy/

The discussion about the introduction of an emissions trading in Europe in order to meet the community's Kyoto target agreed under the Burden Sharing Agreement started in 2000 after the publication the Green Paper (EC; 2000). A number of studies have been carried out on the impacts of these instrument, but they mainly focused on the cost-effectiveness of the scheme and on the cost-savings comparing this instrument with an equivalent direct regulation (same target with or without trading, see NTUA; 2000). These studies were carried out using models and scenario, but they didn't consider the impacts on innovation⁸. For that reason they don't provide a guidance for our analysis, but they contribute in remarking that the cost-effectiveness of the mechanism was one of the factors contributing to the choice of this instrument and building its political feasibility.

The primary aim of this paper is to analyse what factors concerning EU ETS could influence its potential capability of creating a context favourable to the development and diffusion of low-carbon technological solutions. The exam of the theory and of ex-post analysis of past regulations revealed the importance of design issues and stringency. For this reason in the next sections we make an assessment of these elements for EU ETS Phase I.

2.1 The EU ETS design: assessing the distance from an ideal trading mechanism

As emerged in the analysis of past regulations, design issues of environmental policies can have great impact on their innovative potential. For this reason, based on the outcomes of the theory on tradable permits, we identify the design issues that, among all, exert the greatest influence on potential innovative impacts. We then compare the framework established by Directive 2003/87/EC with a theoretical trading mechanism, that incorporates all the design issues most favourable to promote innovation, in order to evaluate EU ETS distance from an ideal trading mechanism.

Before doing that, it is important to focus on a basic element defining EU ETS that cannot be considered a design issue because it mainly depends on EU institutional setting. One of the most important character of EU ETS is in fact its decentralization. Directive 2003/87/EC set a framework of general rules and criteria, but it delegates to Member States the duty to establish the details of the design that are integrated in a National Allocation Plan. NAPs had to be approved by the Commission that assessed their consistency with the common principles set in Annex III of the Directive. Besides the cap-setting process⁹, also monitoring, reporting and verification procedures fall within national competency although they are subjected to the common standards set by the Commission. This process reflects the general EU practice of leaving implementation to member states but it also depends strictly from the reluctance of Member States to cede their influence on energy-related issues and on decisions affecting industries (Egenhofer; 2007). Decentralisation results in a high national discretion in the cap-setting process and makes national authorities vulnerable to industry pressure (Egenhofer et al.; 2006).

⁸ The principal findings of these studies refer to the cost-saving realizable under the hypothesis of allowing trading among polluters and the main findings are that considering a world wide trading of allowances, the total costs of the carbon reductions were expected to be six times lower than in the "without trading" case (2 times for the EU, 3 times for the USA, 5 times for Japan and 4 times for Annex B as a whole). The reduction effort necessary to abate emissions would decrease from around 0.1% of 2010 GDP without trading to around 0.02% of 2010 GDP with full trade (see EC; 2000).

⁹ To this respect, Ellerman and Joskow (2008) observed that the decentralised nature of the cap is the main difference between EU ETS and previous US cap-and-trade experiments.

As for the *nature of the system*, tradable permit schemes can be distinguished in two main categories: baseline-and-credit and cap-and-trade schemes. In the former, operators must respect a relative threshold or benchmark of emissions, calculated for a homogeneous group of activities and on a technical basis. In the second case, operators must respect a fixed limit (cap) on their emissions. According to the theory (Tietenberg; 2001), incentives to promote innovations should be the same under these two main alternatives, provided that the two systems are equivalent. For this reason we consider this design element to be neutral with reference to innovations. EU ETS is a cap-and-trade scheme and the number of allowances allocated to every single installation is determined at national level in the National Allocation Plan.

For what concerns the *coverage* of the system, this feature describes its size and identifies the sectors or the economic activities included in the scheme. Theory suggests that the enlargement of the scheme to new sectors or actors works in favour of its static efficiency, since new opportunities to reduce carbon emissions are made available. However, we consider the effects of an enlargement of the scheme to have ambiguous effects on its potential innovative outcomes. This happens because on one hand the greatest the number of economic activities involved, the highest the amount of opportunities for an innovation to be developed or adopted. At the same time, the availability of carbon abatements at lower (higher) cost reduces (increases) the economic effort needed and the CO₂ price on the market. A reduction (increase) in carbon price is reflected in a minor (higher) economic incentive to develop or adopt a carbon-saving innovation.

A similar interpretation applies for the presence of *opt-in/opt-out* provisions and for the *linkage* with other trading systems. *Linkage* is a fundamental element of EU ETS and its role will be greater in EU ETS Phase II. The amending 'Linking Directive', made it possible the connection between EU ETS and the Kyoto Protocol's project-based mechanisms. Emissions reductions credits generated in developing countries or countries with economies in transition by means of the Clean Development Mechanism (CDM) and Joint Implementation (JI) may be employed as substitutes for ETS allowances. Credits are admitted up to a certain limit in order to respect the additionality principle set in the Kyoto Protocol. Moreover, article 25 of the amended EU ETS Directive acknowledges the linking with other national or regional emissions trading schemes.

Allocation methods and principles have both an indirect and direct influence on the potential role a tradable permit scheme can have in promoting the eco-innovation process. Indirect effects concern the impact of allocation decisions on the cap, that will be examined in the following section about stringency. As for the direct impacts, they depend from single allocation rules. Many alternatives exist as for methods employed for the initial distribution of permits in a cap-and-trade system. Permits in general can be distributed for free (grandfathered) or can be purchased by operators (for instance auctioned). Economic theory on tradable permits asserts that the efficiency of a scheme is assured irrespectively from the initial permits allocation (Tietenberg; 2001). However, more recent contributions showed that the issue is more controversial since allocation rules have distribution effects and can influence both static and dynamic efficiency. When permits are auctioned, operators are forced to make their marginal abatement costs visible and to declare their availability to pay for an emission reduction unit. With auctions it is possible to avoid over-allocation, since rational operators will not buy more permits than the amount necessary to cover their annual emissions. When allowances are distributed for free, on the contrary, firms have an interest in obtaining more permits than the amount needed. Under auctioning, in general the

economic and financial incentive to reduce emissions is stronger compared to scheme where permits are freely distributed, and this condition creates a greater incentive to innovate to further abate emissions. Beyond the two general categories of permits distributed for free or auctioned there is a number of subcategories, especially concerning the method and general administrative rules supporting the free distribution. For instance, permits can be distributed to operators and installation according to their historical emissions, or in application of a performance coefficient, such as a benchmark.

In EU ETS both allocation and cap-setting were decentralized, and for this reason it is very difficult to make a comprehensive assessment of allocation. EU ETS Directive does not impose an allocation method to national authorities that, for Phase I, were free to set their own rules and they were allowed to auction allowances up to a maximum of 5% of the cap for Phase I and of 10% for Phase II. An effect of this great national discretion in allocation methods was that NAPs appeared very different to each other and that member states have been quite creative in the methods employed to calculate the amount of EUAs (European Union Allowances) to allocate to their sectors and installations. As a consequence, as soon as the above mentioned differences and their distortive effects over competition became evident, harmonisation became an issue in EU ETS.

Despite diversity, we can individuate some common basics in allocation rules: the vast majority of the states distributed EUAs for free according to historical emissions, in many cases adjusting them according to projections about future growth trends for sectors - that lately resulted to be inflated (Egenhofer; 2007). In some NAPs, allocation is adjusted including special rules to reward the use of highly efficient technologies (e.g. CHP) or to compensate “early actions”. In some other cases allocation took into account efficiency parameters and reduction potentials of sectors.

The use of benchmarks for NAPs Phase I resulted to be very limited. Benchmarks are based on the performance of the more updated technologies and for this reason they reward the most efficient operators and the ones who developed “early actions”. Benchmarking not only introduces an element of efficiency in the distribution rules, but it is also an equity principle and it solves the problems related to the periodical updating of emissions (Schleich et al.; 2007). Despite these positive points, it has been observed that benchmarks can generate some distorted incentives in case they are biased in favour for a specific technology or fuel. In addition, if they are based on different standards, they can increase complexity and differences among member states.

To conclude about allocation rules, indications from the theory about the best method to stimulate innovation have not been fully respected in the EU ETS. Free allocation was the result of a compromise choice, necessary to have the industry acceptance of EU ETS. In Member States, the possibility of auctioning allowances was in fact subjected to a great resistance and to an intense industrial pressure¹⁰.

As for *new entrants* rules, the vast majority of member states opted for a set aside of allowances to distribute for free to newcomers in application of the principle “first come, first served”. Despite this common element, the allocation of allowances to new entrants varied considerably between member states (use of benchmarks, expected emissions, projected production) thus distorting competition and impacting on

¹⁰ In 2006 only Denmark, Hungary and Ireland auctioned allowances (EEA; 2008).

investment decisions. Theory suggests that the best allocation rule for new entrants in order to stimulate innovation is the purchase of allowances on the market or a system of auctioning. New entrants are fundamental actors for the diffusion of more efficient technologies and with auctioning the incentive to invest in less carbon technologies is maximized.

As for *closures*, in theory, in order to guarantee an innovation-stimuli, the closure of installations should not change the number of allowances circulating. The cancellation of allowances owned by operators that ceased their activity seem logical at first glance, but it does not allow to fully internalize the opportunity cost of emissions. The withdrawal of allowances in fact act as a disincentive to close inefficient plants and to invest in new and more efficient ones. In EU ETS allowances allocated to closed emissions have to be cancelled from the registry. Some member states introduced a transfer rule between closed installations and new plants.

Time strategy of an environmental policy instrument is considered a fundamental characteristic of a successful innovation-oriented policy¹¹. Timing is a factor in strict connection with the stage of innovation that can constitute the solution of the environmental problem addressed, for the simple evidence that innovation does not start with environmental policy, and follow a different and sometimes very uncertain time-schedule on which policies can indeed exert a major influence. The time-schedule of a policy is also unsurprisingly in connection with the innovation patterns of the sectoral system of innovation influenced by the policy considered. When the technological response affects capital intensive industrial sectors where the average duration of the fixed capital is around 20 years, in order to provide a steady economic signal, policies should have a long-term predictable horizon.

Temporal flexibility rules are a fundamental issue of environmental policies as for their potential innovative outcomes. In a trading scheme, temporal flexibility is defined by banking and borrowing rules that can have a contrary impact on the promotion of innovations. Banking of permits allows for the use in the following compliance periods of the permits saved in the present. Banking rewards early reductions, since the savings realized today can be employed in the future. On the other hand borrowing consists in the possibility to use for compliance permits assigned for future periods. This process of anticipation of permits involves a deferment of reductions and investments in innovations and abatement solutions. EU ETS allows for both banking and borrowing and the overall effect of the two mechanisms on innovation is ambiguous. In the section where the results on a case study is presented we will come back to the role of banking and borrowing during Phase I. Although there was no restriction on banking and borrowing intra-period (within Phase I or Phase II), inter-period transfer of permits was not allowed, and the permits not surrendered at the end of Phase I could not be transferred to the subsequent trading period but should be cancelled. This limitation to the temporal flexibility mainly depended from the necessity of maintaining EU ETS compliance separated from Kyoto targets before the beginning of the first commitment period. However, as observed by Ellerman e Joskow (2008) this feature made Phase I “self-contained” and was the major cause of the price declining towards zero in 2006-2007.

¹¹ In particular, timing is considered a factor specifying means and ends of a policy: the basic idea behind this view is illustrated in this sentence: “Political impulses at the wrong time either barely bring about a worthwhile effect or else they cost too much money and time to bring about a real change in economic behaviour. At the right time, even weak political incentives can stimulate external environmentally friendly innovations” (Sartorius and Zundel; 2005).

It is important to specify that banking and borrowing are not the only temporal issues related to EU ETS that could have an impact on its innovative potential. The European Trading Scheme consists of several temporal stages and its time profile is also defined by the length of its allocation periods. Allocation periods of 3 and 5 years are far shorter than investment cycles in the energy-intensive industries. Moreover, the process of updating of the base year in each allocation round undermines the incentive to reduce emissions at present time (Neuhoff et al., 2006). Another element that completes the exam of the time-profile is that EU ETS adoption was realized very quickly, leaving national government and industrial sectors a short span of time to prepare for it. As a consequence, the national implementation processes were accompanied in several Member States by consistent delays, especially in the presentation of NAPs.

Other elements that we can consider to have an impact on the innovative decisions of operators are price volatility and the status of international climate agreements. These points are not EU ETS design issues, but they are related respectively to market dynamics and international climate negotiations. Price volatility is a common feature for new tradable permits schemes (see the analysis of the US experiences in Taylor et al.; 2005 and Ellerman et al., 2003), but it is a further element of uncertainty. The collapse of carbon prices observed in May 2006 reduced the reliability of market for operators. As for the international policy context, the absence of a post-2012 climate regime is a further uncertainty element that reduces predictability and discourages long-term investments.

After this brief analysis of the main EU ETS design issues that can impact on its innovative potential, we can observe that, by and large, the indications emerging from the literature about the best alternatives to adopt in order to make emission trading an instrument able to promote innovations and to create a context incentivizing the diffusion of low-carbon solutions are not reflected in EU ETS design. The European Scheme is distant from an ideal mechanism, or at least it was during its first period of application. Adjustments introduced for Phase II (2008-2012) – like Naps harmonisation – and the amendments proposed for Phase III (European Commission; 2008) seem to improve considerably EU ETS configuration.

Criticism about configuration already emerged in previous studies (Egenhofer et al.; 2006, Oberndorfer and Rennings; 2007). The analysis carried out in 2006 by Egenhofer et al.¹² also covered the issue whether EU ETS was promoting the development and diffusion of low-carbon technologies, and what design and implementation methodologies could be improved in order to reinforce this important aspect of the scheme. The main element deriving from this evaluation was that EU ETS, due to its short-term policy goal was not providing a stable price signal necessary to stimulate investments. Another issue investigated concerns the question whether ETS could become a “tool to provide significant incentives to develop and bring to the market new breakthrough technologies, *i.e.* make R&D on a huge scale profitable”. The analysis pointed out that long-term price signals during Phase I were neither high¹³ nor credible¹⁴ enough to stimulate new breakthrough technologies.

2.2 Stringency of the carbon reduction target during EU ETS Phase I

¹² The analysis was carried out with the purpose of pointing out the main elements the EC should take into account during the review of EU ETS scheduled for 2007.

¹³ To this purpose it has been calculated that with carbon prices <30€ per ton of CO₂ emitted do not make R&D profitable in this field (Egenhofer et al.; 2006).

¹⁴ The credibility of the price signal is undermined by the strong government's role in the setting of prices. Carbon prices are in fact strongly correlated to government's decision on how the cap is set.

The stringency of the target imposed by an environmental policy not surprisingly is recognized as a crucial element influencing its innovative outcomes. Stringency of allocation assures permits' scarcity that is a necessary pre-condition to ensure a positive carbon price.

In general an environmental target can be considered to be stringent if it requires a modification in the behaviour an operator would have in absence of the policy. The magnitude of the modification imposed to business as usual measures stringency. Several studies attempted to measure EU ETS stringency (Betz et al.; 2006, Ecofys; 2005, Schleich et al.; 2007). In many cases the reference employed to assess overallocation was the amount of verified emissions (CITL data), and NAPs, but other studies employed a different approach (Ellerman and Buchner; 2006, Clò; 2007).

When first data on verified emissions were released by the Commission in May 2006 they revealed an excess of allocations over verified emissions equal to 44 MtCO₂ for year 2005 (data covered 99% of installations). This surplus was 5% of total annual allowances and was labelled as over-allocation. After the release of data on real emissions, carbon price collapsed as a consequence of the adjustment between the expectations of market operators and the effective reporting data.

From the exam of Kettner et al. (2007) focusing on CITL and NAPs data it emerged a situation of short and long positions very differentiated among countries and sectors. Major buyers countries proved to be UK, Italy and Spain and the largest supplier countries were Poland, France, Germany and the Czech Republic representing 64% of the net long positions. The aggregation of data by sectors put into evidence that the overwhelming majority of the aggregate demand came from the energy sector. Conversely, the supply-side was balanced between power and non-power sectors.

Over-allocation is not an objective concept; it means that caps have modest goals and that too many allowances have been distributed. However, for a rigorous assessment it is necessary to compare allocations with a reference point or a benchmark.

The analysis realized by Ellerman e Buchner (2006) focused on the causes of the excess of allocation. The authors observed that the simple distance between allocation and verified emissions could not be tagged as "over-allocation", since – at least in theory - many factors intervene in the setting of the level of yearly verified emissions: abatements, economic growth, weather and new entrants and closure dynamics. To assess over-allocation the authors estimated a counterfactual value of BAU emissions, that was calculated multiplying data on historical emissions for the period 2002-2005 with GDP growth rate and with the rate of decline in CO₂ intensity. The counterfactual value was compared with verified emissions. The results of this analysis showed that the abatements of carbon emissions realized by EU ETS participants amounted to a value between 50 and 200 MtCO₂. To assess cap stringency, the authors compared BAU emissions with allocation data and concluded that ETS cap was stringent because the amount of allocated permits in 2005 was 63 MtCO₂ lower than the level of BAU emissions projections for the same year. Of course, their results strictly depends from the principles employed to estimate BAU emissions and from the reliability of historical emissions data.

Clò (2007) developed an alternative methodology to assess cap stringency based on the contribution of EU ETS allocation to the achievement of the Kyoto reduction target and with the consistency with the Polluter Pays principle. The author employed as theoretical reference to compare with NAP allocation the emissions reduction target

EU-15 shall achieve by 2012. In particular, he calculated a “ETS proportional target” range based on EU ETS sectors contribution on national emissions. The author concluded that as for 2005-2007 first cap permits have been on average over-allocated. However, approved caps for Phase II resulted to be stringent since the emissions reduction burden imposed to ETS sectors resulted to be higher than the ETS emissions shares derived from 2005 emissions data.

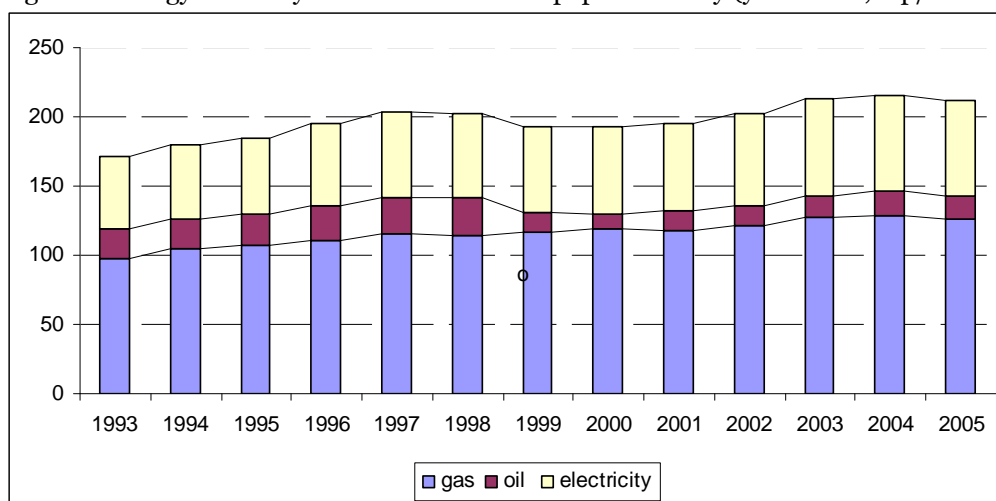
3 The response of the Italian paper industry to EU ETS

In this section we present the results of a survey conducted on one of the industrial sectors affected by EU ETS, the Italian paper industry. The survey investigated the position of paper mills operator in EU ETS (shortage/excess of allowances), the compliance strategies and the adoption of innovative technological solutions to reduce carbon emissions. Survey results show micro-evidences of what happened in reality for a small sample of companies and provides information that cannot be collected using CITL data.

3.1 An overview of the energy and carbon profile of the Italian paper industry

In 2006 the paper industry comprehended 181 installations and 23.000 employees, and realized 10,1% of the European production of paper and cardboard products. Paper manufacturing processes are significantly energy-intensive and requires high amounts of electricity and steam.

Figure 1. Energy-intensity levels for the Italian paper industry (year 2000; tep/milioni di euro)



Source: Enea; 2007

In 2005 the paper industry auto produced about half of the energy it consumed. Renewable energy (hydropower and biomass) represents only 0,5% of the total energy consumption and in the period 1993-2005 natural gas and electricity gained relevance in relation to oil products. To satisfy heat demand and at the same time to improve the overall energy performance, several paper mills adopted CHP plants. The diffusion of cogeneration worked in favour for a reduction of the total energy consumption, but at the same time resulted in an increase in direct carbon emissions.

Carbon emissions discharged by the paper industry are proportioned to its energy consumption and to the fuel carbon-intensity; only a negligible amount of carbon emissions is emitted along the paper manufacturing process. At global level, CO₂ emissions produced by the paper industry are mitigated thanks to the use of biomass-

waste as energy source. Biomass is a renewable energy and is carbon neutral. Depending on the paper manufacturing process adopted, paper mills dispose of different biomass fractions to reuse for energy purposes. However, in Italy the percentage of biomass-waste reused as energy source is far lower compared to the European average. This difference depends first of all to the characteristics of the Italian paper industry, where pulp producers are almost absent and the 80% of the pulp employed is imported. Moreover, biomass-to-energy and waste-to-energy processes encountered some legislative obstacles that in the past prevented the diffusion of plants for the energy conversion of paper sludge and pulper.

In general, the alternative strategies a paper mill can pursue to reduce its carbon intensity falls within these categories: fuel-switch, increase in energy-efficiency (both in the energy production and manufacturing process), increase the use of renewable energy, shift to less energy-intensive products.

3.2 The Italian paper industry in the NAPs

The position of Italy is different compared to the European average, since together with UK, Spain, Ireland and Austria, Italy turned out to be a net buyer of emissions in during Phase I. In 2005 the verified emissions amounted to 225.931.351 tCO₂; the deficit of allowances, representing the net demand for Italy, amounted to 9.781.110 tCO₂.

Table 1. Difference between allowances and verified emissions for Italy (tCO₂)

Year	Allocation tCO ₂ (2005)	Verified emissions tCO ₂	Shortage tCO ₂	Shortage (%)
2005	216.150.241	225.931.351	- 9.781.110	4,5%
2006	216.150.241	225.208.364	-9.058.123	4,2%

Source: Elaboration CITL data (Community Independent Transaction Log)

The process of transposition of the Directive in the national legislation in Italy was characterized for a delay in the respect of the deadlines imposed by the Commission, a short time left to companies for the communication of their historical emissions necessary for the realization of the NAPs and for the great margin of uncertainty surrounding the process. These elements are not favourable to a long-term planning of interventions aimed at reducing carbon emissions.

The Italian National Allocation Plan for Phase I (2005-2007) allocated to the paper industry an amount of 5,09 MtCO₂ per year on average including the New Entrants Reserve (0,58 MtCO₂). The allowances allocated to paper mills represented 2,3% of the national emission cap. As for allocations for Phase II (2008-2012) the allowances distributed were stabilized to the amount allocated for 2007. In 2005 the paper plants included in the NAP were 163, representing 90% of the productive units present in Italy¹⁵.

Paper plants are very different in size, we calculated that 55% of emissions allocated for Phase I were produced by 25 big mills, each one emitting more than 50.000 tCO₂ per year. On the other hand, the 57 smallest installations emitted in total 5,75% of emissions allocated for Phase I¹⁶.

¹⁵ EU ETS Directive does not apply to plants with a daily production inferior to 20 tons/day.

¹⁶ To make a comparison with general EU ETS data we can refer to EEA (2008), who reported that small installations emitting less than 500 tCO₂/year make up 14% of all EU ETS participants and account for about 0,005% of emissions. On the contrary, installations emitting more than 500.000 tCO₂/year account for 7% of the total number of installations but are responsible for more than 80% of the total emissions.

Table 2. Paper industry in the NAP 2005-2007 (MtCO₂)

	2005	2006	2007
EUAs	5,06	5,12	5,09

Source: Ministry of the Environment; 2005

In 2005-2007, at European level, the paper industry received more allowances compared to the emissions produced and verified. This situation qualified the paper sector, at European level, as a net-seller of allowances. However, the Italian paper industry is a net-buyer and represents an exception within this picture in parallel with what happened for Italy in aggregate. To make it simple, we can illustrate this situation comparing the case of two sample paper plants, one representing the Italian paper industry (plant A) and the other representing the paper industries in the rest of Europe (plant B). While plant A in 2005 and 2006 received a number of allowances (EUAs) inferior to the 4% compared to its annual emissions, plant B received an amount of allowances 20% higher compared to its effective emissions. The difference observed can be interpreted as a negative competitive factor for plant A that needed to buy allowances on the EU ETS market or to anticipate the allowances allocated for the future.

Table 3. Allowances and verified emissions

Year	EUAs tCO₂	Verified emissions tCO₂	Shortage tCO₂	Shortage (%)
2005	4.841.897	4.841.897	- 197.103	4,0%
2006	4.841.897	4.841.897	- 116.945	2,4%

Source: Own calculation, Community Independent Transaction Log, 2008

The shortage of emissions registered in 2005 in the Italian paper industry amounted to 197.103 tCO₂, that in 2006 was reduced up to 116.945 tCO₂ amounting to 2,4% of the total allocations. The economic impact of the emissions shortage for 2005 was 0,5% of the industry turnover (if we suppose a carbon price of 20€/tCO₂). However, if we consider that only a small fraction of the shortage registered in 2005 was covered buying allowances on the market and the actual carbon price in 2006/2007, this percentage can be reduced up to twenty times, resulting in a very modest economic impact.

Table 4. Buyers and sellers of allowances in the Italian paper industry (Anno 2005)

Installations	Units		Excess of EUAs		Shortage of EUAs		N.a.*
Small <10.000 tCO ₂	60	37%	15	25%	40	36%	5
Medium	94	58%	26	28%	66	60%	2
Large >100.000 tCO ₂	9	5%	5	55%	4	4%	-
Total	163	100%	46	28%	110	67%	7

*data not available

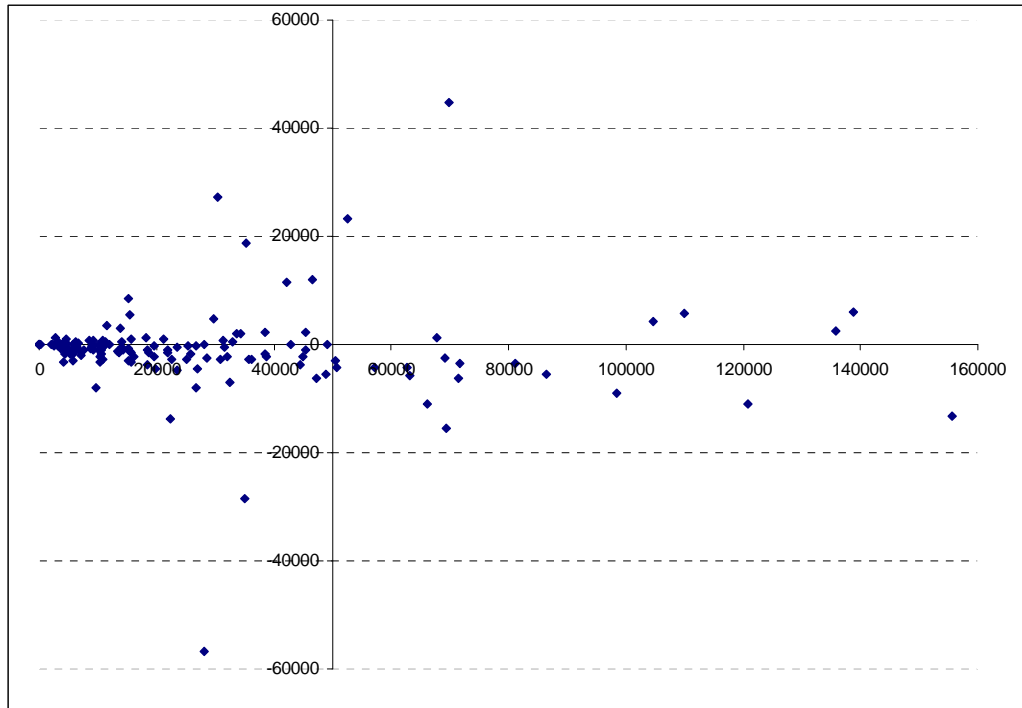
Source: Own calculation, Community Independent Transaction Log, 2007

Behind the average net position of the paper sector, there are very different single positions. Decomposing the total number of paper plants it becomes clear that 110 installations were in shortage of allowances and 46 realized an excess. The gross shortage reached 419.341 tCO₂ and represents the demand of the sector for year 2005. The internal offer of allowances amounted to 222.238 tCO₂.

The following figure illustrates the position of paper plants with reference to their size (expressed by the amount of CO₂ allocated per year) and their shortage/excess of allowances for year 2005. We can distinguish four different groups of installations. The

highest number of installations are concentrated in the centre of the left-side of the graph, where small plants (annual allocation < 50.000 tCO₂) with a shortage of allowances in 2005 are positioned. Data on shortage/excess of emissions make it possible to identify the typology of actors (buyers or sellers) and to define a picture of the Italian paper industry in EU ETS.

Figure 2. Distribution of installation per size (CO₂/year) and surplus/deficit of allowances, year 2005



Source: Own calculation, Community Independent Transaction Log, 2008

3.3 Respondents' strategy

To investigate the role of EU ETS as driving factor for eco-innovations and to learn about firms' response strategies a questionnaire survey was employed. Survey is a methodology frequently employed to investigate the influence of environmental policies over innovation strategies and allows for the exam of a broad range of issues (innovative strategies, innovation typologies, expectations of operators).

The questionnaire was mailed in May/June 2006 to all the paper plants operators included in the NAP together with a text exposing the purpose of the study and assuring anonymity. Of the 163 mailed questionnaires, 38 operators responded giving a response rate of 23%. The responses were examined with the support of expert interviews (carbon consultants, engineers, officials of the Italian Paper Industry Federation – Assocarta).

The results show that, on average, 65% of the respondents were in short of allowances in year 2005, 2006 and 2007. This percentage is consistent with the overall performance of the sector. Seven of the respondent installations asked for an extra-allocation of allowances in consequence of substantial interventions on their equipments (increased capacity) during Phase I.

Table 5. Paper mills with a shortage/surplus/balance

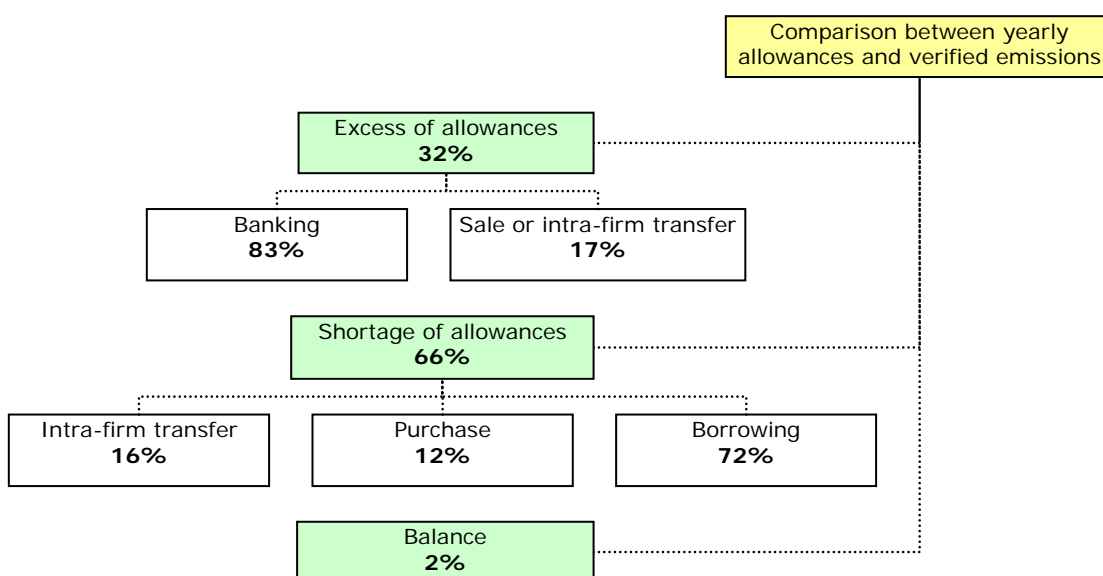
	2005	2006	2007*

Paper mills with a shortage	25	66%	24	63%	27	75%
Paper mills with a surplus	12	31%	13	34%	7	19%
Paper mills with a balance	1	3%	1	3%	2	6%

* operators projections

In case of shortage of allowances, operators can pursue different compliance strategies. They can buy the allowances directly (bilateral exchange) or on the market, with the intermediation of a consultant or a structured platform. In alternative, operators can proceed with an intra-firm exchange, receiving allowances from installations of the same company group, inside or outside Italy. Finally, EU ETS allows for the borrowing of quotas allocated for the following periods; this possibility does not apply to year 2007 since it is not possible to make intra-periods borrowing.

Figure 2. Respondents' compliance strategies (% , year 2005)



The most common strategy applied for years 2005 and 2006 occurred to be the borrowing of allowances, this solution being adopted by 72% and 64% of the respondents in shortage of allowances for years 2005 and 2006 respectively. Under EU ETS yearly issuance of allowances occurs at the end of February but allowances of the precedent year have to be surrendered by the end of April¹⁷. As a consequence, installations can cover their shortage using EUAs issued for the following year. For year 2007, 62% of the respondents foreseen the necessity of recurring to the market for the purchase of the allowances needed to cover their cumulated shortage. The borrowing strategy demonstrated that in years 2005 and 2006 there was much uncertainty about EU ETS administrative management and of the economic consequences, mainly due to the novelty of the instrument and to the delays that accompanied the process of implementation of the EU ETS Directive in Italy. In this context, cautious solutions prevailed over proactive strategies and many operators decided to postpone abatement decisions to the following years.

In case of excess of allowances, operators can sell their surplus on the market, or exchange them with other firms of the same group or save them to make the amount of

¹⁷ As a consequence of the delays in the implementation of EU ETS in Italy, the deadline for year 2005 was extended up to the 15th of September 2006.

extra-allowances available for the following years (banking). This final option could not be realized in 2007 since allowances in excess from Phase I could not be banked to Phase II. Respondents with an excess of allowances in years 2005 and 2006 mainly opted for a conservation of allowances (83%).

The above illustrated structure of responses (Figure 2) can be depicted as a “wait and see” response strategy characterized for a dominance of conservative and cautious decisions and a high incidence in the use of time-flexibility solutions. This picture reflects the conditions of uncertainties described above and the considerations made in the previous section about design. Most of the resources allocated by companies for EU ETS in Phase I were primarily employed to learn about Emission Trading and to comply with the administrative and technical obligations introduced (CO₂ monitoring, communication and verification procedures). With the end of Phase I, we can consider this period concluded and we could expect operators decisions to be directed by different motivations and to be dependent from other drivers.

The questionnaire also investigated the collateral activities developed beyond compliance to EU ETS. More of the 30% of the respondents resorted to consultants in order to manage the administrative activities related to EU ETS compliance rules; 30% of the respondents were engaged in education activities to learn about ETS mechanisms. The high percentage of companies involved in training courses and recurring to external consultancy activities confirms the attitude of firms being involved in the first EU ETS Phase in learning ETS. None of the respondents resulted to be involved in CDM/JI or in Carbon Funds. For 7,9% of the respondents EU ETS acted as an input for R&D activities.

A section of the questionnaire was dedicated to the investigation of the EU ETS effect on investments strategies and innovation decisions. The majority of the respondents (52%) declared not to have realized or planned to introduce technological innovations aimed at reducing CO₂ emissions. On the other end, 13% of the respondent operators declared to have already realized innovation activities and 35% to have developed projects for specific interventions to realize in the following years¹⁸. A simple correlation analysis demonstrated that firm’s size did not have an influence in the decision to introduce an innovation. As for the typology of innovative solutions adopted or planned, 38% were energy-efficient solutions; 23,8% were directed at the optimisation of the production process. This category comprehends the activities aimed at reducing the use of raw materials (water and fibre) that result in a reduction of the energy inputs (and carbon emissions). Only few operators resorted to a fuel switch. No interventions realized or planned concerned raw materials or the set of products offered.

¹⁸ This results are consistent with a study promoted in 2006 by the European Commission and realized by Ecofys and McKinsey (2006) in order to investigate the elements to be taken into account for a comprehensive review of the scheme. This analysis was a web-based survey conducted from June to September 2005 among different stakeholders: industrial companies subjected to EU ETS, associations, NGOs, government bodies and market intermediaries. The main results of that analysis, with respect to the elements of interest for this study, are that almost half of the companies surveyed declared that they already price in the value of CO₂ allowances in their daily operations, and that EU ETS is one of the key issues in long-term decisions, i. e. investments decisions. A specific question of this survey investigated whether EU ETS has impact on decisions to develop innovative technologies. About half of the companies claimed that the EU ETS had a strong or a medium impact on these decisions. More in detail, 19% of the respondents declared that EU ETS had a strong impact (“decisions are significantly influenced by the EU ETS”); for the 34% had a medium impact, for the 31% a little impact and no impact for 16%.

The availability of new technologies able to reduce carbon emissions below the current level is a fundamental pre-condition for the realization of carbon-saving interventions. To this respect, we can refer to the reduction potential of a plant, a machinery, a single installation or a sector. The reduction potential can be calculated as the abatements obtainable with emissions related to the substitution of the technology in use with alternative solutions (new machinery, new system of production..) displaying a lower carbon intensity. In the innovation language, this process of substitution can be identified as innovation diffusion of existing technological solutions, that are new to the company, but not new to the world.

Interviews with experts and machinery suppliers were carried out in order to learn about the reduction potential of the Italian paper industry. The interviewees agreed that Italian paper plants are old on average, and for this reason there are significant margins for improving energy efficiency as well as efficiency in the use of raw materials, both activities resulting in a reduction of CO₂ emissions. It is not possible to identify a single technology able to realize an outstanding reduction in carbon emissions, but a variety of solutions can be adopted all along the production process, each one yielding a modest improvement. The sections of the paper production machine with the highest potential are the pulp preparation and the drying phase where it is possible to install systems for heat recovery. The heat in excess can be employed in other phases of the production process, or for the heating of the buildings inside the paper plant. Other solutions identified were the substitution of traditional engines with inverters, able to save up to 6-10% of the electricity employed. Some of the solutions mentioned refer to specific paper products (e. g. tissue).

Machinery suppliers also revealed that CO₂ was not employed as a selling point for their products. This observation confirms the answer given in the questionnaire by the paper plants operators, who affirmed that they did not receive from suppliers offers for solutions able to help in the compliance with EU ETS. This evidence partially depends from the nature of the technological solution reducing carbon emissions: the majority of them reduces at the same time the energy employed and carbon emissions. The decrease of the energy bill is per se a strong persuading factor for companies, especially in Italy, due to the high energy prices and the steady increase rate they are subject to. The amount of energy that could be saved with the introduction of a specific technological solution is easier to calculate than carbon savings, that depend on the fuel mix and on the typology on combustion plant in use. Moreover, the economic savings realizable through a reduction in carbon emissions depends directly from the short/long position of a plant and from carbon prices, that are far more uncertain than energy prices.

4 Conclusions

The extent to which the EU ETS creates a context favourable to the development and diffusion of innovations is a key criterion against which EU ETS should be assessed. Technology advancements are in fact a key factor for the attainment of the ambitious target set at European level imposing the reduction of 20% of carbon emissions by 2020.

The analysis of EU ETS design and the general assessment of its stringency during Phase I draws the picture of a system scarcely favourable to innovations and not able to reward and incentivise investments. If in theory environmental policies can promote the adoption and diffusion of carbon-friendlier technological solutions, in EU ETS Phase I this potential was sharply weakened due to some flaws in its design. In particular, the main differences between EU ETS framework and an ideal trading mechanism were observed for allocation principles, new entrants and closures rules and issues related to its time profile.

As for stringency, in general it is possible to assert that the national cap-setting process led to insufficiently stringent targets in Phase I and in a price declining towards zero. Emission trading is an economic instrument and the presence of clear and visible economic signals is vital for its proper working. In presence of weak or zero price for carbon reductions it is not possible to realize the economic gains associated with the realization of investments in low-carbon solutions.

From the exam of the reaction of operators from the Italian paper industry it emerged a prevailing “wait and see” response strategy, characterized for a dominance of conservative and cautious decisions and a high incidence in the use of time-flexibility solutions.

Italy is among the few countries where allowances did not exceed emissions and, as a consequence, operators were net buyers of allowances. The response of the operators of the paper industry, as emerged from the survey conducted, resulted to be influenced by the conditions of uncertainties that accompanied the launch of EU ETS and the scarce economic stimuli originating from the carbon market. The high recourse to the borrowing of allowances demonstrate that in years 2005 and 2006 there was much uncertainty about EU ETS administrative management and of the economic consequences, mainly due to the novelty of the instrument and to the delays that accompanied the process of implementation of the EU ETS Directive. In this context, cautious solutions prevailed over proactive strategies and many operators decided to postpone abatement decisions to the following years.

Investment is a long-term issue and the limited time span of the allocation periods resulted not adequate to provide a predictable long-term signal for investments. All these elements lead to modest innovative outcomes. Carbon dioxide emitted by energy-intensive industries cannot be reduced using low-cost end-of-pipe abatement solutions but require improvements in energy-efficiency and investments in renewable. The adoption of these technologies is influenced both from energy and carbon prices and the actors involved in their development and diffusion are machinery suppliers who are fundamental actors in the paper innovation system.

Some changes have been introduced in EU ETS Phase II and more significant modifications have been proposed for the post-2012 extension of EU ETS. It will be interesting to check whether the new rules introduced will remove EU ETS major flaws

emerged in Phase I and will be able to create incentives for clean investments. Positive signals in that direction can be seen as for caps approved for Phase II that, after the conclusion of the Commission's assessment appear to be about 13% lower than the first period cap and 6% lower than 2005 emissions.

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