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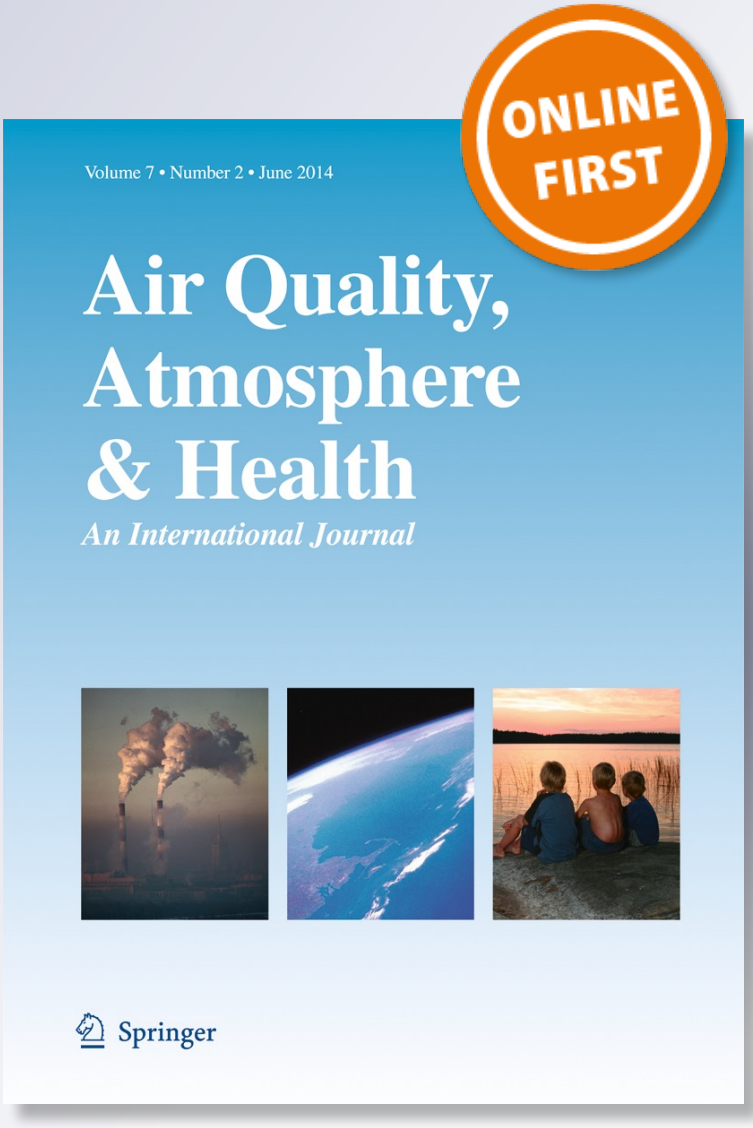

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Abstract The European Integrated Pollution Prevention and Control (IPPC) came into force in 1996. In 2010, the EU Parliament approves the Industrial Emissions Directive (IED) that abrogates the IPPC directive. This directive lays down measures designed to regulate emissions arising from the activities of large European industries which recorded a constant decrease from 1990 to 2011. This trend refers especially to SO_x/SO_2 partly because of some technical changes such as the use of natural gas in the 1990s instead of coal and lignite. We can state that the 2008–2009 crisis is the most serious, affecting not only production but also other key economic sectors such as energy consumption. The aim of this work is to discuss relevant topics such as the current situation of industrial emissions in Europe and the trend of the industrial emissions since the promulgation of the directive. We also discuss the directive's main application tools which are the best available techniques reference documents and the best available techniques that show some weakness. For instance, the "concentration approach" for measuring emissions does not comply with the environment and health problems, because it sets no limit to the production. We absolutely need to improve above mentioned tools if we want to reduce the emission of pollutants to acceptable levels, in spite of the European financial condition. The IPPC aimed at accelerating the reduction trend of the industrial emissions especially between 2000 and 2011. In conclusion, we still haven't found evidences of significant results of its implementation as the emissions behaviour is also strongly influenced by the economy.

Keywords Industrial emissions · Directive IPPC · BREF · BAT · Directive IED · Human health

Abbreviations

BAT	Best available techniques
BAT-AEL	Best available techniques associated emission levels
BREF	Bat reference documents
CEPI	Confederation of European Paper Industries
CIFOR	Center for International Forestry Research
CLRTAP	Convention on Transboundary Air Pollution
ECF	Elemental chlorine free
EEA	European Environment Agency
EEB	European Environmental Bureau
ELD	Environmental Liability Directive
ESP	Electrostatic precipitators
E-PRTR	European Pollutant Release and Transfer Register
IED	Industrial Emission Directive
IPPC	Integrated Pollution Prevention and Control

Introduction

In 1996, the EU promulgates the Integrated Pollution Prevention and Control (IPPC) directive (Directive 96/61/EC) (European Union 1996). The 1996 document is an

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outstanding piece and it was updated in recent years (Directive 2008/1/EC). The IPPC directive determines the framework of reference for each EU member states, for the issue of Integrated Environmental Authorization for industrial activities listed in Annex I of the Directive IPPC. The IPPC directive was abrogated and is now included in the Industrial Emission Directive (IED 2010/75 EU). The main tools of the IED, organized for each industrial sector, are the "best available techniques" (BAT) and best available techniques reference documents (BREF), which contain the BAT and other important definitions.

In order to reinforce some aspects of the IPPC, the EU Parliament implements other important regulatory documents such as the Environmental Liability Directive (ELD) (2004/35/EC) that applies the "polluter pays" principle. Moreover, the environmental protection against environmental crime is ruled by Directive (2008/99/EC), i.e. "Protection of the environment through criminal law". This directive punishes the industrial or agricultural activities that cause serious environmental harm. In 2010, as above reported, the EU Parliament approves the IED that abrogates the IPPC directive in order to take further steps to reduce emissions from industrial production processes. IED entered into force on January 6th, 2011 and had to be transposed into national legislation by member states by January 7th, 2013.

Several years have passed, and during this period, both the European Parliament and the member countries have not given up their commitment to improve the environmental situation. It is time to ask if the IED directive actually fulfilled its objectives.

The aim of this work is to discuss a series of relevant topics. First, we analyse the current situation of industrial emissions in Europe. Second, we discuss the trend of the industrial emissions since the IPPC promulgation.

The logical steps of implementation of the directive start with the approval of the BREF/BAT and continue with its application by the member states. The result of this last step is the number of IPPC certificates (permits) granted to several industries throughout Europe. In theory, a large number of certified plants is supposed to grant lower emission levels. Are the abovementioned measures enough or has the IPPC failed one or more stages of its implementation programme?

We have a section for each topic, accompanied by a critical analysis also in connection with the economic crisis which for almost a decade affected the implementation of the directive.

The current status of industrial emissions in Europe

In order to have reliable information on the current state of the European emissions listed in Annex III of the IPPC directive and its evolution, we need an overview of the industrial production since 2001.

Unfortunately, there aren't detailed information on emissions. Thus, we need to perform an inference analysis of several available data sets. The most relevant data set is the European Pollutant Release and Transfer Register (E-PRTR), with nearly all of the IPPC pollutants released, but only referred from 2007 to 2011. The register was created by Regulation (EC) No 166/2006 of the European Parliament and of the Council of January 18th, 2006 and contains data from about 28,000 industrial facilities covering 65 economic activities in Europe (European Parliament 2006). It is an important tool, relatively new even if not fully yet implemented. From the statistical and environmental point of view, the register shows two weaknesses: the E-PRTR has two threshold levels (one for the capacity of the facilities and one for each contaminant). This information is confidential and the companies (facilities) can decide whether to declare their name or not (European Commission 2006). Firms are required to declare their emission levels to the E-PRTR only if they exceed thresholds limits in order to be included in the registry for statistics purposes. However, some do not have to declare their emission levels even if they represent a significant percentage contributing to the total emissions.

Another relevant set of information is given by the European Environment Agency (EEA) and the Convention on Transboundary Air Pollution (CLRTAP), both available in the pages of Eurostat, a Directorates-General of the European Commission. This data set allows us to follow the evolution of the emissions of sulphur oxides (SO_x/SO_2), nitrogen oxides (NO_x/NO_2) and non-methane volatile organic compounds (NMVOC) in member countries (EU 27), from 1990 to 2010. Figure 1 is based on the Eurobase "Air Pollution" data set (Eurostat 2013).

It reports the values for the sectors "Energy production and distribution" and "Energy use in industry". In the same figure, we also add the values of NO_x/NO_2 and SO_x/SO_2 emissions reported in the E-PRTR (2007 to 2011) (E-PRTR 2013). The result almost fit the SO_x/SO_2 emission levels of

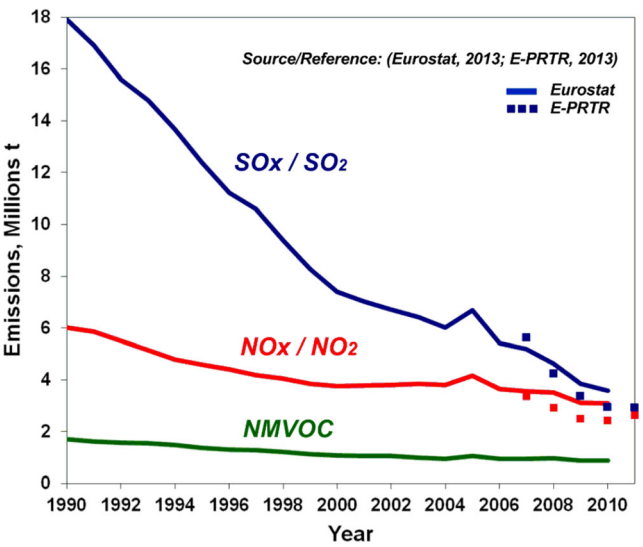

Fig. 1 EU 27 air pollutants emissions trend

both data sets because the sectors producing energy are the biggest sulphur dioxide emitters. The differences between nitrogen dioxide and NMVOC (not shown) trends are logical, since the sectors that generate these pollutants are more numerous in the E-PRTR. However, the trend of all three pollutants should not differ in both data sets if the factors governing their evolution are general principles and not just sectorial trends.

Figure 1 stresses out how from 1990 to 2011 emissions constantly decrease. This trend refers especially to SO_x/SO_2 partly because of some technical changes such as the use of natural gas in the 1990s instead of coal and lignite (European Environment Agency2007) and the reduction of sulphur in industrial gas-oil. From 1990 to 2000, emissions fall very fast and there is clearly a slowdown from 2000 to 2006, with only a slight emission peak in 2005. From 2007 to 2010/2011, emissions continue to decrease generating a plateau-like trend.

Similar trends to those described in Fig. 1 for CO, PM_{10}, dioxins and furans, PAHs (1990–2010) and $PM_{2.5}$ (2000–2010) are reported in a recent report of the EEA in the "Industrial processes" and "Energy use in industry" sections (European Environment Agency 2013a).

Figure 2 shows the four fitting curves built with the same data of Fig. 1 (E-PRTR data not included). Data were processed with Table Curve 2-D version 5.0, SPSS. The general fitting curve (1990–2010) and the fitting curves for the periods considered (i.e. 1990–2000, 2000–2006 and 2006–2010) confirm the emissions trend described above.

The three periods we described for industrial emissions can be connected with the economic cycle. From 1990 to 2000, the industrial production maintains a relatively low level (12 % in relative scale) in the European countries (EU 27), even before the 1992–1993 recession. The pre-crisis emission levels are reached only at the end of 1994 and start to grow after 1996; at the end of 2000, the industrial production reaches its highest level since 1990 (53 %) before being strongly affected by "the millennium recession" 2000–2001.

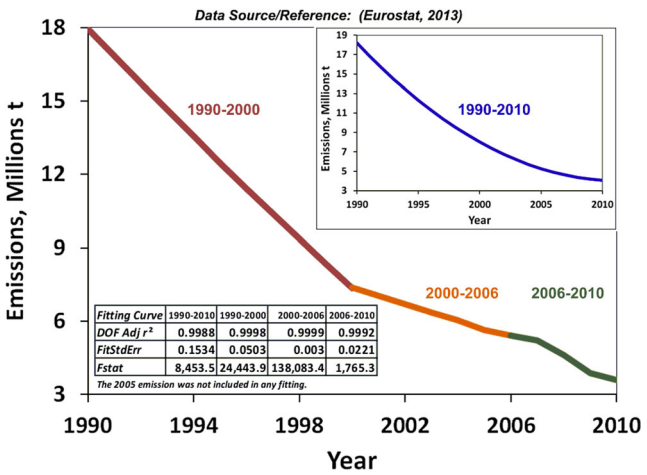

Fig. 2 EU 27 SO_x/SO_2 *fitting curves*

After recession, the production starts to grow again. At the end of 2007, the production level is about 85 %, which is the highest in the decade 1990–2011, but the "financial crisis" (2008–2009) makes the production go back to 1998 levels (i.e. −35 %). By the end of 2011, we notice an increase up to 64 %. We can state that the 2008–2009 crisis is the most serious, affecting production as well as other key economic issues including energy consumption. In 2007, the industrial value added was 20 % higher than in 1995. This percentage dropped to 10–11 % in 2009. In 2007 and 2009, the EU 22 investment ratio was 0.37 and 0.32, respectively, for the sector generation and delivery of electricity, gas and water; 0.18 and 0.16 in the chemical industry; 0.17 and 0.14 in manufacturing and 0.16 and 0.12 in the pulp, paper and publishing sector. Also Germany, France, the UK and especially Italy and Spain had to face the financial crisis (European Commission 2011).

The industrial consumption of energy started to drastically decrease in 2004 and collapsed in 2008. This trend was partially recovered in 2011(Eurostat 2012).

The emissions trend shown in Fig. 1 can be explained as follows: from 1990 to 2000, the dramatic decrease is mainly due to three key factors, which are (a) very low level of industrial production, (b) implementation by member countries of their own national environmental policies and (c) strong impact of new technologies in the industry. Some examples of these technologies are more efficient particulate matter control in the industry by using new electrostatic precipitators (ESP), Fabric filters and Wet scrubbers (Ohlström et al. 2006; Mastropietro 2008). Another example is the use of the elemental chlorine free (ECF) bleaching in the pulp industry (FAO 1997) that was included in the IPPC-BAT in 2001. In this context, it is very difficult to point out which of the three factors influenced more the above-described trend.

We haven't still found a clear explanation for the behaviour of emissions from 2000 to 2011, when the industrial production falls to its lowest levels. In fact, Fig. 3 shows EU 27 emissions vs industrial production (million tons) and depict the decreasing trend of the SO_x/SO_2 emissions connected with the economic crisis period (since 2007/2008) when the industrial production decreased.

The IPPC directive aimed at accelerating the reduction trend of the industrial emissions especially between 2000 and 2011. However, we still haven't found evidences of significant results of its implementation as the emissions behaviour is also strongly influenced by the economy.

Table 1 summarizes non-GHG emissions for 11 contaminants during 2011, from the 2007–2011 data set updated in 2013 (E-PRTR 2013); these pollutants were selected as representative emissions of the most important industrial sectors. For example, CO, PM_{10} and PAHs are common to all sectors with combustion facilities; the PAHs are typical indicators of biofuels. All of them are highly dangerous pollutants which can affect both for human health and the environment.

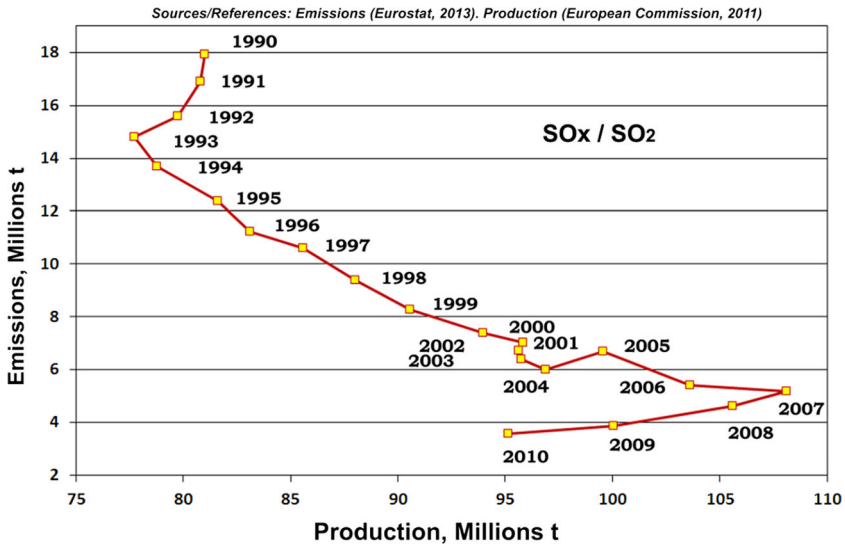

Fig. 3 EU 27 air emissions vs. industrial production

The most emitting industrial sectors (including those reported in Table 1) are as follows: energy sector, production and processing of metals, mineral industry, chemical industry, waste and waste water management and paper and wood production processing (including production of pulp from timber or similar fibrous materials, papers and board) (E-PRTR 2013).

From Table 1, we observe that out of 28,000 facilities reported in the E-PRTR, only 543 declared CO emissions, 491 PM_{10} and just 250 dioxins and furans. Above mentioned data point out that most industries don't give information on their emission levels. We therefore don't know if they are off threshold or not. We also noticed (Table 1) that most emission values are still very high, particularly CO, sulphur and nitrogen oxides, dioxins and furans. If we consider release per facility, we get an average of more than 1,000 t/year by facility, which is still too high.

In fact, in 2007, the European Commission reported:

> *The industrial emissions in the European Union remain too high and are having negative effects on human health and the environment. Clearer rules are strict and necessary to ensure that the industrial basis of the necessary high environmental standards in across the EU. The European Union must ensure that companies meet their obligations and use the best available techniques* (European Union 2007).

Moreover, on 18th December 2013, the European Commission made three proposals to the European Parliament: "A Clean Air Programme for Europe", on the reduction of national emissions of certain atmospheric pollutants, on the limitation of emissions of certain pollutants into the air from medium combustion plants (i.e. *"…a growing category of small power plants whose emissions of air pollutants are not yet subject to any EU limits"*) and on the acceptance of the Amendment to the 1999 Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution to combat acidification, eutrophication and ground-level ozone (European Commission 2013a).

This recent document pinpoint out the alarming situation on the EU emissions and its implications on economy and human health:

> *… Despite these successes, the EU is still a long way short of its long-term goal - to improve air quality to such a level as to eliminate significant harm to human health and the environment…In 2010, an estimated*

Table 1 E-PRTR 2011. Eleven pollutant releases

All EU 27 reporting states, by region

Compounds	Releases (*t*)	Facilities (*n*)
Carbon monoxide (CO)	3,340,188	543
Nitrogen oxides (NO_x/NO_2)	2,631,786	2,541
Sulphur oxides (SO_x/SO_2)	2,925,196	1,237
Non-methane volatile organic compounds (NMVOC)	419,888	842
Particulate matter (PM 10)	151,473	491
Total nitrogen	394,028	1,175
Total phosphorus	38,043	1,029
Polycyclic aromatic hydrocarbons (PAHs)	220	154
Mercury and compounds (as Hg)	34	831
Cadmium and compounds (as Cd)	28	527
Total	9,900,884	9,370
PCDD + PCDF (dioxins + furans) (as g-Teq)	991	250

None accidental releases to air, water and soil. Omissions on confidentiality do not substantially alter the values. All facilities reporting in this year (2011). Source: E-PRTR Official Web Page. Interactive Statistic. http://prtr.ec.europa.eu/PollutantReleases.aspx

400000 people died prematurely from air pollution in the EU, and almost two-thirds of the EU land area was exposed to excess nutrients from air pollution. The damage to health has a huge economic cost, estimated at EUR 330-940 billion (3-9 % of EU GDP) ("Citizens' summary" companion document).

The most important emissions that have to be considered in the proposals are as follows: PM (PM_{10} and particularly $PM_{2.5}$), SO_2, NO_x/NO_2, ground-level O_3, NH_3 and VOCs. The strategies for the reduction of these emissions are essentially to strengthen national policies and to promote the application of the existing EU air quality management framework. The achievement of these objectives are planned for 2020 (emissions reduction) and 2030 (population health improvement).

In new estimates recently released (March 2014), the World Health Organization reports a direct link between air pollution (ambient and household) with human health. This report states that in 2012, around seven million people died as a result of air pollution exposure. The estimation for Europe, considering only ambient air pollution, is about 480,000 people's deaths (WHO 2014).

The IPPC directive, 1996–2008

The IPPC directive (European Union 1996) has three relevant aspects: the first and most important is a series of statements and articles that define the purpose or essence of the legislation. The second is related to the application of the "best available techniques" (BAT) that are essential in the authorization process. The third aspect implements the mechanism aimed at establishing and updating the BAT for each industrial sector. These are basically regular meetings, consisting in *"an exchange of information between EU Member States, industries and non-governmental organisations (NGOs) concerned on best available techniques."* (Decision 2012/119/EU). The results of these meetings are reported in a reference document (BREF), which contains the BAT and the emissions level associated with the use of particular combination of BAT (BAT-AELs). However, by definition, a BREF is a descriptive document and it does not prescribe the use of any technique or specific technology, nor does it interpret IED. These aspects will be fully debated hereafter.

We report the essence of the IPPC (European Union 1996):

The purpose of this Directive is to achieve integrated prevention and control of pollution …It lays down measures designed to prevent or, where that is not practicable, to reduce emissions in the air, water and land… including measures concerning waste, in order to achieve a high level of protection of the environment taken as a whole…

…'best available techniques' means the most effective and advanced stage in the development of activities and their methods of operation which indicate the practical suitability of particular techniques for providing in principle the basis for emission limit… 'best' means most effective in achieving a high general level of protection of the environment as a whole.

"The permit shall include emission limit values for polluting substances, in particular those listed in Annex III…" Annex III shows a basic and incomplete list of pollutants emitted into the atmosphere and in water. Dioxins and furans are referred to as "air" pollutants; particulate matter appears only as "dust", without mentioning $PM_{2.5}$ or ultrafine particles (UFP).

If we consider the essence of the IPPC directive, it is clear that the environmental protection must be seen in its whole. For instance, "river" means not only water, but also the surrounding atmosphere and the ground, biota etc. Thus *"if part of the ecosystem is damaged, the whole is affected"* (Bourdeau and Treshow 1978; Dai et al. 2013; Helbing 2013). But, unfortunately, there is no specific mention of the ecosystem inhabitants' health. This aspect is lacking and in fact, "human health" is mentioned only in the definition of "pollutant" (European Union 1996).

The BREFs (IPPC directive, 1996–2008)

The first stage of the implementation of the IPPC directive is to approve the BREF and BAT for the different industrial sectors. Key questions are as follows: *does the essence of the IPPC respect these rules? Are they sufficiently strict or too permissive? Can the proposed action plan be applied? How much pollution is too much?*

The implementation of a BAT requires much work. We often have to face a conservative legislation which is not always interested in developing the necessary changes and promoting innovative trends. Our first challenge is to give a suitable quantification of the environmental benefits of a BAT. It seems that the only way to evaluate a BAT is to use a qualitative approach combined with expert judgement (Dijkmans 2000). Recently, new methods have been proposed to help stakeholders (industrialist, authorities) on the evaluation of existing BAT techniques. For instance, the life cycle assessment (LCA) (Ibáñez-Forés et al. 2013), L-BAT methodology (Cikankowitz and Laforest 2013) and decision-making tool based on a multicriteria analysis approach (Laforest et al. 2013). All these methodologies represent an improvement in the BAT selection process.

If we consider the financial aspect, IPPC compliance does not only require more investments but also affects future profits as BAT implementation costs are too high. In some cases, the lowest emission level required is "beyond BAT" because of technical constraints and/or economic issues (Schoenberger 2009). On the other hand, investment in BAT

compliance can also be considered an advantage that allows firms to enhance their market value (Cañón-De-Francia et al. 2007) and eventually to improve the productivity and flexibility (Giner-Santonja et al. 2012). Anyway, it is extremely difficult to give an appropriate analysis of the BAT for all main industrial sectors and try to summarize it in this work. Certainly, there are some common factors (unit operations, standard equipment, other), but a detailed analysis of BAT requires experts in every single industrial sector.

Here, we discuss two important aspects of the BREF. We refer to the "List of Emissions and Expression of Emissions Levels Associated with the BAT".

The list of pollutant emissions "associated with the BAT" in the IPPC directive is inadequate and too short, for the six most pollutant industry sectors. In general, the parameters selected are the most commonly used in mills operation. It is however worth noting that those relevant for the environmental performance are still lacking: persistent organic pollutants (POPs), heavy metals, NMVOC and PAH are not present in most BREFs. These lists have not even considered Annex III of the directive or the international experience concerning those industries and their environmental impacts.

Surprisingly, the BREF committee didn't take into account the list of pollutants used by the E-PRTR (from 2007), which is very similar to Annex III previously mentioned. In both cases, the most relevant omissions are those related to POPs and other persistent bio-accumulative compounds that are dangerous even if emitted in trace amounts for each industrial unit.

The other issue in BREFs is the "Expression of Emission Levels" for each pollutant associated with the BAT. "Mg/Nm^3" or "mg/m^3" is the usual expressions of emissions in air and water in most BREFs. For instance, speaking of pulp, paper and board industry, "mg/Nm^3" and "mg/t" produced have been the standards for a long time. The way of measuring emissions should be changed with "mg of pollutant per ton produced" in order to check the efficiency of a plant. The "concentration approach" in measuring emissions has little to do with environment and health problems, as there is no limit to production and consumption of resources.

As a matter of fact, if emissions are due to the production in its whole, most BREFs assume that the higher the production, the lesser it affects the environment. This point of view is however unacceptable. The harm produced by the pollutant to the environment is masked by the increment of production: "as the denominator of the expression tends to infinite, the damage tends to zero". The same happens if we take the average of emissions per year. Data averaged yearly disguise all punctual episodes, and danger is reduced by delaying the time for averaging the amount of pollutant.

Let us consider the impact from another point of view. Imagine to monitor a river and its surrounding area. Our purpose is to detect the amount of pollutants (or several emitted compounds). It is also very important to know the rate of accumulation of pollutants, since these data give us the critical levels of the whole ecosystem. "Emission concentration" or "Kg/t produced" is useless in any of the situations described above. In short, the relevant expression for emissions data are the discharge rate (m^3/h) plus the concentration (mg/m^3) of each pollutant, or in other words mass per unit time (kg/h, t/year, other similar). In fact, this is the expression used in all Eurostat documents as well as in the E-PRTR when referring to industrial emissions.

"Mass per unit time" is also the only expression "associated with BAT" really useful for national authorities who must decide the "emission limits", deliver the correct permits and monitor mill operations. Let's fix the limit in terms of "mg of pollutant/t produced" as emission and production levels are strictly related. A 600,000-t/year plant needs to emit double as much as a 300,000-t/year plant. The problem concerns also the mills with levels of production up to 800,000 or 1,000,000 t/year. All theories are however useless if the legislation of member countries does not provide any limits to the plants.

This situation is already present in several EU industries. Please see the report "Distribution of value added by enterprise size in 2007" (European Commission 2011).

As far as the pulp, paper and board industry with a traditional profile of 200,000 to 300,000 t/year concerns, we have now a lower number of factories with greater average size, including mills of 500,000 and more than 600,000 t/year.

In 2001 Europe had about 1,100 mills producing paper and paperboard and 230 producing pulp; in 2011, the former became 800, and the latter 170. In 2001, 8.1 % of paper and paperboard mills and 19.2 % of the pulp mills exceeded 300,000 t/year. In 2011, the respective values were 12.4 and 30.8 % (CEPI 2012). The trend is based only on economic factors, characteristic of an economy of scale and the automation of plants: i.e. the reduction of initial investment per ton of pulp produced, less labour (cost) per production unit and other economic and financial benefits.

This is not a suitable condition for the environment in general and people's health in particular. It increases health risk of nearby populations and affects the environment (see for instance Lee et al. 2002).

The international attitude of this industrial sector is alarming. European companies build and operate numerous Greenfield mills of 1,000,000 or 1,500,000 t/year in Asia and Latin America. The most recent projects for Indonesia are one or two start ups of 2,000,000 t/year (CIFOR 2011). Most of these enterprises were financed with EU, member countries or World Bank funds. All those plants are considered IPPC-BAT compliance and ask to be recognized for their "very high environmental standard"…actually, all of them emit huge amounts of pollutants (European Union 2007; CEPI 2011).

These European companies exported BREF and BAT along with the plants…but taking good care of the business, they

prevented to export the essence of the IPPC directive and the strictest national standards of their countries.

The IED 2010/75/EU

On November 24th, 2010, the European Parliament approved the IED which abrogated the IPPC directive. The target of the new directive was to establish more strict policies for the emission of industrial pollutants, especially in key sectors such as power generation, combustion and co-combustion of different fossil fuels and biofuels (large combustion plants), organic solvents management and others. Two main requirements were implemented: the strengthening of the BREF concept (see also: http://eippcb.jrc.es/reference) and the "emission limit values" (ELVs) established for a discrete number of critical cases within the same directive.

With the IED, some relevant changes were implemented in the BREFs that are as follows:

> *The permit conditions including emission limit values (ELVs) must be based on the Best Available Techniques (BAT), as defined in the IPPC Directive. The IED Directive introduced the … BAT conclusions (documents containing information on the emission levels associated with the best available techniques) also called [BAT_AELs] … shall be the reference for setting permit conditions. To assist the licensing authorities and companies to determine BAT, the Commission organizes an exchange of information between experts from the EU Member States, industry and environmental organizations. This work is co-ordinated by the European IPPC Bureau of the Institute for Prospective Technology Studies at the EU Joint Research Centre in Seville (Spain). This results in the adoption and publication by the Commission of the BAT conclusions and BAT Reference Documents (the so-called BREFs)* (European Commission 2012a).

The main critics of the IED is that there isn't a new criteria to develop a BAT in order to set *"emission levels associated with the best available techniques"* (BAT-AELs) for each industrial sector (Polders et al. 2012). Anyway, this directive will be applied in different steps, from 2013 to 2016, and we will be able to evaluate its results only in the future.

The European Environmental Bureau (EEB) reported relevant issues about the implementation of the IPPC in the IED. For instance, the EEB reports that the legally binding emission limit values (ELVs) are not ambitious enough to provide air quality objectives (European Environmental 2008). Another relevant document (European Environmental 2011) proposes to lower the NO_x ELVs for cement kilns co-incinerating waste from 800 to 500 mg/Nm^3. These actions allow to mitigate the environmental impact but they don't consider the production limit levels. Thus, if no limit of production is considered (i.e. mega plants), the possibilities of pollution are unlimited.

The current status of the BAT-IPPC implementation in Europe

We observe that in a sample of 43,264 existing estimated installations covered by the IPPC directive for 27 member states, the main problem lies in the low percentage of permits issued that agree with the low BAT-IPPC implementation. Data report that until October 30th, 2007, installations covered by the IPPC directive are approximately 44,291 (91 %), with 4,618 (9 %) permits on-going in the EU 27 (European Commission - DG Environment 2009).

Most IPPC permits were issued by Germany and the UK (90 %) followed by Spain (80 %) and Italy (50 %). It is worth noting that the number of permits released is not the same for all member states as in some of them, they need to be issued for each installation, while others need a single permit for more than one installation (European Commission - DG Environment 2009).

The increasing number of permits can be seen as a consequence of the efficiency, which does not necessarily refer to their quality (i.e. BAT-AELs). In fact, in terms of emission limit values (ELVs) and BAT, Germany, Italy, Spain and the UK had some difficulties in applying the principles of the IPPC directive. In fact, most member states have not yet adopted a clear procedure in order to establish a BAT methodology (Goovaerts et al. 2011).

For instance, in Germany, the selection of BAT takes place through national guidelines, and in Spain through the translation of the BREF reports. In Italy, some difficulties arise from the scarce knowledge on the application of BAT and the lack of resources for the IPPC directive implementation. As far as Spain concerns, other problems were observed in the interpretation of the BREF reports by the different regional governments. Moreover, Germany and Spain adopt different criteria for setting ELVs if compared to Italy, the UK and other member states. These criteria aim at a local environmental or high-level emission protection (Goovaerts et al. 2011).

The main problem is the difficulty in using the BREF reports because there is a lack of information on BAT associated with BAT-AEL (BAT associated emission levels). If we consider ELVs and the BAT suggested by the IPPC authorized installations of large combustion plants (LCP), we observe that only about 20 % of the ELVs (NO_x, SO_2, CO and dust) are less or equal to the upper limits of BAT-AEL range averaging period (Goovaerts et al. 2011).

For NO_x, SO_2 emissions and dust (in LCP plants), the emissions were largely below the ELVs declared in the authorizations, but in most cases, they were higher than BAT-AEL (Goovaerts et al. 2011). Most of the emissions in LCP comply with the ELVs stated in the IPPC permit, but they are higher than the BAT-AEL BREF report.

The UK Government published a report with ten case studies on the implementation of the IPPC directive (Defra 2008). The conclusions outline that in some cases, the IPPC permits have been issued without respecting the national regulatory "Sector Guide Notes", thus leading to a conflict between the application and the basic information required for the determination of the permits. Another issue was the inconsistency of the ELVs with the values of BAT-AEL BREF reports (Defra 2008).

In this section, we analyse the BAT-IPPC implementation problems and the IPPC conditions in the authorization processes which can also be a consequence of the economic changes.

Discussion

We are firmly convinced that we have to respect the IPPC essence of 1996, and therefore, all efforts should aim at improving the implementation of the BREFs and BAT. In this section, we would like to remark the following key points:

IPPC: visibility of its results in statistics In "The current status of industrial emissions in Europe", we stress out a real concern about the lack of statistical evidence related to the possible successes of the IPPC drective after 16 years of its promulgation in Europe. Maybe, the European Commission has evidence of these successes through the monitoring of control mills, their status before and after the application of the directive. If available, it would be interesting to publish them in order to understand if and how to improve the environmental and health protection.

Has the economic crisis influenced the BAT-IPPC implementation? The European Commission (2012b) reports investments up to 2.5 % of GDP from 2008 to 2011. From 2005 to 2012 the industrial production in the EU decreased by 10 % as a consequence of the economic crisis and the increase of the energy prices (27 %) (European Commission 2012b). For instance, the pulp, paper and paper product sector progressively increased by more 12 % between 2002 and 2007. But, the production levels in the last months of 2008 clearly decreased, with the pulp, paper and paper products recording a loss of 8.8 % if compared to the outcomes of 2007 (European Commission 2009).

In general, there is not always a clear relationship between emissions' reduction and the detected concentrations of atmospheric pollutants in the air. They are also influenced by an increasing contribution of the long-distance transport of air pollutants from other countries.

The European Commission (European Commission 2012c) reports that crisis is now affecting most member states (EU 27), thus reducing the ability of Europe's political and economic systems to pursue a sustainable development.

Present health risk of industrial emissions suggest the need of the IPPC implementation. Recent works confirm that concentrations of pollutants are still higher than the legal limits recommended by most European countries thus seriously affecting human health. Let's just consider one of this high-level pollutant: PM and ultrafine particles (UFP). Many epidemiological studies confirm a positive correlation between the level of pollution and the increased morbidity and mortality among adults and children, contributing to a reduction in life expectancy (Dockery 2009; Halonen et al. 2009; Krewski 2009; Pope et al. 2009). In fact, studies made near IPPC registered industrial plants recorded increased risk levels for some illnesses in nearby residents. In 8,098 Spanish towns, about 2,146 deaths for pleural cancer related to asbestos exposure were recorded in the period between 1997 and 2006. After 3 years, in 2009, deaths recorded were 183 and 58 among men and women, respectively, (López-Abente et al. 2012). This study shows a positive correlation for pleural cancer mortality between citizens living at less than 2 km from the IPPC registered industries and the pollutant emissions of 24 industrial groups (López-Abente et al. 2012). Workers of paper and board industries show a statistically significant number of lung cancer cases caused by sulphur gases and airborne organochlorinated compound mixtures (Lee et al. 2002), dust wood (Szadkowska-Stańczyk et al. 1998) and inorganic dust pollutants (Szadkowska-Stańczyk and Szymczak 2001). Monge-Corella et al. (2008) surveyed lung cancer mortality in 8,073 towns over the period 1994–2003 in pulp and paper industry (P&PI) in Spain. Even if no association between these industries and lung cancer has ever been observed, we can't ignore it. They observed that only in 2 out of 18 facilities, the risk of mortality was associated with the distance to the installations (50 km). Epidemiological studies conducted by Pirastu et al. (2011) in Italy in the industrial area of Taranto (i.e. "Progetto Sentieri") confirmed the correlation between the emission of industrial gases into the atmosphere and lung cancer deaths (10 % more than the other cancers monitored in the surrounding area). Furthermore, in the same area, Pirastu et al. (2011) recorded an increase of cancer deaths caused by 9 (70 %) to 13 different types of cancer analysed in this study.

The European Commission (European Commission 2013b) found a relationship between the industrial gases emitted into the atmosphere and serious consequences for human health and the environment. They also found that Italy does not warrant ILVA (the mega steel plant in Taranto, South Italy) to meet the EU requirements about industrial emissions (IED).

Weaknesses of the BREFs In "The IED 2010/75/EU", we pointed out the insufficiency of the list of pollutants emissions "Associated with the BAT" as well as the inadequacy of "Expression of Emissions Levels" for each pollutant associated with the BAT.

In order to protect the environment, "IPPC permits" should also consider the production levels. In particular, pulp mills throw into the environment 10–15 t of highly hazardous chemical supplies per 100 t produced (CEPI 2011; EcoMetrix 2010).

It is worth noting that every year in EU 27, around 40 % of workers (80 million people) are exposed to health risk factors and 27 % of them (56 million) to factors that can affect mental well-being (Eurostat Health 2009a). In the EU 27 manufacturing industry, serious work "accidents" are ca. 616,750 every year, with 608 deaths (Eurostat Health 2009b).

BREF responsibility Above-listed drawbacks are actually happening probably because of the limits of the BREFs and BAT and the low influence of the IED in the European industrial activity. In fact, as above reported, a BREF is a descriptive document and it does not prescribe the use of any technique or specific technology, nor does it interpret IED. Another key relevant point with the BREFs is the scarce consideration of the social welfare and the forecast of the possible environmental and health damage connected with a particular BAT.

However, we have several good examples of BAT implementation, i.e by using life cycle assessment in the cement industries (Valderrama et al. 2012) or the use of multicriteria analysis and eco-efficiency analysis for emerging technologies for surface coating (Geldermann and Treiz 2008). But, the concept of BREF responsibility should be expanded including together environmental, economical, risk, health and social aspects.

Conclusions

Industrial pollutant emissions in Europe have decreased since 1990, but the level is still very high and represents a serious risk for people's health. The future trend of emissions is uncertain and the evolution of the economy can influence it.

There is no evidence on the role of the IPPC directive in this trend. We suppose that it has had a positive influence, but it is very hard to prove on the basis of the existing information.

The application of the directive in all EU member countries is quite satisfactory, but still not sufficient. Most major European industries comply with the directive but we need to go on with the implementation of above mentioned measures in order to protect the environment. We need drastic improvements in the BREFs and BAT in order to reduce industrial emissions pollutants to acceptable levels, in spite of the European financial condition.

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