IMPACTS ON AIR QUALITY FROM EU-ETS AND IPPC IMPLEMENTATION IN ROMANIAN IRON&STEEL PLANTS

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Abstract: Human activity and natural processes lead to emissions of several gaseous and particulate compounds into the atmosphere affecting both air quality and climate. It is widely recognized that measures to abate air pollution and greenhouse gases often target the same emissions. In order to comply with legislations introduced to address air pollution as well as climate change the Romanian iron and steel industry has reacted by improving technology and the quality of raw materials and also by optimizing production chains.

Key words: *air quality, climate change, Romanian iron and steel industry*

INTRODUCTION

The manufacture of iron and steel has a complex industrial structure. Iron and steel industry uses, handles, stores or undertakes important amounts of raw materials, fuels, energy, gases, wastewaters and different types of wastes and almost half of the input ends up as off-gases, process gases and solid production residues (Stahl, 2008).

The main technological routes for iron and steel making are:

- integrated route (BF/BOF route) based on iron ore and coke used in blast furnaces and follows by basic oxygen furnaces and rolling mills. The oxygen conversion process consists of blowing oxygen under pressure into the converter previously charged with liquid pig iron and scrap. The oxygen is injected until the bath is completely transformed into steel. In 2011 this was the main technological route in the world with a 69.4% share of total production. At EU 27 level this route was also the main route with a share of 57.4% , (World Steel Association, 2012)
- electric route (EAF route) based on melting scrap using the thermal energy from electric arcs struck between graphite electrodes. Electric arc furnaces (EAF) range in size from small units of approximately one ton capacity used in foundries for producing cast products and up to about 400 ton units used for secondary steelmaking. In 2011, in the world this technological route represent a share of 29.4% from total production, and 42.6% at EU-27 level, (World Steel Association, 2012).

The open heart technology (OH) represent an old technology, and the liquid steel produced with this technology represent a small share of the total liquid steel production (1.1% from world production and 0% in EU-27, in 2011), (World Steel Association, 2012).

In Romania, the iron and steel industry was based initial on local iron ore and coal reserves, and was build using integrated route (but equipped with open heart furnaces). After 1989 the Romanian iron and steel industry had to meet global challenges and requirements on raising product quality, optimize production chains and environmental protection. In the last 20 years, types and the weights of the technologies used were changed. The main changes are the closure of all integrated routes based on open heart furnaces (table 1) since 2000 and also the change in share of liquid steel manufactured on EAF route (Steel Statistical Yearbook, 2012), (Steel Statistical Yearbook, 2009), (Steel Statistical Yearbook, 1999).

Table 1. Romanian iron and steel plant and steel making route

Iron & steel plant/ city	Founding year	Steel making route	
		Past	Actual
Galati	1961	BF/BOF	BF/BOF
Hunedoara	1882	BF/ OH	EAF
Targoviste	1973	EAF	EAF
Campia Turzii	1920	EAF	EAF
Resita	1771	BF/OH	EAF
Otelu Rosu	1796	EAF	EAF
Calarasi	1976	EAF	EAF

Also, the iron and steel technology were marked by the optimization and refined of classical methods of production at various stages (electric arc furnaces, blast furnaces, etc.) rather than a mass introduction of radical new technologies. These improvements allowed significant reductions in energy use and pollution, whilst increasing product quality.
The main quantity of steel produced in Romania in the period 1992-2011 was produced on integrated route (BF/BOF) with a maximum share of 82% (in 2002) and a minimum of 49% (in 2011). BF/BOF steel production recorded a minimum value of 1790 kt in 2009 due the economic crisis and the maximum value was recorded in 1998 (4,690 kt) and 2006 (4,682 kt).
Electric steel production in the analyzed period (1992-2011) had also a variation in quantity, starting from a minimum 842 kt (in 1999) and reaching a maximum of 1,995 kt (in 2011). At the same time, analyzing the dynamics of total weight of electric steel, there is a significant variation between 15 to 51%.
Because the environmental impact of these two technological routes is different in magnitude (impact of manufacturing of electric steel is lower than steel produced on BF/BOF route) the change in weights of technological routes and the improvements made in technologies led to an improvement of air quality and reduction of greenhouse gases, (Strezov, V., Evans A and Evans T, 2013). Parts of the technological improvements were required in order to comply with the IPPC directive, and many Romanian iron and steel plants have to fulfil these requirements according to the compliance plans.

IMPACTS OF EU-ETS IMPLEMENTATION

Climate change issues, including CO2 emissions reducing, became a priority for Romania, especially after the Kyoto Protocol ratification by Law no. 3 / 2001. According this Protocol, Romania must reduce its greenhouse gases emissions by 8% against 1989 base year.
After EU accession on January 1, 2007 and requirement of the Directive 2003/87/EC implementation, on the European Union Emissions Trading Scheme (EU-ETS), Romanian industrial units assigned additional responsibilities in addition to those already existing by Kyoto Protocol applying.
Generally, there are two main types of evaluation, monitoring and validation methods of CO2 emissions occurring in iron and steel industry:

- a method based on the values of the steel output and of the factors of emission recommended by IPCC, this being an useful method, for ETS equipments (included within the European Trading Scheme for CO2 emissions), as for those non-ETS (which are not included within the EU ETS);
- the Carbon balance for a certain technological route, realized on the amount references of fuel, raw materials and materials with Carbon content (input-output), for a certain time range (monthly, yearly etc.) – method recommended for ETS equipments.

The total CO2 emissions, generated by an iron and steel works, represents the sum of direct emissions exhausted into the atmosphere by the respective unit and of indirect emissions, due to the electric energy consumption (emissions exhausted into the atmosphere by the electric energy producer). The direct emissions represent the sum of emissions generated within the technological processes and of those resulting from the combustion processes.
The direct amount of CO2 emissions (tons) generates by an iron and steel plant is equal to the number of emission certificates accepted by the validation authority for the reporting year (used emission certificates).
In the table 2 are showed the CO2 emissions released from Romanian iron and steel plant included in EU-ETS, from both technological routes. These data are based on reports regarding CO2 emissions verified and validated by independent reviewers, accepted and published by National Registry of Greenhouse Gases Emissions, (Emisii CO2 verificate 2011, 2012), (Emisii CO2 verificate 2010, 2011), (Emisii CO2 verificate 2009, 2010), (Emisii CO2 verificate 2008, 2009), (Emisii CO2 verificate 2007, 2008).

Table 2. Quantities and CO2 emission factor from Romanian iron and steel plants

Year	CO2 emissions, tons			Emission factor, tCO2/t steel		
	Total	BOF route	EAF route	national	BOF route	EAF route
2007	10172141	9750598	421543	1.62	2.24	0.22
2008	7859540	7586062	273478	1.56	2.27	0.16
2009	3958173	3799190	158983	1.43	2.12	0.16
2010	4812842	4583475	229367	1.29	2.30	0.13
2011	4481488	4248582	232906	1.16	2.26	0.12

In the period 2007 -2011 the national emission factor for EAF route decreased by 48% (from 0.22 tCO2/t steel in 2007 to 0.12 tCO2/t steel in 2011), mainly because of technologies improvement and higher quality of raw materials. Despite the technological improvements made in the process of steelmaking on BOF route, the CO2 emission factor not follow the same path with the EAF emission factor, mainly cause of the complexity of the process and the lack of flexibility in on/off the production process. Due to the above and change in weights of production processes, at national level the emission factor decreased by 28%, from 1.62 tCO2/t steel in 2007 at 1.16 tCO2/t steel in 2011.

IMPACTS OF IPPC DIRECTIVE

Air pollution is a local, regional and transboundary problem caused by the emission of specific pollutants, which either directly or through chemical reactions lead to negative impacts. Each pollutant produces a range of effects from mild to severe as concentration or exposure increases. The Air Quality Directive 2008/50/EC, which replaced many of the previous EU air quality legislation - complemented by Directive 2004/107/ EC - set legally binding limits for ground-level concentrations of outdoor air pollutants such as PM and nitrogen dioxide (NO2).

The most problematic pollutants in terms of harm to human health for Europe are, in the present, the PM and O3 emissions (Air quality in Europe, 2011). Efforts made between 1999 and 2009, to reduce emissions of pollutants have resulted in a considerably decreased value of PM precursor emissions in the EU (SOx emissions with 56 %, NOx by 28 %, and NH3 by 11 %). Regarding emissions of primary PM10 and PM2.5 these are decreased by 16 % and 21 % respectively in the same period. (Air quality in Europe, 2011). Also, air quality co-benefits of greenhouse gases reduction policies could offset a large fraction of the cost of the reductions with the greatest potential for co-benefits in the developing world (Nemet, G.F., Holloway, T., Meier, P., 2010).

The main pollutants released from iron and steel plants are total suspended particulates (mainly PM10), SO2 and NOx. For the impact assessment on air quality of measures taken by Romanian iron and steel industry in order to comply with Integrated Polution Prevention and Control (IPPC) and air quality legislation, were used data from AirBase database system of the European Environmental Agency (EEA). The types of stations selected were industrial types and for type of area were urban types, in order to be representative for the selected purpose. Another criterion of selection of stations was the shortest distance from industrial site. The main problem is the lack of enough data, means that data not cover all the years and all the cities where are located the iron and steel plant, in order to permit a consistent analysis. Despite this drawback, some conclusion about the emissions level and trends can be done. Due the frequent changes in environmental legislation in terms of adopting more restrictive limit values for atmospheric pollutants, the selected period was 2007 - 2010, because we can compare the measurement results with the same limit values.

The main constituent of the particulate matter emitted in iron and steel processes are iron oxides. Along with these in dusts and fumes in workplace air can be present volatilize heavy metals (Zn, Cr, Ni and Mn) issued from processes conducted at high temperatures, (Tsai, J-H. Lin K-H, Chen C-Y, Ding J—Y, Choa C-G, Chiang H-L, 2007).

The statistical indicators regarding values of PM10 measured in period 2007 – 2010 in points located near industrial sites (table 3) show that the annual values of concentrations are below the threshold value (40 µg/m3). Also, almost the 95% of daily concentrations are below the threshold value, except the Calarasi (in 2007) and Targoviste (in 2010), but only for Calarasi the number of days with concentration higher than daily threshold value is higher that number provided by legislation (35 days).

Table 3. The statistical indicators regarding PM10 concentration values

Iron & steel plant/ city	Steel making route	Year	Annual mean value, µg/m^3	Maximum daily value, µg/m^3	95 percentile daily value, µg/m^3	Days with conc. > 50 µg/m^3
Calarasi	EAF	2007	35.5	119.2	75.8	50
Galati	BF- BOF	2008	22.6	87.2	48.5	14
Hunedoara	EAF	2009	22.3	81.7	47.2	11
Targoviste	EAF	2009	19.7	50.1	41.3	1
Resita	EAF	2009	21.0	70.3	45.8	10
Targoviste	EAF	2010	22.9	78.4	51.7	17
Resita	EAF	2010	21.7	68.3	47.0	9

In order to show the trend in terms of the impact of technological improvements made by steel plant situated in Calarasi city on PM10 emissions, the main statistical indicators are analyzed (table 4). The maximum annual mean value was registered in 2004 (50.8 µg/m3) and the minimum value in 2007 (35.5 µg/m3). The greatest reduction was for maximum daily value that has decreased with more than 50% from 256.0 µg/m3 in 2003 to 119.2 µg/m3 in 2007.

Table 4. PM10 emissions trend from a Calarasi iron and steel plant

Year	Annual mean value, µg/m^3	Maximum daily value, µg/m^3	95 percentile daily value, µg/m^3
2003	43.1	256.0	85.2
2004	50.8	221.5	114.1
2005	41.9	169.7	90.1
2006	42.8	135.0	91.0
2007	35.5	119.2	75.8

The statistical indicators regarding values of SO2 measured in period 2007 – 2010 in points located near industrial sites (table 5) show small annual concentration values. Also the maximum daily concentrations are lower than the threshold value (125 µg/m3) for all the measurement points.

Table 5. The statistical indicators regarding SO2 measured concentration values

Iron & steel plant/ city	Steel making route	Year	Annual mean value, µg/m^3	Maximum daily value, µg/m^3	95 percentile daily value, µg/m^3	Days with conc. > 125 µg/m^3
Calarasi	EAF	2007	9.0	47.3	24.9	0
Calarasi	EAF	2008	6.9	38.8	17.2	0
Hunedoara	EAF	2009	4.4	15.9	8.2	0
Targoviste	EAF	2009	11.7	57.2	24.3	0
Targoviste	EAF	2010	20.2	55.4	37.5	0
Resita	EAF	2010	6.0	32.9	13.8	0

Regarding the NO2 measured concentration values in period 2007 – 2010, the statistical indicators (table 6) show that the annual concentration values are lower than the threshold value (40 µg/m3), but the maximum hour concentration (200 µg/m3) is exceeded once in Calarasi in 2007 (235.2 µg/m3) and also once in Targoviste in 2009 (210.3 µg/m3).

Table 6. The statistical indicators regarding NO2 concentration values

Iron & steel plant/ city	Steel making route	Year	Annual mean value, µg/m^3	Maximum hour value, µg/m^3	95 percentile hour value, g/m^3	Hours with conc. > 200 µg/m^3
Calarasi	EAF	2007	5.4	235.2	37.7	1
Calarasi	EAF	2008	8.4	62.2	20.7	0
Galati	BF- BOF	2008	14.8	77.5	32.9	0
Targoviste	EAF	2009	24.2	210.3	65.1	1
Otelu Rosu	EAF	2009	10.5	86.1	25.9	0
Targoviste	EAF	2010	25.4	163.0	61.1	0
Otelu Rosu	EAF	2010	12.3	82.2	29.4	0

Comparative analysis of current CO2 values of the romanian iron and steel plants with those that can be reached through full implementation of Best Available Techniques (BAT), recommended by Best Available Techniques Reference Documents (BREF) reveals a potentially important decrease in emission factors. Thus for the romanian BF/BOF route is possible a reduction with 15% of direct CO2 emissions and for romanian EAF route a decrease with 35% from total CO2 emissions (mainly because of the necesity of decrease of electricity consumptions), (Melinte, I. , Balanescu, M, 2010).

CONCLUSIONS

Air quality and climate change can be tackled together by defining policies and measures developed through an integrated approach. As a result, improving understanding of air pollution and developing and implementing effective policy to reduce it, remains a challenge and a priority.

In order to meet global challenges and requirements in raising product quality, optimize production chains and environmental protection, the Romanian iron and steel industry has passed through a vast restructuring process in the last 20 years. Also the change in weights of technological routes and the improvements made in technology has led to reduction of greenhouse gases and an improvement of air quality.

In the period 2007-2011, the value of the national CO2 emission factor decreased by 28% as a result of the important reduction of EAF emission factor (48%) and changes in weights of technological routes. The full implementation of IPPC directive will bring another important reduction of CO2 emissions in both technological routes.

Also, the measures taken by Romanian iron and steel industry in order to comply with IPPC Directive and air quality legislation led to reductions in emissions of air pollutants specific to this industry (PM10, SO2 and NOx).

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