The EU Emission Trading System: for an effective and viable reform

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Abstract

The European Union Emission Trading System (EU ETS or simply ETS) has now been in place for more than 10 years. There is broad consensus that, although emissions have been below the intended objective during this period, this result is hardly due to the ETS. In these 10 years, several changes have been introduced to the initial rules. Lately, the European Council and Parliament, based on proposals from the European Commission (EC), decided to reform the ETS by introducing a market stability reserve (MSR) with the aim of overcoming the lack of effectiveness regarding ETS, as implicitly recognized by these institutions. In fact, there were other possibilities for reforming the ETS. The purpose of this paper is to present the reasons that favour the introduction of a reserve price for auctions of EU emission allowances (EUAs) as soon as possible, but at least by the fourth phase of the ETS. It also explains why it would be an effective and no-regret option to start from a low level of the reserve price and reaching in about ten years the level making it convenient to switch from coal to gas in electricity production.

The paper is divided into five sections. The first section summarizes the key stages of the history the EU ETS with some comments. The second section analyses the factors that explain the reduction in emissions, particularly during the second phase of the ETS. The next section examines the decisions that have been taken regarding the amount of primary offering of emission permits. The fourth section discusses the reasons that have led to the surplus of permits in circulation since the end of the second ETS phase and the remedies proposed by the European Commission. Finally, the paper presents the case for the introduction and fixing of the minimum and maximum price during the auction for the sale of permits.

Keywords: EU ETS, emissions trading, cap and trade, EUAs price, climate change mitigation policy

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Premise

The European Union Emission Trading System (EU ETS or simply ETS) has now been in place for more than 10 years. There is broad consensus that, although emissions have been below the intended objective during this period, this result is hardly due to the ETS. In these 10 years, several changes have been introduced to the initial rules. Lately, the European Council and Parliament, based on proposals from the European Commission (EC), decided to reform the ETS by introducing a market stability reserve (MSR) with the aim of overcoming the lack of effectiveness regarding ETS, as implicitly recognized by these institutions. In fact, there were other possibilities for reforming the ETS. The purpose of this paper is to present the reasons that favour the introduction of a reserve price for auctions of EU emission allowances (EUAs) as soon as possible, but at least by the fourth phase of the ETS. It also explains why it would be an effective and no-regret option to start from a low level of the reserve price and reaching in about ten years the level making it convenient to switch from coal to gas in electricity production.

The paper is divided into five sections. The first section summarizes the key stages of the history the EU ETS with some comments. The second section analyses the factors that explain the reduction in emissions, particularly during the second phase of the ETS. The next section examines the decisions that have been taken regarding the amount of primary offering of emission permits. The fourth section discusses the reasons that have led to the surplus of permits in circulation since the end of the second ETS phase and the remedies proposed by the European Commission. Finally, the paper presents the case for the introduction and fixing of the minimum and maximum price during the auction for the sale of permits.

1. A short history of the ETS

The history of the EU ETS, which was originally known as the Emission Trading Scheme, is now longer than a decade (see Tab. 1). Its beginnings were marked by the approval of Directive 2003/87/EC concerning major industrial installations, which were responsible for more than 40% of EU greenhouse gas (GHG) emissions. The 2003 ETS directive provided for two periods (or phases) of application: a first three-year trial period starting in 2005 and a second five-year period starting in 2008. The goal was that the average annual emissions of the big GHG emitters (around 11,000 ETS installations) should decrease by at least 8% compared to 1990 during the period 2008-2012, so that the EU could meet its commitment to the Kyoto Protocol.

Table 1 – Main events concerning the EU ETS

2003	– EU ETS directive adopted
2004	– EU linking directive with Kyoto Protocol adopted
2005	– ETS Phase I (2005-2007) launched on 1 January
2007	– National Allocation Plans (NAPs) for Phase II assessed by the EC – Bulgaria and Romania join the EU ETS
2008	– ETS Phase II (2008-2012) begins – Norway, Iceland and Liechtenstein join the EU ETS – EU ETS aviation directive adopted
2009	– Adoption of the 2020 EU energy and climate package (effort-sharing directives) with a revised ETS directive for Phase III (2013-2020)
2011	– EC releases "Towards a 2050 Low-carbon Economy Roadmap"
2012	– Aviation included in the ETS
2013	– Beginning of ETS Phase III (2013-2020) – Croatia joins the EU ETS
2014	– Backloading measures for auctioning EUAs implemented – Adoption of new targets for ETS Phase IV (2021-2030)
2015	– MSR approved

The decision to set up the ETS, which belongs to the cap-and-trade (CaT) policy tools category, was made based on the economic theory, which assures that this tool helps in achieving the goal of reducing emissions in an economically efficient manner. The cap, corresponding to the number of allowances put into circulation, is set by the authorities, while the trade among concerned parties ensures that there is equality between the price of permits exchanged and the marginal cost of abatement for each participant. It was also expected that the price of permits ascended progressively in order to push the ETS installations to gradually reduce their emissions.

During the first two phases, EU Member States were given the task of allocating allowances among the facilities located in their territory under the control of the EC. The ETS directive also required the distribution of the EUEAs almost without charge. These choices were made in order to overcome the initial opposition of certain companies and some Member States.

In subsequent years, the ETS directive has been amended or integrated several times. In 2004, the EU approved the so-called "Linking Directive" (Directive 2004/101/EC), which gave the concerned parties the opportunity to fulfil their obligations using emission reductions generated from projects realized (almost entirely) outside the EU and evidenced by certified emission reductions (CERs) and emission reduction units (ERUs). This decision was rather logical as it was consistent with the "flexible mechanisms" referred to in the Kyoto Protocol, which the EU wanted to implement, although it was not entirely clear at that time what the results would be (see later). Another important change occurred in 2008, when Directive 2008/101/EC was issued, which stated that, starting from 2012, aviation activities would be included in the ETS.

More important amendments were introduced in 2009 by Directive 2009/29/EC, approved before COP15 was due to be held in December 2009 in Copenhagen, which was supposed to prolong the Kyoto Protocol beyond 2012. This directive extended the ETS from 2013 to 2020, in order to fully realize a single European market for the issuance of emission permits. The new EU-wide cap (as opposed to 27 Member States' individual caps) for 2020 was set at 21%, below the 2005 emission level, which was consistent with the pledge made by European Council in March 2007 to reduce the EU's emissions in 2020 by at least 20% (or 30%, if other industrialized countries were ready to follow suit during COP15) compared to 1990. To achieve this target, the directive established that, each year, 1.74% fewer allowances would be issued. The other main changes introduced by the directive for this third phase[1] were:

- harmonized rules at EU level for free allocations (overcoming national differences from the first phase);
- progressive replacement of free allocation with auctioning of EUEAs with no free allocation for power plants from 2013 and decreasing free allocation for other installations;
- establishment of a regulated regime (based on sectoral benchmarks) for 100%-free allocation of EUAs to installations subject to the risk of carbon leakage;
- expansion, even if limited, of sectors and GHGs liable to emission limits.

At the end of the second phase, the number of permits in circulation was considerably higher than those needed by ETS installations to meet their obligations. Given that, contrary to what happened between the first and second phase, the unused permits could be stored for the third phase, there was a clear awareness that a surplus was to last. This prospect pushed the EC to anticipate, in 2012, the report on the functioning of the carbon market, which the ETS directive envisaged for 2013 (EC, 2012a, p. 3). In that report, in order to tackle the structural supply-demand imbalance of EUEAs, the EC proposed six options, of which five concerned supply (EC, 2012a, p. 11). Although "discretionary price management mechanisms", which we shall examine in Section 5, were considered in some detail the only one that was judged as being "relatively fast" to deploy involved "retiring a number of allowances". Besides, the EC had proposed to assume the power to adapt the volume of EUAs auctioned according to the circumstances (EC, 2012b). The discussion between the EC, European Council and European Parliament ended up with the so-called "backloading decision", i.e., an amendment of Regulation No. 1031/2010 postponing the auctioning of 900 million EUAs (400 million in 2014, 300 million in 2015 and 200 million in 2016) until 2019-2020.

[1] For a more detailed illustration of the rules of the Phase III, see, for example, Löfgren et al. (2015).

Despite the concern expressed by the EC in 2012 about the surplus of permits in circulation, an increase has been observed in subsequent years. Even the "backloading solution" appeared insufficient, while the problem concerning the surplus of permits on the market (and consequently their low price) remained on the table.

Having to decide the policy to be followed after 2020, in 2013, the EC published the Green Paper, "A 2030 Framework for Climate and Energy Policies" (CE, 2013). This document is perhaps the most honest assessment of the EU's overall climate and energy policy, and the EU ETS in particular. The EC expressed this view:

> The ETS delivers a uniform carbon price for large industrial installations, the power sector and in the aviation sector. It covers more than 10.000 installations and nearly 50% of all EU GHG emissions. This uniform price ensures that climate goals are met cost-effectively and that business across the EU has a level playing field. The carbon price is now part of EU businesses' operational and investment decisions and has contributed to substantial emissions reductions. *But it has not succeeded in being a major driver towards long term low carbon investments* (emphasis added). Despite the fact that the ETS emission cap decreases to around -21% by 2020 compared to 2005 and continues to decrease after 2020, in principle giving a legal guarantee that major low carbon investments will be needed, the current large surplus of allowances, caused in part by the economic crisis, prevents this from being reflected in the carbon price. *The low carbon price is not providing investors with sufficient incentive to invest and increases the risk of "carbon lock-in"* [emphasis added]. Some Member States are concerned with this evolution and have taken, or are considering taking national measures, such as taxes for carbon intensive fuels in ETS sectors. There is an increasing risk of policy fragmentation threatening the Single Market, with national and sectoral policies undermining the role of the ETS and level playing field it was meant to create. (EC, 2013, p. 4)

The document went onto state:

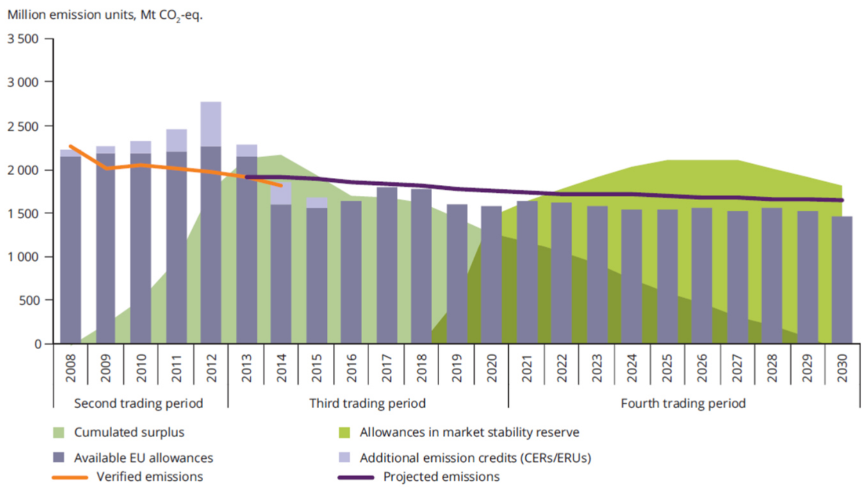
> The current climate and energy targets for GHG reduction, the share of renewable energy sources and energy savings were designed to be mutually supporting and there are indeed interactions between them. Higher shares of renewable energy can deliver GHG reductions so long as these do not substitute other low-carbon energy sources while improved energy efficiency can help reduce GHG emissions and facilitate attainment of the renewables target. There are obvious synergies but there are also potential trade-offs. For example, *more than anticipated energy savings and greater than expected renewable energy production can lower the carbon price by weakening the demand for emission allowances in the ETS. This in turn can weaken the price signal of the ETS for innovation and investments in efficiency and the deployment of low-carbon technologies* [emphasis added] whilst not affecting attainment of the overall GHG reduction target. (EC, 2013, p. 7)

The EC, therefore, acknowledged that the EU's climate and energy policy presented a coordination and design problem. However, the EC has not considered a radical change in the tools used and never seriously questioned the continuation of the ETS. Its attention has been focused on how to reabsorb the surplus allowances and push up the price of EUEAs. Early in 2014, the EC has proposed to launch the fourth phase of the ETS for the period 2021-2030, as well as introduce a permanent mechanism, named Market Stability Reserve (MSR), to adjust the number of allowances auctioned according to the quantity of allowances present in the market (CE, 2014).

In October 2014, the European Council endorsed an overall binding EU target of at least a 40% reduction in GHG emissions by 2030, compared to 1990. Moreover, it approved a specific reduction target for the ETS sector amounting to 43%, compared to 2005, with a linear decrease in the number of EUAs issued by 2.2% per annum between 2021 and 2030 (instead of 1.74% between 2013 and 2020) (European Council, 2014). Meanwhile, the MSR was approved by the European Parliament in July 2015 and by the European Council in September 2015. It was also decided that the MSR would be operational from the start of 2019 and that the 900 million "backloaded allowances" would be placed in the MSR instead of being auctioned in 2019-2020 as initially stated.

Despite these measures, there is certainly no prospects, as of the end of 2016, of rapidly absorbing the surplus of EUAs in circulation. According to the European Environmental Agency (EEA), based on the projections submitted by Member States in 2015, the surplus of permits could be absorbed in 2030 (see Fig. 1). Indeed, the EEA states that: "Given that a static baseline is applied in order to calculate the elimination of the surplus, the projected emissions from Member States are not responsive to the expected change in EUEA prices as a consequence of the MSR. The current estimation of the elimination of the surplus may therefore be an over-estimate" (EEA, 2015, p. 27). Note also that Figure 1 shows that the surplus in private hands today is entirely transferred to the MSR during the next decade and is still there in 2030. Nothing is known about its fate after that date.

Figure 1 – Outlook on the supply and demand of allowances until 2030



Source: EEA (2015), based on the EEA/EU ETS data viewer; deliveries for projections and national programmes by EU Member States (see http://cdr.eionet.europa.eu), compiled by the ETC/ACM, as of 31 August 2015.

The surplus of permits in circulation depends on the demand and supply of allowances. The assessment of the demand and supply of EUAs can be made at the end of each period, as the EUAs can be "banked", with the number of permits to be put into circulation determined in stages. In the next section, therefore, we will examine the reasons that explain the trend regarding demand in the first two ETS periods, while, in the ensuing sections, we shall comment on both the supply and the reasons advanced by the EC to justify the surplus of permits, which has accumulated.

2. Trends in demand for permits in the EU ETS

2.1. The demand for EUAs

Operators of industrial installations (and aircraft operators, which are not considered in this paper) subject to the ETS are required to monitor and report their emissions to the respective competent authority. These operators must surrender, by 30 April, the amount of allowances equal to their emissions in the previous year. Accordingly, the primary annual demand for EUAs corresponds to the amount of CO2, which the parties subject to ETS emit in a given year. Instead, the trading volume is usually much higher[2] because it depends not only on the needs of the operators required to surrender EUAs, but also on the purchases for financial reasons. Nevertheless, although the trading volume through organized exchanges or direct contracts "over the counter" is important for many reasons, what is more important is the demand for permits in order to comply with the ETS. In the following, therefore, we will only consider the demand linked to emissions.

The ETS scope has been changed slightly over time by countries, sectors and the GHG situation (see Tab. 1). Considering the "consistent scope adjustment"[3] calculated by the EEA to obtain comparable data in the three phases, the emissions of stationary installations decreased very strongly between the first and second ETS phases (average annual emissions were 14% lower in the second phase), and continued to decline in the third phase (see Tab. 2). In an attempt to explain the evolution of the demand, we examine what happened in the first two ETS phases, which are now fully complete.

[2] For example, in 2012, the traded volume was 7.903 billion tonnes, while the verified emissions were 1.897 billion tonnes (see: https://ec.europa.eu/clima/sites/clima/files/factsheet_ets_en.pdf).

[3] The "consistent scope adjustment" is a correction of EUTL data on allocated allowances and verified emissions from 2005 until 2012, calculated by the EEA in order to align historical data with the scope of Phase III of the EU ETS.

Table 2 – Estimate stationary installations' emissions to reflect the EU ETS scope for Phase III ($MtCO_{2\text{-}eq}$)

Phase I (2005-2007			Phase II (2008-2012)			Phase III (2013-2020)	
Year	Verified emissions	"Consistent scope" (with Phase III) emissions	Year	Verified emissions	"Consistent scope" (with Phase III) emissions	Year	Verified emissions
2005	2 014.08	2 377.16	2008	2 100.31	2 258.85	2013	1 908.21
2006	2 035.79	2 383.39	2009	1 860.39	2 003.90	2014	1 813.56
2007	2 164.73	2 400.28	2010	1 919.53	2 051.53	2015	1 800.37
			2011	1 885.31	2 010.27		
			2012	1 848.46	1 968.61		

Source: www.eea.europa.eu/data-and-maps/data/data-viewers/emissions-trading-viewer, accessed October 2016.

2.2. Decomposition analysis of the emission trend in the first two ETS phases

The trend regarding CO_2 and other GHG emissions depends on many factors, which are usually grouped under three categories: the level of economic activity, the structure of GDP and the emission intensity (CO_2 emitted per unit of value added) of each branch of activity.

The first influential variable is certainly GDP see, for example, EEA (2014). However, when examining the trend of ETS emissions, a reference to the GDP trend is not enough because emission intensity and production dynamics of different activities, which comprise GDP, vary widely. For example, the average annual value of global production of the EU-28 countries in the second ETS phase was 2.3% higher than in the first, while the production value in the ETS sectors was 5.2% lower (see Tab. 3). A structural change in the economy, and particularly an increase/decrease of importance of the ETS sectors, must thus be taken into account. Finally, the evolution of ETS emissions is influenced by what happens inside each industrial sector: a change in the processes, increasing energy efficiency or a substitution of energy sources can affect emission intensity. These last elements can be grouped under the heading of "technological change", although they are very different from each other. A CAT system can hardly affect the level of activity or the production structure to any significant extent, although it should impact more on technological change, even though, as we shall see, attributing a change in emission intensity to the introduction of the ETS is not straightforward.

Table 3 – Second vs. first phase of the EU ETS: emissions and gross value added for the EU-27

	Phase I (annual average)	Phase II (annual average)	Difference (%)
CO2 emissions:	million tons of CO_2		
ETS for the EU-27[(1)], Consistent scope[(2)]	2 145	1 922	-10.4%
Value added and its components[(3)]	EUR billions (at constant 2005 prices)		
Gross value added at basic prices	10 660	10 901	+2.3%
Manufacturing	1 819	1 774	-2.5%
Electricity, gas, steam	177	179	+1.1%
ETS sectors	404	383	-5.2%

(1) Data for Romania and Bulgaria in 2005 and 2006 have been estimated.
(2) Here "consistent scope" means consistent for the first two phases and for the EU-27. Emissions reported in Tab. 2 are "consistent" with the perimeter of Phase III.
(3) Based on OECD statistics of value added at constant 2005 basic prices (source: https://stats.oecd.org/index.aspx?queryid=60702) and on Tab. 2 with regard to correspondence between economic activities and ETS sectors. Note also that we have neglected the difference between the EU-27 and EU28 countries, since Croatia accounted for between 0.34% and 0.38% of total value added of the EU-28 throughout the period.

The usual way to calculate the influence of each of these factors is to make a decomposition analysis. For example, the EC, in the "Climate Action Progress Report 2015" (EC, 2015a), presents the results of a decomposition analysis for global emissions[4]. Here, we will carry out the same exercise, but only in reference to ETS sectors.

The greatest difficulty to decompose the overall emission reduction according to the three listed items (activity, structure and intensity) is to have coherent data for emissions and economic activity. As a matter of fact, some industrial sectors, which weigh heavily on global emissions, have instead a limited influence on total value added of industry and even less on GDP. This explains why data concerning emissions and production value have different statistical breakdowns. From the emissions point of view, four activities (electricity generation, refining, iron metallurgy and cement production) account for about three quarters of total ETS emissions, but there are no economic data available with the same breakdown. Consequently, we were obliged to aggregate e the ETS sectors to some extent in order to achieve greater consistency with economic data[5]. Tab. 4 summarizes the classification by sectors and the correspondences we used for ETS emissions and economic activity data.

[4] Other similar decomposition exercises were performed by the EEA for GHG emissions by the global EU economy; see, for example, EEA (2011, 2014).

[5] In spite of this, however, the risk of non-perfect homogeneity between the two sets of data remains.

Table 4 – Correspondence between ETS sectors and economic activities classifications

ETS emission classification: European Union Transaction Log (EUTL) codes	**(§)**	**Economic activities classification**: ISIC, Rev. 4, codes	**(#)**
20 (combustion of fuels)	72.6%	D (electricity, gas, steam and air conditioning supply)	1.6%
21 (refining of mineral oil) (6.9%) 22 (production of coke) (0.7%)	7.6%	19 (manufacture of coke and refined petroleum products)	0.3%
24 (production of pig iron or steel) (5.4%) 25 (production or processing of ferrous metals) (0.3%) 26 (production of primary aluminium) (0.0%) 27 (production of secondary aluminium) (0.3%) 28 (production or processing of non-ferrous metals) (0.0%)	6.1%	24 (manufacture of basic metals)	0.6%
29 (production of cement clinker) (7.0%) 30 (production of lime or calcination of dolomite/magnesite) (1.7%) 31 (manufacture of glass) (1.0%) 32 (manufacture of ceramics) (0.8%)	10.4%	23 (manufacture of other non-metallic mineral products)	0.7%
35 (production of pulp) (0.3%) 36 (production of paper or cardboard) (1.3%)	1.6%	17 (manufacture of paper and paper products)	0.4%
All others	1.6%	All remaining manufacturing sectors	14.6%

(§) Percentage of total emissions during the first two phases of the ETS
(#) Percentage of gross value added of the EU-28 during the period 2005-2012

With the aggregations we made, five categories cover almost entirely the ETS emissions (98%), but their corresponding value added weight is less than 4% of GDP (see Tab. 2). This confirms why it makes little sense to look at the performance of the global economy in order to study the trend of ETS emissions and suggests calculating the "structural effect" only in reference to the change in weight of the five important sectors from the emissions point of view. We also excluded the "all other sectors" category from our analysis because it includes very uneven activities, whose weight is very small in terms of total ETS emissions.

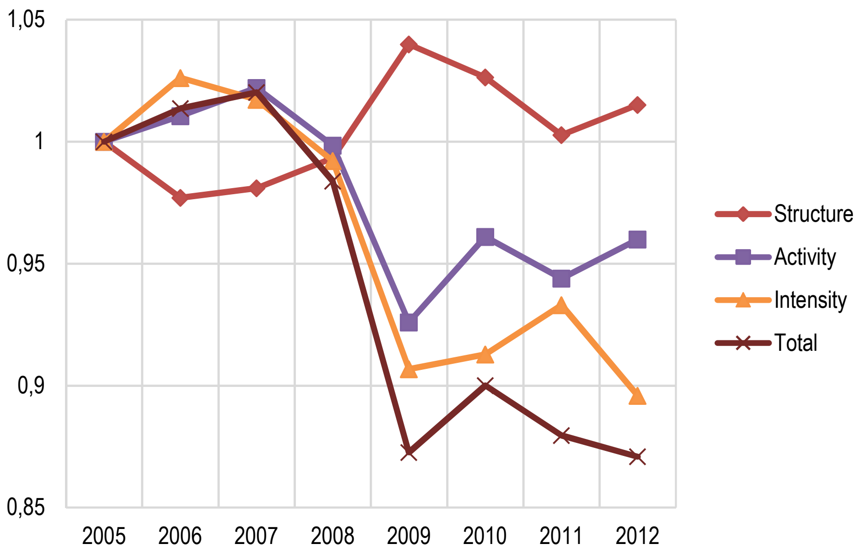
Another problem relates to the geographical scope of emissions. As Romania and Bulgaria only entered the EU ETS in 2007, we estimated their emissions in 2005 and 2006 by using the data published on the EEA website[6] and other available information.

The dynamics of global emissions was different in the two ETS phases (see Tab. A1 in the Appendix). In the first phase, total emissions remained approximately con-

[6] http://www.eea.europa.eu/data-and-maps/data/data-viewers/emissions-trading-viewer.

stant. In the second phase, emissions decreased sharply in 2009 because of the economic downturn, which hit the entire EU economy and even more the ETS sectors, while, in the following years, there was a modest recovery. Overall, the average annual emissions in the second phase were 10.4% lower than in the first one. The decomposition analysis shows that the decrease in total emissions is explained first by the intensity effect (-8.5%), then by the activity effect (-5.2%) (see Fig. 2). Instead, the structural (or composition) effect would have caused an increase (+3.1%) in total emissions. In absolute terms, in the entire second period, ETS sectors emitted 1,120 MtCO2 less than they would have emitted if the first phase conditions has been unchanged. According to the decomposition analysis, the diminution of emission intensity and the activity level respectively contributed, by 895 and 555 MtCO2, to the decrease in ETS emissions, which were partially offset by an increase of 330 MtCO2 caused by the composition change of the value added of the ETS sectors.

Figure 2 – CO_2 emission changes in the EU-ETS: decomposition analysis 2005-2012



Source: our calculations are based on data from Tab. A1.

Since the decomposition analysis shows evidence that the intensity effect was predominant in decreasing total emissions in the second ETS phase, and that the ETS is supposed to push towards the reduction of emission intensity, at first glance, one might say that the ETS in the second phase was very successful. That said, it is not possible to attribute with certainty the decrease in sectoral emission intensity to the ETS for at least three reasons. Firstly, there may be a variation in the composition of production within the individual sectors, the analysis of which has been prevented by the lack of detailed data. Secondly, the emission intensity reduction could have been brought about by different causes resulting from the ETS. Finally, we must remember that the perimeter of the emissions and the added value data do not perfectly coincide. To clarify these issues, at least partially, we will examine what happened regarding electricity and cement production, which account for more than 60% of total ETS emissions.

2.2.1. The emission trend in power generation

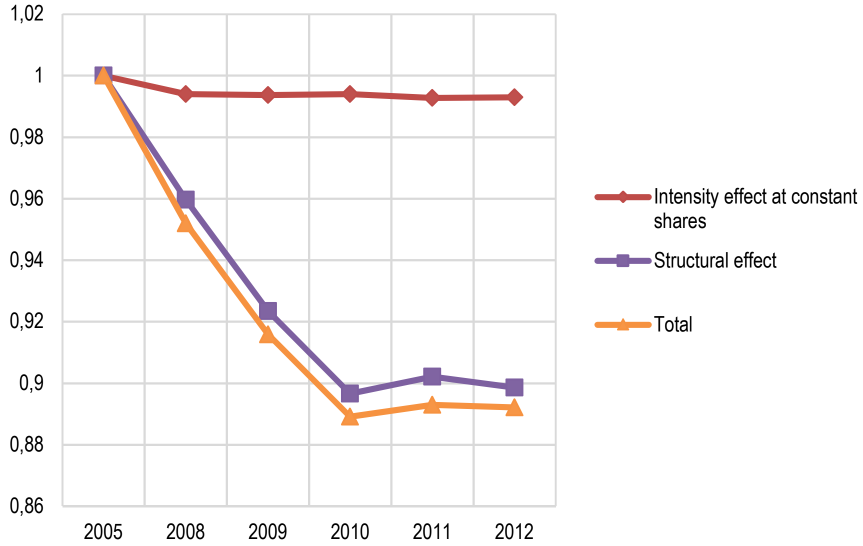
The "combustion of fuels" is by far the most important ETS sector (representing around 70% of ETS emissions) and largely involves the electricity industry. The average annual value added of the "electricity, gas, steam and air conditioning supply" branch was 1% higher in the second ETS phase compared to the first one. Instead, the average annual emissions relating to the "combustion of fuels" decreased by 10%. The ratio of the two figures shows that the average emission (or carbon) intensity (tCO2/unit of value added) decreased by 11% (see Tab. A1 in the Appendix). This suggests that the emission reduction by plants involved in the combustion of fuels was due to a decrease in their carbon intensity. It remains to be seen why this intensity decreased. The answer may be found by analysing what happened in the electricity sector, which is responsible for most of the emissions in the "combustion of fuels" category.

At an immediate level, it should be specified that, instead of emission intensity, it is more productive to examine the "emission factor" trend with regard to electricity generation, i.e., the ratio of the emissions of CO2 to electricity generated (tCO2/MWh), for two reasons. First, we have more detailed and accurate data (see Tab. A2). Second, a physical index is more representative of the emissions per unit of production, although emission factor and emission intensity are strictly linked.

The average emission of CO2 per MWh was 10% lower in the second phase of the ETS compared to the first one, which equates to the same amount as the decrease in the emission intensity by installations in the combustion of fuels. This result intuitively confirms that the power sector dominates the combustion of fuels sector, and that emission intensity and emission factor are strictly correlated.

The reduction in the emission factor can be explained either by an improvement in the performance of power plants or by a modification of the structure of the sources used to generate electricity. To check this, we can apply the technique of decomposition to the data on the electricity sector. The results show that the improvement in the emission factor is due solely to the "structural change" of the shares of the sources used to generate electricity (see Fig. 3). Indeed, in the period considered, the coal-fired, gas-fired and fuel oil power plants have not become significantly more efficient. It was the increase in the share of renewable energy sources in electricity (RES-E) generation that resulted in a reduction in emissions. Moreover, if it were not for the simultaneous decrease in nuclear production, the decrease in total emissions due to the substitution of fossil fuels with RES-E would have been even stronger.

Figure 3 – Emission factor of electricity generation in the EU: decomposition analysis of its variation



Source: our calculations based on data from Tab. A2.

The consequent question is whether the ETS can be held responsible for the development of electricity production from renewable sources. The answer is largely negative. Subsidies to achieve the goal of renewable quotas set by the EU, rather than the ETS, was responsible for the great development in RES-E. Indeed, the price of EUAs was certainly not high enough to make it cheaper to generate electricity from renewables. On the contrary, subsidies given by governments made the investments in RES-E affordable. To prove this statement, it is enough to compare, on an equivalent basis, the level of the two types of incentive. As shown in Tab. 5, the average direct subsidy to RES-E in the EU was seven to 20 times higher than the equivalent incentive resulting from the avoided purchase of EUAs. It is also noteworthy that RES-E promotion has depressed the price of permits even further, making it less necessary to reduce emissions in other ETS sectors or through substitution of fossil fuels in power generation.

Table 5 – Comparison of incentives for RES-E production in the EU through direct subsidies and the ETS

		2009	2010	2011	2012	2013
Average subsidy	(EUR/MWh)	69.4	90.3	114.4	107.4	110.9
Average emission factor of fossil production	(tCO2/MWh)	0.708	0.703	0.715	0.745	0.753
Implicit average subsidy for CO2 emission avoided	(EUR/tCO2)	98.0	128.4	160.0	144.3	147.3
Average EUA price	(EUR/tCO2)	13.1	14.4	13.0	7.4	4.5

Source: Tab. A2 and our calculations based on CEER reports (De Paoli, 2016).

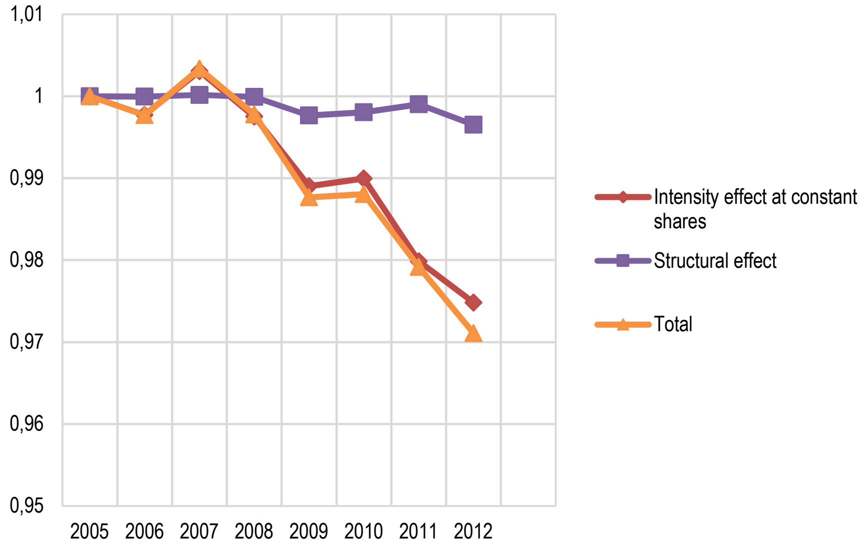
2.2.2. The emission trend in cement production

Even for "non-metallic minerals", which represent the second largest emitter among the ETS sectors, it is possible to conduct an analysis similar to that undertaken for emissions involving the "combustion of fuels". The average annual emissions of non-metallic minerals were 17% lower over the period 2008-2012, compared to the period 2005-2007. The reduction of emissions was due to the lower level of activity (which was lower by 13% on average) and an improvement in emission intensity (-5%) (see Tab. A1). Production of cement clinker is responsible for two thirds of the emissions of non-metallic minerals installations included in the ETS. Thanks to the "GNR Project" of the Cement Sustainability Initiative, it is possible to obtain very detailed data on the production and emissions of the cement industry[7]. By using these data, we get a picture of the cement industry, which is similar to that of the entire non-metallic minerals sector, although we are able to understand better what has happened (see Tab. A3).

The average annual production of clinker in the period 2008-2012 in the EU-28 was lower by 21%, compared to the 2005-2007 period, while the average emission was lower by 22%. This means that the reduction in activity almost explains the reduction in emissions in full. In fact, the average emission factor (tCO2/tonne of cement) in the second phase was just 1.6% lower than in the first phase. By performing a decomposition analysis of the emission factor of clinker, taking into account that there are different technologies of production, we obtained the results as shown in Fig. 4. The overall reduction in the emission factor has been modest, which was not due to a change in the clinker production mode, but to a tendency towards a modest, but steady, reduction in emissions per tonne of clinker.

[7] GNR reports are available online at: http://www.wbcsdcement.org/GNR-2013/index.html.

Figure 4 – Decomposition analysis of the emission factor for cement



Source: our calculations based on data from Tab. A3.

3. The supply of EUAs and international credits

The primary supply of permits on the ETS market depends, first of all, on the EUAs placed into circulation, both free or for a fee, by the EU. In turn, the allowances issued by the EU depend on the cap fixed at the beginning of each phase. The external credits used to offset the obligation to deliver is the second source for the supply of permits. The amount of external credits (or "offsets") depends on the deployment of international projects, but also on the limits set by EU for the compliance with delivering on obligations.

The annual cap for the EU-27 (including Romania and Bulgaria) in the first phase of the ETS was 2,298.5 million permits (IP-07-1614). In 2004, there was no precise historical data to set this cap, with many countries submitting a request that was decidedly superior to the emissions of the plants located in their respective territory[8]. However, the goal in the first phase was not so much to reduce emissions, but rather to start the system. In the second phase, the EC has been much more severe in accepting the cap proposed by individual Member States. The overall cap for stationary plants of the EU-27 was set at 2080.93 MtCO2, i.e., 10.5% below the cap proposed by the Member States and 9.5% below the first phase cap. This decision was highly

[8] The proof is that verified emissions in 2005 were above the cap in just four countries (Spain, Italy, Austria and Ireland). It seems very unlikely that companies were able to reduce their emissions immediately in 2005.

consistent with the EU engagement to reduce the EU-15 emissions by 8% in the period 2008-2012, compared with 1990, according to the Kyoto Protocol commitment and the assumption that ETS installations had to contribute more than the rest of the economy. The cap for the third phase was set in order to ensure that, in 2020, the emissions would be lower by 21%, compared with 2005. The cap was fixed at 2084.3 million tonnes (for fixed installations) for 2013 and set to fall linearly by 38.26 million EUA per year in order to reach 1778.2 MtCO2-eq by 2020[9]. The decrease in the cap during the third phase is higher than it seems when looking at the absolute values because Croatia joined the system, with other sectors and other gases being included in the ETS, from 2013 (see Section 1).

The allocation of EUAs in the first two phases was significantly in line with the cap set. During the first phase, 6.3 billion EUAs were issued, while 10.4 billion EUAs were distributed during the second phase (see Tab. 6). Permits were given almost entirely for free in both the first (99.9%) and second phases (97.3%), exceeding the requirements of Directive 2003/87, which stipulated that the free allocation should be at least 95% in the first phase and 90% in the second phase.

Table 6 – EU ETS: summary of supply and demand of allowances

	Freely allocated allowances	**Allowances auctioned or sold**	**Total allocated allowances (EUA or EUAA*)**	**CERs**	**ERUs**	**Total international credits**
2005	2 096	0	2 096	0	0	0
2006	2 072	7	2 079	0	0	0
2007	2 153	2	2 195	0	0	0
					Surrendered	
2008	1 958	53	2 011	84	0	84
2009	1 972	79	2 049	78	3	81
2010	1 998	92	2 081	117	20	137
2011	2 017	93	2 101	178	76	254
2012	2 054	125	2 169	214	279	493
					Exchanged	
2013	1 013	1 103	2 116	66	133	199
2014	934	631	1 566	129	58	187
2015	871	625	1 496	22	1	24

* EU aviation allowance
Source: EEA, EU ETS Data viewer, accessed October 2016

[9] See: http://ec.europa.eu/clima/policies/ets/cap/index_en.htm (accessed October 2016).

The second source of permits are the international credits (or “offsets”), the use of which was allowed by the “Linking Directive” in order to comply with ETS obligations. This decision was in line with the EU accession to the Kyoto Protocol, which provided for Annex 1 countries (industrialized countries) to comply with their emission limits by using offsets from emission-saving projects accomplished in developing countries or developed countries. The first type of projects falls within the scope of the Clean Development Mechanism (CDM), which issues CERs. The second type of projects belongs to the Joint Implementation, which generates ERUs. The inclusion of these “flexible mechanisms”, and particularly the CDM, in the Kyoto Protocol had two goals: lowering the cost of reducing global emissions and helping developing countries to undertake “clean investments”.

Since the EU always insisted that industrialized countries had to reduce, at least partially, their internal emissions, the “Linking Directive” provided for each Member State to specify the percentage of CERs or ERUs, which could be used, in its NAP. The process for the approval of NAPs by the EC led to the recognition of the possibility of using international credits at different levels (for example, Germany received permission to use international credits up to 20% and the UK up to 8%). On average, companies participating in the second phase of the ETS were authorized to use 1.4 billion international credits, corresponding to 13.5% of the total assigned allowances, despite the fact that, during the second phase, they only surrendered about 1.04 billion CERS or ERUs (see Tab. 7).

The recognition of offsets deserves some consideration. At the time when the EU decided the amount of usable offsets for the second ETS phase, nobody knew exactly how the supply and demand of international credits would develop[10]. After this decision, it was then discovered that the offer was large and intended almost exclusively for the EU market[11]. At the end of 2012, CDM projects resulted in the issue of 1.47 billion CERs, while, according to official data, registered projects could result in 8.46 billion CERs by 2020[12]. Although this is an upper limit, which almost certainly will not be achieved, it signals the potential abundance of CERs, especially given the limited demand. The amount of ERUs available on the market was more limited, but certainly not negligible (about 0.7 billion by the beginning of 2013 and an accumulated total expected to be 1.4 billion by 2020[13]).

[10] “When that decision was taken, no-one knew very clearly how many credits were likely to be placed on the market up to 2012: the pace of development of projects around the world and the level of demand for these credits outside the European system were both very uncertain” (de Perthuis and Trotignon, 2012).

[11] The second largest buyer was Japan, which used about 165 million offsets to comply with its Kyoto commitment. compared to 11,726 offsets used by the EU (see http://unfccc.int/kyoto_protocol/)

[12] Official data are published on the UNFCCC website (http://cdm.unfccc.int/Statistics/Public/index.html) and on the UNEP DTU Partnership website (http://www.unepdtu.org/urc-tool-box).

[13] Data are available at http://cdmpipeline.org/.

Table 7 – Limit and use of international credits during the second phase of the ETS

Country	JI/CDM limit 2008-2012		CERs/ERUs surrendered	Surrendered vs. limit
	in %	in M EUA	M EUA	%
Austria	10	15.4	14.0	91%
Belgium	8.4	24.6	19.1	78%
Bulgaria	12.55	26.5	23.4	88%
Cyprus	10	2.7	2.6	96%
Czech Republic	10	43.4	38.6	89%
Denmark	17.01	20.8	12.5	60%
Estonia	4	NA	2.7	>90%
Finland	10	18.8	16.3	87%
France	13.5	89.6	75.6	84%
Germany	20	453.1	302.2	67%
Greece	9	31.1	27.9	90%
Hungary	10	13.5	9.8	73%
Ireland	10	11.2	6.6	59%
Italy	14.99	146.8	95.5	65%
Latvia	10	1.7	1.6	96%
Lithuania	20	8.8	6.8	78%
Luxembourg	10	1.3	0.8	64%
Malta	TBD	NA	1.1	-
Netherlands	10	42.9	28.6	67%
Poland	10	104.3	95.6	92%
Portugal	10	17.4	14.7	84%
Romania	10	38.0	32.2	85%
Slovakia	7	10.8	10.0	93%
Slovenia	15.76	6.5	6.2	95%
Spain	Ca. 20	152.3	107.1	70%
Sweden	10	11.4	10.1	89%
United Kingdom	8	98.5	77.4	79%
Total	**13.5**	**Ca. 1 398**	**1038.9**	**75%**

NA: not available; TBD: to be decided
Source: Calculations based on EC IP/07/1614 and the EEA's EU ETS data viewer.

Much credit has been attributed to the "Kyoto mechanisms", particularly the CDM: "[The CDM] has helped to establish a global price on GHG emission reductions. Further, it has managed to establish a fairly credible, internationally-recognized, carbon offset market that is worth \$2.7 billion with participation from a large number of developing countries and private investors. It has also created processes and methodologies" (Gillenwater and Seres, 2011, p. 35). However, this judgement was only valid as of early 2011, before the collapse of the CERs' price and perhaps before a more effective evaluation could be carried out. Certainly, both the CDM and JI were useful "learning-by-doing" initiatives, with some initial errors having been corrected, but the additionality and the baseline problems remain difficult to solve in an indisputable way. For example, many have noticed that three quarters of CERs surrendered by ETS installations come from China, the country responsible for the biggest increase in CO2 emissions during the same period. Even stronger criticism has been advanced toward ERUs, which have been accused of being "hot air laundering", mainly by Russia and Ukraine, which had large surpluses of assigned allowances due to the collapse of the Soviet system, not because of energy-saving projects (Carbon Market Watch, 2013).

The biggest benefit attributed to international credits (similar to that for the ETS itself), however, is that it allows for emission reduction at a minimum cost. This objective was explicitly announced in the preamble to the "Linking Directive", which states: "Linking the Kyoto Protocol project-based mechanisms to the Community scheme… will increase the diversity of low-cost compliance options within the Community scheme leading to a reduction of the overall costs of compliance". However, whenever there are simple, low-cost solutions to reduce large amounts of emissions (as in the case of HFC gases), or when there are projects that would have been made anyway, it is clear that offsets can flood the market, in turn bringing down prices of allowances and preventing a proper price signal for needed decarbonization efforts. Imposing a ceiling on the use of offsets can limit this effect (and create two markets), although this may not be sufficient to prevent an inappropriate carbon price for the needed internal decarbonization efforts.

In the third phase, currently in progress, things are changing. The cap will decrease each year by an amount corresponding to 1.74% of allowances allocated in 2010, with auctioning the default rule, albeit implemented progressively. In 2013, more than 50% of the allowances were auctioned (see Tab. 6), although this percentage has decreased in the following years because part of the permits was "backloaded" (see Section 1). Consequently, the supply of permits in 2014, 2015 and 2016 was below the cap that was initially set. In the third phase, it is also possible to use the EUEAs allocated in the second phase, but not surrendered, in order to comply with the obligations. Moreover, unused international credits during the second phase were authorized to be used in the third phase, but they had to be converted into EUAs by 31 March 2015, since CERS and ERUs are no longer compliance units. Since CERs and ERUs were abundant and cost far less than EUEAs, on expiry, all credits in respect of the offset parts, which were not used in the second phase (around 400 million credits), were fully converted into EUAs (see Tab. 6). Presently, the new regulation adopted in 2013 (No. 1123/2013) provides for a modest increase in the offsets usable in Phase III, while the EU "does not currently envisage continuing use of international credits after 2020”[14] (although the Paris Agreement could change this position in the future).

4. The surplus of available allowances in the EU ETS: causes and remedies

By comparing the results of the two previous sections, we can now calculate the imbalance that has occurred between demand and supply of permits. That said, we will mostly discuss whether the causes of the imbalance indicated by the EC are correct and whether the remedies provided are consistent with the objectives of reducing emissions in the long term.

The slight surplus of allowances at the end of the first phase of the ETS (155 million; see Tab. 8) made the price of EUA fall to zero. This imbalance did not cause any great concern because it was a test phase and the permits could not be used in the later stages. Yet the EU, as we have seen, decided to significantly reduce the annual number of permits provided in the second phase in order to comply with its Kyoto Protocol commitment. It was also believed that such a restriction, despite the possibility of using offsets, would have brought the market back into balance and pushed up the price of permits. Before the end of the second phase, however, the surplus had grown substantially, reaching 1.75 GtCO2 (see Tab. 8), and appeared destined to remain there because, unlike in the first phase, there was now the possibility to subsequently use EUAs. It came as no surprise that the price of EUAs also fell after the initial increase in 2008.

The explanation of the surplus by the EC is summarized on the Climate Directorate’s website as follows: “The surplus of allowances is largely due to the economic crisis (which reduced emissions more than anticipated) and high imports of international credits”[15]. This should mean that, if there had been no economic crisis and “high-level” use of offsets, the surplus would not have occurred. But, looking at the data, this thesis seems only partly correct; above all, it is formulated too generally to be able to verify the extent of the contribution of each element to the surplus during the second phase.

[14] This is the statement on the official website of the EU Climate Action Directorate (accessed October 2006) (http://ec.europa.eu/clima/policies/ets/credits/index_en.htm).

[15] http://ec.europa.eu/clima/policies/ets/reform/index_en.htm (accessed October 2016).

*Table 8 – Estimated surplus of available allowances in the EU ETS (MtCO2-eq)**

	Verified emissions	**Total allocated allowances**	**International credits (used or exchanged)**	**Estimated cumulated surplus**
2005	2 014.1	2 096.4	0	82.4
2006	2 035.8	2 078.5	0	125.1
2007	2 164.7	2 194.6	0	155.0
2005-2007	**6 214.6**	**6 369.6**	**0**	**155.0**
annual average	**2 071.5**	**2 123.2**	**0**	**51.7**
2008	2 119.7	2 010.9	83.6	-25.2
2009	1 879.6	2 049.4	80.8	225.4
2010	1 938.8	2 080.8	137.2	504.6
2011	1 904.4	2 101.2	253.6	955.0
2012	1 867.0	2 169.2	492.7	1 749.9
2008-2012	**9 709.5**	**10 411.5**	**1 047.9**	**1 749.9**
annual average	**1 941.9**	**2 082.3**	**209.6**	**350.0**
2013	1 908.2	2 115.9	132.8	2 090.4
2014	1 813.6	1 565.8	253.8	2 096.4
2015	1 800.4	1 495.6	24.0	1 815.5

* All countries and all stationary installations
Source: ETS data viewer. The ETS information was extracted from the EC's EUTL on 3 May 2016.

Let us first examine the "economic crisis" argument. To measure the impact of the crisis, we need to identify what the assumptions would have been relating to the rate of growth had there been no crisis. We also need to know whether or not that rate of growth was supposed to be the same for all economic sectors. Finally, we need to know the supposed trend of carbon intensity and its link with economic growth (without the ETS effect), as emissions depend not only on growth but also on carbon intensity trends.

These items have never been clearly highlighted by the EC, except perhaps in 2005, when it published a guide for the allocation of permits for the second ETS phase. In that document, the EC stated that Member States could set the amount of EUAs assignable to each ETS sector by "assuming the trading sector to have a constant share in emissions and a similar potential to reduce emissions as the entire economy" (EC, 2005, p. 5). This means, implicitly, that the EC made the assumption that ETS sectors showed the same trend as the rest of the economy. Regarding the growth rate and carbon intensity trends, the above-mentioned document provides the information contained in Tab. 9.

Table 9 – Historic and estimated GDP growth rates and carbon intensity trends

	Annual GDP change (in %)	**Annual carbon intensity* (improvement in %)**	**Combined net effect on annual emission trend (in %)**
Actual development 1990-2000			
EU-25	2.0	2.3	-0.3
EU-15	2.0	1.9	0.1
New Member States	1.7	3.9	-2.2
Estimated development 2000-2010			
EU-25	*2.5*	*2.2*	*0.3*
EU-15	*2.4*	*2.1*	*0.3*
New Member States	*3.8*	*3.6*	*0.2*

*It needs to be to be emphasized that the estimates for the period 2000 to 2010 **do not account for the incentives created by the first phase of the EU ETS and are therefore very likely to underestimate the actual reductions in carbon intensity during that period**. (Emphasis added to the original text).
Source: EC, 2005, p. 5

In summary, the opinion of the EC at the time of deciding on the second ETS phase was that:

- growth in activity would be 2.5% per year;
- it was not necessary to distinguish between the trend for ETS sectors and that for the rest of the economy;
- economic growth and carbon intensity reduction tended to offset each other, leaving the total level of emissions almost unchanged (+0.3% per year) before the introduction of the ETS.

If we compare these assumptions with what happened during the second ETS phase, we can see that the starting hypotheses has been proven to be quite wrong (see Tab. 10). Neglecting the failure to predict the crisis, which of course was outside the reach of everybody, the EC nevertheless made the mistake of not considering that the growth rate of the ETS sectors was intended to be less than that of the rest of the economy (between 2000 and 2005 ETS sectors had already grown by half compared to other activities). The second mistake was not to deepen the study of carbon intensity within the ETS sectors, instead relying again on historical values of carbon intensity in terms of GDP and assuming that the ETS sectors would have done even better than the rest of economy, thanks to limits on their emissions. Actually, the ETS sector performed markedly worse than the rest of the economy and this fact deserves a more thorough investigation. One explanation could be that there is a link between growth and carbon intensity trends. The EC itself expressed this opinion: "In principle, the faster an economy grows, the faster new technologies are put to use and the faster the capital stock is renewed, thereby improving productivity and carbon intensity… Furthermore, the introduction of the EU ETS and the EU-wide carbon price in the trading sector will stimulate further reductions in carbon intensity" (EC, 2005, pp. 4-5). However, as the EC notes, the introduction of the ETS would have pushed the ETS sectors to further reduce their carbon intensity. Moreover, the non-ETS sectors, although they grew very little, showed better performance than in the previous period. This confirms how risky it is to assume a rate of carbon intensity improvement without an adequate examination of the underlying factors. A third mistake is not at all considering the impact on the ETS sectors of other directives (in particular the directive on the use of renewable sources).

Table 10 – Comparison between forecasted and real trends in the EU in the period 2008-2012

	Annual change in value added		**Annual carbon intensity improvement**	
	EC assumption	**Real**	**EC assumption**	**Real**
Whole economy	2.5%	0.56%	2.2%	2.9%
ETS sectors	2.5%	-1.34%	2.2%	1.5%
Whole economy except ETS sectors	2.5%	0.63%	2.2%	2.5%

In light of the above considerations, it is not easy to calculate what would have been the ETS sector emissions, had the EC's assumptions about economic growth been proved correct. If we apply the general assumptions about growth (+ 2.5% per year) and about the decrease in carbon intensity (-2.2% per year) to the ETS sectors for the entire period, we can calculate that the total emissions in the second phase would have been about 10.8 billion tCO2. Actually, the EC seemed to have expected a higher carbon intensity reduction for ETS sectors, meaning that the expected emissions were perhaps lower, that is, close to the amount of the permits approved by the EC (10.4 billion)[16]. If we accept that the projected emissions under "normal" conditions were between 10.4 and 10.8 billion tCO2, and we attribute the actual level of emissions (9.6 billion) to the lack of growth in the ETS sectors, then the "economic crisis" can be held liable for an excessive number of permits in circulation of between 0.8 and 1.2 billion EUAs.

Even accepting the ex post EC's argument, that the (unforeseen) lack of growth has been the main cause of the surplus of the permits, in order to prevent the recurrence of these consequences, we must recognize that it is necessary to correct at least two flaws in the future. First of all, the assignment rules of the ETS quotas very loosely considered the difficulty in forecasting production trends in each sector, but experience shows that it is too risky to assume that all sectors will develop in the same way. Second, the allocation of permits to each installation for free was made ex ante, based on historical conditions (grandfathering), rather than on verifying the

[16] This assumption turned out to be completely wrong, since the ETS sectors have decreased their carbon intensity less than expected. That said, this forecast error helped to reduce the excess of permits in circulation.

ex post level of production. This flaw also has an anti-competitive effect: the most efficient plants, which increase production, do not have sufficient allowances, while less efficient plants, which reduce production, are able to sell some of permits they received for free. This shortcoming, although partially corrected by the benchmarking criterion used in the third ETS phase, continues to play an important role, since, apart from the electricity sector, other sectors largely fall under the discipline of carbon leakage and continue to receive permits for free, based on their production at the beginning of the period, despite some thresholds having been introduced (Marcu et al., 2016). The remedy to both these defects is quite simple: devise an ex post allocation method of EUAs, based on an ex post measure of the level of production[17].

The second explanation given by the EC for the large surplus of EUAs in circulation at the end of the second phase involves the "high import of international credits". This statement masks the fact that the EU erred in not deciding the amount of EUAs to be allocated in the second ETS as the difference between the emissions cap set and all authorized international credits.

Before the start of Phase III, the EC approved that up to 1.4 billion offsets could be used (or be banked for the next stages) (see Tab. 7). Therefore, everybody knew that the total amount of permits available during Phase III was 10.4 billion EUEAs, allocated by EU Member States, plus 1.4 billion international credits, which could be purchased. Since, as we said, CERs and ERUs proved to be abundant, while their price has always been quoted at a discount to that of EUEAs on the market (see Fig. 4), it should be no surprise that 75% of the offsets were used in the second phase and the remainder in the third (see Tab. 8)[18]. The main criticism that can be addressed to this decision is probably the violation of the European declaration, also contained in the Linking Directive, which stated that "the use of the mechanisms [CDM and JI] should be supplemental to domestic action. Domestic action will thus constitute a significant element of the effort made". The process of approval of NAPs ended up with an average cut of 10.5% in the allocations proposed by Member States, along with the recognition of the possibility of using up to 13.5% of international credits. Since Member States had asked to emit even more than in the first phase, the cut of 10.5% approximately corresponded to what was needed to comply with the EU's Kyoto commitment. That said, the allowed use of international credits in practice compensated completely for the emission reduction required, since it was possible to avoid internal reduction efforts by resorting to CERs and ERUs.

[17] It should not be too difficult to introduce a system, which never exceeds the cap and sometimes allocates less emission permits. An interesting model of "dynamic allocation" has been proposed in the Netherlands (Borkent et al., 2014).

[18] Towards the end of the second phase, as the EU decided to restrict the possibility of using CERs and ERUs in Phase III and there were not many other outlets, their price began to diverge from that of EUEAs, collapsing to almost zero in 2012, as had happened for EUAs at the end of Phase I. The very low price, however, pushed even more the companies that were subject to the ETS to use these credits to meet their obligations in 2011 and, above all, in 2012, then convert the remaining amount into EUAs in Phase III (see Tab. 8).

Figure 4 – Price trends for EUAs and CERs (Futures front month)

Source: ICE, https://www.theice.com/products/197

As already mentioned, the EU now seems more aware of the problem and has allowed a very limited use of offsets in the third phase. According to experience and theory, a more structural solution to this problem may be represented by: a) considering all admitted international credits as actually issued if they come from countries without a quantitative emission limit; and b) when the EU accepts interchangeable emission permits with other countries/areas with a CaT system in place, carefully examining the degree of severity of the cap imposed in that country/area.

After recognizing that the crisis in the ETS sectors, which was not foreseen in terms of its size and length, and the size of the opportunity to use international credits, which have been important factors in the accumulation of ETS permits, the question concerns whether these two factors fully explain the current surplus. It is widely recognized, even by ETS defenders (IETA, 2015), that part of GHG emission reduction was caused by other European policies, which had other goals. In particular, the

Renewable Energy Directive and the Energy Efficiency Directive, which have focused on reducing the use of fossil fuels everywhere, have also resulted in a reduction of CO2 emissions in the ETS sectors. The reduction of emissions by power installations in the second trading period can be estimated at around 700 million tons of CO2, due in large part to the replacement of fossil fuels with RES-E, and only in small part to the improvement in the efficiency of thermal plants (see Section 2.2). Similar results have been obtained by other studies (Gloaguen and Alberola, 2013). It should be emphasized that the overlapping of effects between different EU policies has had an important consequence on the demand for permits in the ETS sectors and, therefore, on the price of EUAs. In fact, as any simple economic analysis shows, such as that of Fowlie (2016), the impact of the cumulative production of RES-E on the demand for permits cannot be overlooked. Since RES-E deployment is not linked to the ETS, but to the subsidies given by Member States to comply with targets for renewables, there is a need to take into account the mutual influence of different policies.

5. How should the EU ETS be reformed?

There is a widespread opinion, confirmed by our analysis, that the ETS has had little effect on reducing GHG emissions in the EU[19]. Nonetheless, as has been recently pointed out (de Perthuis, Solier, Trotignon, 2016), on the website of the EC since 2005 has stood the claim: "The EU ETS is a cornerstone of the EU's policy to combat climate change and its key tool for reducing greenhouse gas emissions cost-effectively", to which was added with a touch of pride: "It is the world's first major carbon market and remains the biggest one". So far the criticism does not dent the Commission's belief that ETS should be kept anyway. Although the CAT put into practice has many limitations that the theory tends to overlook, this article does not aim to resume this discussion[20]. Remembering that the choice of an instrument is not just a technical issue, but also a political one (Jenkins, 2014) and that once a choice is made, it tends to remain, it is better to focus on how to improve the design of ETS.

According to the EC, to date, the limited effectiveness of the ETS is due to the excess of permits, which have been put on the market. For this reason, since 2012, the EC has proposed a "structural reform" that seeks to reabsorb the surplus of permits and prevent this situation from recurring in the future. As we mentioned, when

[19] The literature examining the ETS and its results is very substantial. Its review would require an ad hoc piece of work, that is outside the scope of this article. In any case, there are papers that have already tried to carry out such an analysis from different points of view (e.g., Laing et al., 2013). In general, the opinion that the ETS has been ineffective prevails, even though there are some who believe that "the EU ETS achieved immediate and significant emission reductions at low cost" (Brown, Hanafi and Petsock, 2012).

[20] We have already expressed elsewhere (De Paoli, 2015, p. 13-16) the reasons that lead us to believe that it is preferable to set the price of permits and look at the amount of emissions instead of setting the cap and looking at the price of permits. For a critique of the supposed effectiveness of the CAP in some US applications, see Damian 2014.

the surplus was beginning to grow at an alarming rate, the EC presented six options to tackle the problem (EC, 2012). Five options envisaged various initiatives to boost demand or reduce the supply of permits. Only one envisaged a direct intervention on the EUAs price. The discussion then led to the introduction of a Market Stability Reserve, which was approved in October 2015. The MSR is designed as a means to adjust the supply of allowances in the annual auctions according to the EUAs in circulation. By adjusting the quantities in response to the demand for permits, the reserve is also assigned the task of enhancing “synergy with other climate and energy policies” (OJ, 9.10.2015, L264/2).

Leaving aside the doubts about the effectiveness of the MSR in rapidly absorbing the surplus of permits (see Section 1), the first amazing thing about this reform is that the official documents never clearly explained why the existence of a surplus of permits is of concern. Since the aim of a CAT system is that emissions do not exceed the cap that is set, the remainder of some permits means that the aim has largely been achieved. Of course, if this happens, the price of permits will become very low (or even reach zero if they mature). But reforming the system because the emissions were lower than the predetermined cap would not make sense. However, it makes sense if the price of permits is an important element for the effectiveness of the ETS. This is also probably the opinion of the Commission even though the EC has never explicitly declared it. As a result, the second surprising aspect of the reform is that the official documents do not contain any discussion on the price level of emission permits.

This is a serious shortcoming because the price of permits must be considered a determining factor when judging the success of the ETS for the following reasoning. First of all the objective of the ETS is not just to keep emissions below a certain level in a given year or period without worrying about what happens later. The ETS has been devised to contribute to almost completely eliminating the GHG emissions within a certain span of time that has already been announced by the EU. In October 2009, the European Council agreed to support “an EU objective, in the context of necessary reductions according to the IPCC by developed countries as a group, to reduce emissions by 80-95% by 2050 compared to 1990 levels” (EUCO. 15265/09). This objective has been confirmed and repeated several times, such as when approving a low-carbon strategy (EC 2011), which is now considered the EU aim for 2050. Moreover, whenever the interim targets for reducing emissions were set, the ETS sectors received a tougher goal than the general one. Secondly, to achieve the target of significantly reducing emissions in the ETS sectors, large investments are needed. Lastly, since these investments are decided on the basis of the expected price of permits, the prices must be sufficiently high, credible and known early enough so that investments are made in time.

Certainly, gradually decreasing the cap set by ETS is one way to define a progressive emission reduction path. However, when structural or significant changes in the production mode are required, there is no certainty that the compliance with the cap up to a certain date (that might also be due to fortuitous circumstances) ensures that future targets will also be met. If indeed the ETS had done its job, the price of the permits would have been tied to the emissions abatement cost and to the factors that determine it. On the contrary, the analysis of the price of the EUAs in the first two phases shows that only a very small part of the price is explained by factors such as economic activity, convenience to fuel switching, RES-E deployment or the supply of Kyoto credits, which, according to theory, should determine its evolution (Koch et al., 2014). Therefore, the ETS based on the determination of permits put into circulation has not been able to bring out a price signal capable of guiding the initiatives to be undertaken to "decarbonise" the ETS sectors.

The decision to introduce the MSR does not seem able to solve the problem for the future. In any event so far MSR proved ineffective since it did not change the expectations of the operators and the EUAs price even decreased to 5 EUR during 2016. Even the limited (or no) opposition to this mechanism by the industry is a signal that its relevance may be modest[21]. In summary, in order to decarbonize the economy, the EU needs a different solution from that of MSR which will simply remove a number of permits from the market for a few years. Without abandoning the ETS and the auctioning of EUAs, a better solution is readily available. A floor price could be introduced as a reserve price at the auctions, i.e., the minimum price below which permits are not sold at auctions. At the same time, it might be useful to introduce a maximum price for permits in order to limit price volatility and the risk concerning the loss of competitiveness of European companies. The ceiling price may be the price at which the auctioneer is willing to sell any amount of permits requested. The excess of permits sold could be deducted during subsequent auctions. The proposed solution, namely, an auction for a given amount of permits with a price collar, is shared by many (for ex. de Perthuis, Solier, Trotignon 2016) and is not at all innovative, since it is already implemented in three CAT systems, similar to the ETS, operating in California and Quebec and in the form of the Regional Greenhouse Gas Initiative, whose members include some of the States in the Eastern USA. In all these cases, there has been a careful evaluation of the convenience of introducing at least a reserve price at auction (e.g., Holt et al., 2007).

Contrary to North American administrations, the EC has sought to pinpoint the weaknesses of auctions with a collar solution. The central argument of the EC runs like this:

> Discretionary price-based mechanisms, such as a carbon price floor and a reserve, with an explicit carbon price objective, would alter the very nature of the current EU ETS being a quantity-based market instrument[22]. They require governance arrangements, including a process to decide on the level of the price floor or the levels that would activate

[21] When a regulation is supported by those who are regulated, you can expect that this is in order to defend their interests (Stiegler, 1971), or that it only harms them to a minor extent, or that they fear far more severe actions if this regulation were abandoned.

[22] The three issues raised to criticize "discretionary price management" are quite weak and sometimes wrong. For example, with regard to the first: "If it [the floor price] would not lead to cancellation of allowances which were withdrawn from the auctioning process because prices [offered] were too low, then it would not achieve any additional environmental benefit which is determined by the cap" (EC, 2012, p. 10). This statement is incorrect. First, because delaying emissions by putting them aside in a reserve fund provides an environmental benefit,

the reserve. This carries a downside in that the carbon price may become primarily a product of administrative and political decisions (or expectations about them), rather than a result of the interplay of market supply and demand. (EC, 2012, p. 10).

Certainly, if the reserve price and the amount of permits to be auctioned are sufficiently high, the functioning of the ETS mechanism is transformed and becomes close to that of a carbon tax. For example, in the first eight joint auctions held in California and Quebec, the settlement price was equal, or very near, to the reserve price; meanwhile, in the most recent auctions, only a fraction of permits auctioned were sold[23.] In our opinion, this is not a drawback, but a useful step towards a more rational policy in fighting climate change (De Paoli, 2015). In fact, as we previously stated, if the aim of the ETS is simply to keep emissions below the cap, there would have been no reason, so far, to have any concerns or reform it. If, on the contrary, the concern is to provide investors with a stable and credible price signal, the MSR is not an appropriate response. The EU seems convinced that a rigid mechanism for the adjustment of the EUEAs in circulation could miraculously limit price fluctuations and raise EUA prices to an unspecified, yet "adequate" level, but this is far from certain. According to some simulations based on the initial proposal (Trotignon et al., 2014), the MSR could cause increases in EUA prices, which could be very different depending on the reactions of subjects to the ETS and could enhance EUA price volatility.

The fear of the EC, that "the carbon price may become a product of administrative and political decisions, rather than a result of the interplay of market supply and demand", is also contradictory: first, cap setting is also "an administrative and political decision"; second, even the introduction of an MSR is an administrative and policy decision, which limits the free market (by influencing the price, without declaring it). In combatting climate change, policy intervention is inevitable[24].

As we mentioned, in the North American experience the auction settlement price has always been near the minimum price[25]. This indicates that what really matters is the reserve price since the authorities are very unlikely to set a cap so stringent that the would hit the ceiling. At auction, the adoption of a reserve price has been traditionally recommended by economists in order to prevent selling below the seller's opportunity cost and avoid the risk of collusion (e.g., Ausubel and Cramton, 2004). That aside, in the case of the ETS, the most important benefit of a reserve price is that it can be fixed

even if modest. Second, because the guarantee of a minimum price (provided it is high enough) can stimulate decision-making leading to a reduction in emissions. Third, because if the reserve fund continues to grow, it is likely that even the emission cap will be reduced.

[23] Full information on California's auctions is available at: www.arb.ca.gov/cc/capandtrade/auction/auction_archive.htm.

[24] The EC seems to believe that there is an optimal Pigouvian tax determined by the market with minimal government intervention. If anything, we are facing a problem of Marshallian tax, determined directly by the public decision maker for the purpose that he thinks right to pursue (Damian 2011, Caldari and Masini 2011).

[25] The case of RGGI is a partial exception because the reserve price has been set at a very low level (in 2016, it was $2.10); even the trigger price (equivalent to the ceiling price) is quite low (8.00 USD in 2016). Consequently, the price fluctuates between the floor and the cap.

in order to promote the use of the most environmentally efficient technologies, facilitate new investments and search for new technological solutions. Such a reserve price should be known in advance for a certain period of time and regularly increased (never decreased) in order to offer credible signals to investors/emitters.

If institutions (and researchers) wish to limit political discretion, and anchor policy decisions on the floor price of ETS to a "scientific" base, the solution is to use the information about the curve of the marginal abatement cost of CO2 emissions. In our opinion, this problem is not difficult to solve. Electricity generation is undoubtedly the first ETS sector, that must be considered in order to reduce emissions, since more than half of total ETS emissions come from power plants. Coal and lignite plants are responsible for at least 70% of emissions in the power sector. Consequently, to reduce emissions in the electricity sector, it is above all necessary to reduce emissions from lignite and coal-fired power plants. To do this, there are three possibilities: deploy more zero-emission power plants (RES-E and nuclear plants); carry out carbon capture and storage (CCS); or replace coal with gas. Leaving aside nuclear energy for social and economic reasons, renewables (wind, solar, biomass etc.) offer the best prospects in the long term, though, in many cases, their abatement cost of carbon is still quite high and above all they need some decades to almost completely replace fossil fuels in power generation. CCS is a technology that is still being developed, with uncertain (but probably high) costs involved. Fuel switching is probably the cheapest and quickest solution given that there are many combined-cycle gas turbine (CCGT) plants that are hardly used at the moment in Europe. Thus the value of the permits which switches from coal to existing gas-fired plants the electricity generation seems the best way to determine the floor price of EUAs[26]. Moreover, although this value depends on fuel prices and the heat rate of power plants, its variability could be estimated within a range that is not too large (De Paoli, 2015).

The choice of the ceiling price of EUAs does not have an easily identifiable point of reference. An easy way to fix this would be to take, as a value, the current level of the relevant fine (EUR100/tCO2), which the ETS issues to those who do not deliver the permits due at the end of the year. Obviously, to transform the fine into a ceiling price, it is necessary that the present value of the fine should become the one to which all the required permits are distributed. Other solutions can certainly be found. However, the value of the ceiling price is less important because, due to political reasons, it is very difficult that the emission limits be set so stringent as to bring the price of permits to the ceiling.

It seems possible to conclude that reforming the EU ETS by introducing a reserve price of the auctions progressively reaching the replacement value of coal with gas in electricity production is certainly a rational solution. This is a no-regret option, given that all studies agree that the price of carbon should significantly increase over

[26] Obviously, the replacement of existing coal plants with new gas plants takes more time and requires a higher CO2 price (it also depends on the capacity factor of the plants). However, as the investment cost of CCGT plants involves a limited share of total generation costs, the additional increase of the CO2 price necessary to justify such a substitution is also limited (Sartor et al., 2015).

time in order to achieve the objectives of reducing emissions at the level required and, in turn, limit the global temperature increase. It is also a no-regret option on the basis that the electricity sector is certain to make a substantial contribution to the "additional reduction of around 556 million tCO2 in the period 2012-2030" in the fourth phase of the ETS (CE, 2015, p. 2). The initial value of the floor price (to be adopted as soon as possible) may be similar to that of the California cap-and-trade program (12,73 USD in 2016). This initial value is low enough to be accepted without too much difficulty in Europe and would have the advantage of potentially linking the EU ETS to the second ETS market in order of importance. In fact we must keep in mind that, if the ultimate goal is to connect the ETS systems around the world, their prices must converge. However, the reform should have a clear medium-term objective to achieve a level of EUAs price that makes it convenient switching from coal (without CCS) to gas in power generation. This means that to achieve a level of EUAs around 50 EUR in 2025-2030, the annual growth rate should be 10 to 15%, well above the 5% (plus inflation) set in California.

A reserve price, which progressively increases by default up to the value of switching from coal to gas, is an effective reform because it gives a clear signal to all companies subject to the ETS, thus allowing them to plan their actions in an adequate time horizon and therefore makes the ETS actually responsible for the reduction of emissions. However, a reform of this type also offers numerous other benefits:

- it shows a price signal, which could be used in non-ETS sectors and is more in line with the social cost of carbon;
- it helps to bring together the environmental policies of EU Member States;
- it promotes the deployment of RES-E, while decreasing the need for subsidies at the same time;
- it stimulates R&D to develop CCS and, at the same time, impose a ceiling on the costs of this technology.

Is the introduction of a floor (and ceiling) price in the EU ETS also a viable solution? The answer is certainly positive from a technical point of view (it is not so difficult to agree on the price path to reduce emissions in the already fixed quantity), but is more problematic from a political point of view. For the moment, why the adoption of a cap-and-floor of EUAs price is not on the EU political agenda despite its advantages? The answer is easy: it is very difficult to reach a consensus among Member States on this issue. In addition, the current system is satisfactory for both the administrative bureaucracy and companies because it allows scope for negotiation and, while the price of permits remains so low, the burden imposed by ETS is not too disruptive. Nevertheless, how long can the EU avoid dealing with the harmonization of environmental taxation and accepting the consequences of its stated commitment to tackle climate change? The hope is that some countries (eg France)[27]

[27] For example, in February 2016, the French government proposed this approach in its contribution to the discussion on the reform of the ETS (the French proposal is published in this issue of EPEE). Other Member States, which have already introduced a carbon tax, should

put on the table this proposal making it feasible thanks to the adaptation period to reach the "switching price" and special treatment granted to weaker countries and more impacted (such as Poland) by this policy measure.

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not be opposed to this idea. This does not mean that there are no problems to be dealt with in order to implement this solution. These include:

1) the different impact for each individual Member State;

2) the consequences for the companies and the families of the increase in energy prices;

3) the use of the revenue arising from the sharp increase in the price of EUAs.

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Appendix

Table A1 – Emissions and gross value added of ETS sectors during the first two phases of EU ETS

	Emissions (Mt CO2-eq) (1)										
	Combustion of fuels		Refining and coke		Iron, steel & other metals		Cement and other non-metal. minerals		Pulp and Paper		Total
2005	1 541.1	74%	159.6	8%	131.3	6%	229.5	11%	34.8	2%	2 096.2
2006	1 555.4	73%	159.9	8%	134.5	6%	233.2	11%	34.6	2%	2 117.7
2007	1 565.6	73%	160.2	7%	134.8	6%	242.1	11%	33.5	2%	2 136.3
2008	1 496.6	73%	159.5	8%	140.0	7%	232.4	11%	33.7	2%	2 062.3
2009	1 365.7	75%	146.3	8%	99.0	5%	186.4	10%	29.9	2%	1 827.3
2010	1 400.6	74%	146.0	8%	117.2	6%	188.5	10%	31.9	2%	1 884.1
2011	1 370.4	74%	146.2	8%	115.5	6%	188.0	10%	30.5	2%	1 850.6
2012	1 358.7	75%	139.5	8%	111.0	6%	176.5	10%	29.4	2%	1 815.1
	Value added (EUR, millions 2005) (2)										
	Electricity. gas. steam		Refining and coke		Basic metals		Non-metallic minerals		Paper and paper product		Total
2005	179 996	45%	30 941	8%	70 171	18%	74 337	19%	44 620	11%	400 065
2006	172 314	43%	35 083	9%	72 630	18%	78 179	19%	46 043	11%	404 248
2007	177 195	43%	32 017	8%	73 431	18%	79 541	19%	46 717	11%	408 902
2008	177 216	44%	31 303	8%	69 026	17%	76 253	19%	45 610	11%	399 409
2009	178 197	48%	31 233	8%	55 462	15%	63 084	17%	42 442	11%	370 418
2010	182 166	47%	30 572	8%	61 496	16%	64 597	17%	45 610	12%	384 441
2011	172 094	46%	27 922	7%	64 895	17%	68 151	18%	44 546	12%	377 607
2012	182 888	48%	22 298	6%	68 147	18%	64 105	17%	46 598	12%	384 036
	Emission intensity (kg CO2eq/€ of VA) (3)										
2005	8.562		5.157		1.871		3.087		0.780		5.240
2006	9.027		4.559		1.852		2.983		0.752		5.239
2007	8.836		5.004		1.836		3.044		0.717		5.225
2008	8.445		5.097		2.028		3.048		0.738		5.163
2009	7.664		4.684		1.786		2.954		0.705		4.933
2010	7.688		4.774		1.905		2.918		0.699		4.901
2011	7.963		5.234		1.780		2.759		0.685		4.901
2012	7.429		6.258		1.629		2.753		0.630		4.726

(1) Source: EEA ETS data viewer and our estimate for Bulgaria and Romania in 2005 and 2006
(2) Source: OECD, Value added and its components by activity. ISIC rev4. Data refers to EU-28 instead of EU-27 but we have neglected the difference because of GDP of Croatia represents only 0.3% of total GDP.
(3) Source: our calculations based on emissions and VA sectoral data

Table A2 – Production, fuel use and CO2 emissions in the electricity sector in the EU-28

	Solid fossil fuels	Crude oil and petroleum products	Natural gas and derived gases	Nuclear	Renewable energies	Waste (non ren.) and other	Total
			Gross electricity generation (TWh)				
2005	960.3	142.8	704.0	997.7	495.7	24.9	3 325.4
2006	983.1	136.2	719.1	989.9	521.3	21.8	3 371.3
2007	985.9	115.1	776.9	935.3	549.9	20.3	3 383.4
2008	899.7	108.3	825.7	937.2	594.8	21.2	3 386.9
2009	822.1	98.9	758.2	894.0	627.4	21.6	3 222.1
2010	829.5	86.9	799.4	916.6	710.4	23.5	3 366.4
2011	850.7	73.5	735.5	906.7	706.4	24.9	3 297.7
2012	901.0	73.9	616.0	882.4	798.5	25.7	3 297.5
2013	875.7	61.0	542.2	876.8	889.1	25.7	3 270.6
2014	808.7	57.4	490.1	876.3	930.9	27.3	3 190.7
	Input of fossil fuels for power stations (ktoe)						
2005	228 792	32 374	135 361				
2008	214 630	25 045	153 058				
2009	196 322	22 645	140 419				
2010	196 738	20 469	149 838				
2011	201 983	17 420	136 359				
2012	214 482	16 881	114 938				
2013	207 324	13 414	101 406				
2014	190 639	12 879	92 227				
			Emission factors (t CO2/MWh)				
	Solid fuels	**Oil products**	**Gas**	**Av. fossil fuels**			**Global average**
2005	0.958	0.726	0.449	0.741			0.403
2008	0.959	0.741	0.433	0.709			0.384
2009	0.960	0.733	0.432	0.708			0.369
2010	0.954	0.754	0.437	0.703			0.358
2011	0.955	0.759	0.433	0.715			0.360
2012	0.957	0.731	0.436	0.745			0.359
2013	0.952	0.704	0.437	0.753			0.340
2014	0.948	0.719	0.439	0.754			0.321

Sources: Electricity generation from Eurostat [nrg_105a]. Input of fossil fuels from Eurostat, Energy balances, 2016 Edition; Emission factors: our calculation based on Eurostat data and IPCC-2006 emission factors for combustion.

Table A3 – Production, emission of CO2 and emission factors of clinker by kiln type in the EU-28

Year	Dry with pre-heater and pre-calciner	Dry with pre-heater without precalciner	Dry without pre-heater (Long dry KILN)	Mixed KILN type	Semi-wet / semi-dry	Wet / shaft KILN	Total
Total production volumes of clinker | Grey cement (Mt clinker)							
2005	75.08	55.90	5.53	16.99	15.36	8.38	177.25
2006	78.49	57.50	6.10	17.07	15.36	8.76	183.28
2007	81.52	60.91	6.31	17.38	15.16	9.54	190.83
2008	76.00	58.52	6.03	15.13	13.56	8.98	178.21
2009	65.46	46.26	4.38	10.93	10.37	6.05	143.46
2010	62.46	46.16	6.77	10.92	9.58	6.01	141.91
2011	61.00	45.45	6.83	10.32	9.32	6.69	139.60
2012	58.08	36.23	9.23	7.23	9.90	4.27	124.95
2013	57.05	34.62	8.23	6.89	9.24	4.03	120.06
Total gross CO2 emissions (excluding CO2 from on-site power generation) - Grey cement - (Mt CO2)							
2005	63.87	47.66	4.83	15.11	13.46	8.58	153.51
2006	66.43	49.13	5.33	14.87	13.48	9.14	158.37
2007	69.26	52.31	5.52	15.26	13.42	10.06	165.83
2008	64.19	50.07	5.27	13.14	11.92	9.42	154.01
2009	55.33	39.27	3.76	9.24	9.03	6.10	122.72
2010	52.78	39.24	5.66	9.29	8.43	6.03	121.44
2011	50.76	38.49	5.72	8.68	8.12	6.61	118.38
2012	47.98	30.24	7.71	6.10	8.79	4.27	105.09
2013	46.58	28.90	6.56	5.81	7.84	4.00	99.69
Emission factors (tCO2/t clinker)							
2005	0.85	0.85	0.87	0.89	0.88	1.02	0.87
2006	0.85	0.85	0.87	0.87	0.88	1.04	0.86
2007	0.85	0.86	0.87	0.88	0.89	1.05	0.87
2008	0.84	0.86	0.87	0.87	0.88	1.05	0.86
2009	0.85	0.85	0.86	0.85	0.87	1.01	0.86
2010	0.85	0.85	0.84	0.85	0.88	1.00	0.86
2011	0.83	0.85	0.84	0.84	0.87	0.99	0.85
2012	0.83	0.83	0.83	0.84	0.89	1.00	0.84
2013	0.82	0.83	0.80	0.84	0.85	0.99	0.83

Source: GNR project. http://www.wbcsdcement.org/GNR-2013/index.html