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# Using BAT performance as an evaluation method of techniques

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## **Abstract:**

The European Integrated Pollution Prevention and Control (IPPC) directive compels the more polluting industries to apply Best Available Techniques (BAT) in order to reach an adequate level of environmental protection. In Europe, despite the difficulty of implementing the IPPC directive, there is nowadays an increasing endeavour to develop methodologies for quantitative integrated assessments of pollution, improve the understanding and application of BAT at the installation stage and facilitate their selection for European Reference Documents.

The methodology proposed in this article aims at helping stakeholders (industrialists, authorities) deal with the update of their exploitation licence (i.e. in this case, the French technical report). Taking into account the local context of the studied companies, the methodology focuses on the evaluation of existing BAT techniques and provides a general framework for the assessment of production units and management processes. The methodology is carried out as a four-step procedure involving an environmental and risk performance assessment tool and an evaluation grid for the production unit. Each production unit is rated through an evaluation grid made of six levels of compliance with the performance of BAT. The aggregation of these marks allows the comparison to the IPPC objectives. Finally, the applicability of this qualitative assessment has been validated through several metal finishing facilities.

**Keywords:** IPPC Directive, Best Available Techniques (BAT), French technical report, environmental assessment, metal finishing industry.

## **1. Introduction**

The requirements of the IPPC directive (directive 2008/1/EC abrogating directive 96/61/EC relative to Integrated Pollution Prevention and Control) impose on highly polluting industries in Europe an obligation to apply Best Available Techniques (BAT) in order to reach an adequate level of environmental protection. This European set of regulations is based on four main principles:

- a comprehensive approach to environmental impact (water, air, soil, energy, waste production, etc.) with a mandatory exploitation permit system: this authorization procedure outlines the conditions and provides rules or technical guidelines for industrial sites. This integrated approach also implies the need for the coordination between competent authorities in the effective implementation of this directive. It does not set out a methodology to assist in the integration of its main principles at plant level.
- flexibility or customization (local conditions) : the objective is to ensure that local conditions are taken into account.

- ensuring the application of BAT: this concept is the start of many information exchange activities on BAT (known as the “Sevilla Process”<sup>1</sup>(Schoenberger, 2009)) between European member states, leading to thematic BREFs (BAT REference document).
- encouraging greater participation of stakeholders.

Since 1996, Member States have met considerable difficulties in implementing the IPPC directive. Many studies have been carried out in order to support this implementation and to use the BAT concept to help both industry operators and government legislators. Brechet et al. (2008) pointed out that the first scientific papers gave an overview of the concept and focused on the issues at stake in this directive, identifying possible links with voluntary agreement (Cunningham, 2000) and clean technologies (Silvo et al., 2009). Cikankowitz et al. (2010) analyze the progress of the IPPC implementation in Europe, and more precisely in France, by proposing a synthetic balance of the main “hot spots” of its application. Thanks to this recent review, it is clearly crucial to develop environmental performance assessment methodologies in the IPPC context. This methodology will help operators to compare and to validate their existing techniques as BAT. It would also select BAT for the procedures leading to exploitation permit, at the level of an individual installation. The literature contains an ever-increasing number of case studies which describe the implementation of the aforesaid regulation for industrial sectors as well as for the fruit and vegetable processing industry (Derden et al., 2002), the dairy industry (Honkasalo et al., 2005), the Finnish pulp and paper industry (Silvo et al., 2009), the steel and glass industry (Rave, 2008), etc.

Concerning the exploitation permit procedures, a survey conducted by the European Commission underlines that by mid-2006, hardly half of the concerned installations had been granted a permit to exploit (Watson, 2007). The latest results of the IPPC implementation (2009) show that 14 countries were not in compliance. France was at 72% of conformity in July 2009, Greece 53%, Slovenia 41% in January 2009 and Malta 38% in August 2009 (Cikankowitz and Laforest, 2010). These delays have led the European Commission to refer the matter to the European court in the case of 6 countries - Denmark, Spain, Greece, the Netherlands, Portugal and Slovenia- and to send an early warning to France, Austria and Sweden concerning 1700 installations which operate without a license. Note that 1647 installations belong to the France case study (Boughriet, 2010), and several member states like France and Sweden have implemented integrated licensing systems before the IPPC regulation that are quite similar in terms of requirements and philosophy (Styles et al., 2009a).

Even if the IPPC directive has been inspired by the principles of the French law of July 19, 1976 relative to industrial sites officially classified for the protection of the environment (ICPE) (Lucas, 2001), article 13 of the IPPC makes the difference. The IPPC goes further by setting an obligation upon the concerned industries to periodically reconsider and update their permit conditions. Every ten years, operators must provide the competent authority with a technical report on their installation and on the impact of their activities, in order to have their permit renewed. This report must either justify the use of BAT or show that the environmental performance of the user techniques could perform as well as or better than BAT as defined in the BREF. In terms of good practice, processes, choice of raw materials and natural resources, waste management etc.

The IPPC has been transposed into national regulations by new or renewed member states decrees. This directive has been crucial in setting up new or modified installations since October 30, 1999. A delay of 8 years (as of October 30, 2007) has been set for all existing factories or plant sites to comply and in particular to apply appropriate BATs. In France, there was some delay in the establishment of awareness about what the IPPC involves and how it differs from the ICPE regulation.

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<sup>1</sup> The first European Conference on the information exchange on BAT took place in Stuttgart, Germany from 6 to 7 April 2000 (Derden, 2002) and was called ‘The Sevilla Process: a driver for environmental performance in industry’; since this conference, the exchange of information on BAT has also been called ‘The Sevilla Process (Schoenberger, 2009).

Besides, in spite of efforts, more than one year after full IPPC compliance, 80% of efforts were still not in compliance with the requirements of the directive. Indeed, industries and competent authorities faced considerable difficulties in comparing the performance of existing techniques with the BAT performance and consequently in judging the quality of technical reports.

Many environmental assessment tools exist whose scope may exceed the physical limits of an industrial installation. For example, like the Life Cycle Assessment is nowadays the only methodology that quantifies a set of environmental impacts and that highlights cross-media effects (ISO, 2006)(Aissani, 2008). Moreover, some tools are based on the aggregation of indicators, or propose environmental performances from one single sort of indicator such as carbon balance or ecological footprint. Then industrial operators have difficulties in assessing their environmental impact as a whole through an integrated approach in terms of management procedures and technologies. Thus, operators need to identify other coherent, accessible and representative indicators of the general industrial context in order to exhibit an overall performance level.

In the context of the IPPC directive, which became increasingly strict as we will see later, some methodologies have been developed for a deeper and better understanding of the selection procedure of the BAT concept for operators at installation level (Geldermann and Rentz, 2004) and for national policy-makers (Dijkmans, 2000; (Samindi et al., 2011). For example, the Flemish Institute for Technological Research (VITO) proposed a methodology for BAT assessment for some industrial sectors (vehicle refinishing and manure processing) to be defined in the BREFs (Dijkmans, 2000). The University of Santiago de Compostela presents a method to help both industries and the competent authority to identify candidate techniques, as well as best environmental practice and preventive and abatement techniques such as BAT for the heavy ceramic industry (Barros, 2007). Nevertheless, although the BAT selection cannot be ignored at sector and plant level (Dijkmans, 2000), there is no environmental performance assessment methodology which helps operators at plant level to compare their existing techniques to BAT environmental performance as required by the IPPC directive, and so to decide whether or not to validate them as BAT. When installations already have a licensing system to operate, diagnostics have to be done periodically before selecting and deciding whether or not to implement new techniques with better environmental performance and adapted to local conditions. The contribution of this paper is to propose an adequate methodology to help operators of metal finishing, at plant level, to compare their existing techniques and decide whether or not to validate them as BAT before the new BAT selection procedure, in order to improve the environmental performance in a continuous way.

This article is laid out as follows: first, the French IPPC application context and the difficulties in defining the BAT concept at local level are presented. Then, the general steps and associated tools of our L-BAT methodology are described. Moreover, a case study for metal finishing will explain and highlight how these tools are used. Finally, the limits, advantages and place of the L-BAT methodology in relation to other methodologies are discussed before the conclusion.

## **2. Application context of the IPPC directive for metal finishing industries**

### **2.1. Definition of Best Available Techniques**

The BAT principle is defined by the European directive 2008/1/EC of January the 15<sup>th</sup>, 2008 on Integrated Pollution Prevention and Control (IPPC)<sup>2</sup> as being “the most effective and advanced stage

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<sup>2</sup> Schoenberger (2009) reminds that The Directive of the European Parliament and of the Council concerning integrated pollution prevention and control (IPPC Directive) has recently been codified (Directive 2008/1/EC). The codified act includes all the previous amendments to Directive 96/61/EC and introduces some linguistic changes and adaptations (e.g. updating the number of legislation referred to in the text). The substance of Directive 96/61/EC has not been changed.

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 values designed to prevent and, where that is not practicable, generally to reduce emissions and the impact on the environment as a whole” (Directive, 2008).

The terms “techniques”, “available” and “best”, are defined as follows:

- “techniques” shall include both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned,
- “available” techniques shall mean those developed on a scale which allows implementation in the relevant industrial sector, under economically and technically viable conditions, taking into consideration the costs and advantages, whether or not the techniques are used or produced within the Member State in question, as long as they are reasonably accessible to the operator, and
- “best” shall mean most effective in achieving a high general level of protection of the Environment as a whole.

The principle of best available techniques (BAT), as defined by the IPPC directive n° 2008/1/EC, has become a significant issue for industry to deal with, and the implementation of this Directive actually compels companies to apply BAT (Litten, 2002). We would like to remind the readers that the implementation of the IPPC directive requires that industries use techniques which have the same performance as Best Available Techniques (BAT). The concept of BAT is the core of the IPPC directive (Cikankowitz and Laforest, 2010)(Directive, 2008).

As a result of the philosophy of this directive, BAT represents the combination of technical processes and management practices with overall positive environmental and cost benefits (Dijkmans, 2000; Directive, 2008; Bréchet and Tulkens, 2009).

To determine if techniques used could be considered as BAT, appendix 4 of the IPPC directive provides 12 considerations to be taken into account. Furthermore, there are technical guides on BAT provided by an information exchange activity: the BREFs (Litten, 2002). Roudier (2007), Laforest (2008), and Schoenberger (2009) point out that the Article 16.2 of the directive requires the European Commission to organize an exchange of information concerning BAT between member states and the industries concerned. The objectives are: (1) to encourage European countries to achieve technological homogenization; (2) to disseminate the emission levels and techniques used in the European Community throughout the world; (3) to help Member States to effectively implement the regulations; and (4) to accomplish a comprehensive database, notably with the publication of reference documents. Moreover, clean technologies as well as curative techniques can be considered as BAT (Laforest, 2008; De Chefdebien, 2001). Finally, a BAT depends on the specific local context in terms of technical, economic and environmental aspects. The BREFs describe a set of BAT in terms of associated emission and consumption levels and with some qualitative criteria, but it is not homogeneous for all the techniques. However, a BAT in a BREF is not an imperative BAT for a company at a local scale. On top of that, a BAT for one plant is not necessarily a BAT for another plant belonging to the same activity sector. The following paragraph will emphasize this viewpoint and will show the need for an environmental performance assessment methodology adapted to operators at plant level.

## **2.2.Barriers to the application of the IPPC directive in France**

As mentioned before, the objective of the directive is to attain a unified and coherent level of environmental protection based on the use of BAT. The IPPC directive should have been (be) implemented by October, the 30<sup>th</sup> 1999 in all new activities or in all modifications having an impact on the environment. Every existing European industrial activities were required to comply with it by October 2007 (Cikankowitz et al., 2009; Lucas, 2000).

However, on October the 30<sup>th</sup> 2007, only a few French companies were fully in accordance with the IPPC Directive. A subsequent investigation identified that BATs are responsible for the difficulties in effectively implementing the IPPC directive. This concept involves 3 distinct aspects: political concerns, techno-economic regards and stakeholders' participation.

First of all, the political aspect is at the source of the delayed awareness in France and of how it differs from the ICPE legislation defined in 1976. In addition, many regulatory texts have been published in the past ten years, but these do not propose practical methodologies for operators to comply with the IPPC directive. The key point of the transposition of this directive in French legislation is the development of a study comparing their processes with Best Available Techniques (BAT) through a periodic technical report (Arrete, 2006; Circulaire, 2006; Appel, 2007).

The major hindrance for industries is the non-comprehension of the BREFs documents and their use, mainly because of the lack of tools or of an approved and structured reference framework. All stakeholders interviewed indicated that: (1) the BREF remains a difficult document to use at local level for a company: there are deficiencies in content, quality, accuracy and homogeneity but this document is extremely significant, sensible and essential despite the difficulties. (2) The BREF should remain a technical guide, and not a prescriptive catalogue with emission limit values which are already defined in specific regulatory texts (Roudier, 2007). Furthermore, at the present time in Europe, there is neither a rigorous definition of the BAT concept nor an acceptable application of the IPPC directive. BAT evaluation and application are less demanding, so whether a technique is BAT depends on the local context. Besides, a common interpretation of the BAT concept is to concede that only the techniques given in the BREF are BAT. BREFs are European references whereas the BAT is applied at installation level. It is crucial to emphasize the fact that a particular BAT for a company is not necessarily suitable for another company in the same activity sector. Indeed, BATs are the fruit of local adaptation (technical, geographical and economic). Finally, there is a lack of dialogue between stakeholders at different levels: between industries and administrations and between institutions which do not encourage stakeholders to meet with them and to develop a known and official environmental performance assessment methodology of existing techniques. This methodology could help industries to prove that they use techniques with BAT equivalent performances. That is why many technical reports are still incomplete.

In order to speed up and simplify compliance with the IPPC directive, the French Environment Ministry decided to reformulate the majority of existing regulatory texts. The objective is to bring emission limit values (ELV) thresholds in line with the BAT environmental performance levels defined in the BREFs, which was not the case until now. Consequently, industries which automatically comply with these ELV are declared "IPPC compatible". Nevertheless, this approach restricts IPPC compliance and BAT analyses to one single ELV. Even if BAT and ELV must both be verified, as Barros et al. (2007) point out, the IPPC principles seem to go further. Undeniably, ELV compliance justifies the use of BAT or other techniques with equivalent performance at an industrial site, as suggested in the IPPC directive, but it is not enough and simply very restrictive compared to the IPPC aspirations. From a theoretical point of view, this leads us to conclude that the BAT concept can be understood, defined, analyzed and assessed through two different but complementary approaches: (1) the emission and consumption levels are defined in the BREFs which establish ELV for national regulation at sectoral level and (2) the screening of the environmental aspects of each technique, practice and organizational measure or management procedure implemented is done step by step. The methodology we present focuses on this second aspect. Nowadays, the BAT assessment is mainly based on the emission and consumption levels achieved by the techniques applied (Silvo et al., 2009). But the results depend on where the installation is located and on the economical viability of operators. This demonstrates also that the ELV perspective alone is insufficient to draw conclusions on the BAT performance.

The case of the surface treatment industry is the most representative for illustrating the actions of the French administration. This sector has been bound by a ministerial decree since 1985. However, in order to comply with the IPPC directive, the new decree (June 30, 2006), which abrogated the old one, defined the ELV on the BAT performance levels of the Surface Treatment of Metals and plastics (STM BREF). Since June the 30<sup>th</sup> 2006, metal finishing industries which only respected this ELV are declared “IPPC compatible” (European ZeroPlus, 2009; Cikankowitz, 2008). Operators must analyse the environmental performance technique by technique, but the current simplification is not well adapted to encourage a “step by step” analysis. Furthermore, local conditions and some properties of the installation cannot be taken into account. Moreover, it may also reduce the economic and innovatory potential of the company. Thus, a single confined principle (ELV) to evaluate the environmental impact cannot give a clear and complete vision. Hence, there is no real environmental performance assessment of pollution prevention and control actions within the meaning of the IPPC directive (O’Malley, 1999). Besides, nowadays, the competent authority declines to accept the French technical reports if there is no reference to the BREFs. Consequently, a single mode of compliance with the emission limit values is not enough.

### **2.3.Are there any BAT assessment methodologies?**

Currently, only few methodologies are suitable for the assessment of environmental performance (Samindi, 2011) (O’Malley, 1999), either for operators or for the administrations according to the IPPC directive. The national regulations define objectives for results but do not provide any means of reaching them. This flexibility leads to inequalities in implementation between EU member states and within these states.

Figure 1 positions the characteristics of some identified assessment methodologies (MIOW + model in (Derden et al., 2002), BEAsT (Georgopoulou et al., 2008), the PNUE methodology (PNUE, 2004), VITO (Dijkmans, 2000), etc.). They were developed under the IPPC directive in relation to their level of application, that is to say, whether they are adapted for local use (industries) or for a higher level in the selection of BAT for BREFs (administration).

This figure points out that some BAT assessment methodologies. However, analysis shows that on the one hand they do not concern the assessment of BAT at local level but contribute to the definition of BAT for BREFs (European level). On the other hand, they are not adapted to SMEs. Besides, either the environmental impact is not considered (only the LCA methodology provides this kind of results) or depends on regional issues, or the methods are based on a monetary approach to the environmental impact.

Since early 2000 and despite the pressure of the IPPC directive, only two main methodologies correspond exactly to the IPPC requirements and the BAT definition, namely the VITO methodology (Dijkmans, 2000) and a reference installation approach developed by Geldermann and Rentz (2004). However, these methodologies are relevant for selecting or determining BAT for BREFs at the EU level and for installation at plant level respectively, but are not adequate for comparing the performance of existing techniques with the BAT one.

Vito focuses on the fact that BATs can be selected at plant level but need primarily to be determined at sector level. So Vito has developed a qualitative approach, based on expert judgment, to assist the Flemish authorities in defining BAT for specific sectors and to inform the competent authorities of developments in BAT. A four-step procedure is defined to decide whether a candidate BAT can be considered as BAT: (1) the technique is technically feasible, (2) it has clear cross-media environmental benefits, (3) the cost of the technique is not excessive (MIOW + model) and (4) there is no better alternative. The result is clear and simple thanks to the +/- scores used.

Geldermann et al. (2004) differentiate BAT determination and assessment of cross-media aspects on two levels: (1) general determination of BAT for industrial sectors at EU level and (2) local application of generally identified BAT during the process of granting the permit. They proposed an integrated approach for BAT determination at EU level in four steps. This procedure, called reference installation, corresponds to the structure of the life cycle assessment but does not follow life cycle thinking (cradle to grave) and does not use the analysis models which quantify the potential environmental impact from data inventory (consumption and emission or inputs and outputs) of the system studied.

Since mid-2008 more and more research works have shown new BAT assessment methodologies which try to focus on the quantification of the environmental impact, or a combination of the environmental benefits and an assessment of costs. Samindi et al., (2011) studied several methodologies based on LCA or multicriteria analysis tools which all help at the selection of BAT. They are based on different factors such as technical, financial, external pressure or degree of risk and usability. Moreover, he proposes a framework to compare BAT to technique in order to determine a best qualified technique but this tool concerns specifically application of new techniques or in a new environment.

We conclude that there are no environmental assessment methodologies at local level to help operators to justify that they are using (and not selecting) techniques with a performance equivalent to BAT. Goldstein et al. (2011) proposed a methodology which assesses the environmental performance of cleaner technologies in an IPPC context. Despite the fact that this methodology, applied for 3 activity sectors, takes into account general and activity's specificities, environmental management and technical indicators, they do not mention the 12 considerations proposed in the IPPC directive, the BREFs and the cross-media effects. Indeed, there are no assessment methodologies suggesting a simple, cross-sectoral and universal step that is adapted to the reality of industrial SMEs. However, it appears that only the assessment methodologies developed by the Belgian center, Vito and Geldermann, corresponds more closely to the definition of BAT as well as IPPC principles in terms of an integrated approach (technical feasibility, environmental benefits and economic viability). Yet the Vito methods help the Belgian government to select the BAT for BREFs.

Our assumption is that ELV based on the BAT concept of the BREF is in compliance. What about the screening of the processes and organizational measures? Is it possible to develop an adequate environmental assessment methodology to help industries to compare the performance of existing techniques with that of the best available techniques of the BREFs? This is important because the IPPC directive requires the environmental performance of the techniques to be re-examined after the licensing of the installation. A methodology could help industries to make a first diagnosis or inventory of the environmental performance of their existing techniques before selecting alternative BAT options in order to improve performance and reach the BAT performance. At this time, alternative techniques have to be characterized at process level with regard to environmental benefits, technical practicability and especially economic feasibility. The VITO (Dijkmans, 2000) and Geldermann (2004) methodology could be used to do this. For two years, more and more methodologies have been focusing on multi-dimensional methodology or on a set of practical indicators to identify the best available techniques, as well as Brechet et al. (2008) and Silvo et al. (2009). Some papers on BAT assessment show a correlation between the BAT methodology and the LCA one. But Geldermann pointed out that even if the procedure of the reference installation approach for BAT determination is based on the ISO 14040 standard, BAT determination is distinct from LCA studies; he underlined that the aim is not to determine the overall impact of the techniques on the environment as a whole (Geldermann and Rentz, 2004). Nowadays, apart from the LCA methodology which ensures that there is no pollution transfer from one medium to another (ISO, 2006), or the possibility of multicriteria analysis, no methodology proposes algorithms for weighing up the environmental benefit brought about by pollution reduction in one medium (e.g. air) combined with decreased environmental performance in another medium (waste, energy) (Dijkmans, 2000). That is



why Dijkmans et al. (2000) decided to adopt a qualitative approach combined with expert judgment for the cross-media evaluation of candidate BAT.

Despite the advantages of the LCA methodology, collecting the data is very time-consuming. The limits of this methodology exceed the boundaries of a company so it involves many stakeholders. In addition, local conditions are not taken into account to characterize the potential environmental impact which is, except for eutrophication, global (acidification, human toxicity, global warming, etc.). Nevertheless, Geldermann (2004) bases his methodology on the LCA framework and promotes its use. Indeed, some authors suggest the possibility of combining the LCA with BAT existing qualitative assessment methodologies in order to improve the environmental impact assessment and the cross-media effect evaluation (Silvo et al., 2009; Geldermann and Rentz, 2004; Georgopoulou et al., 2008; Nieminem et al., 2007). For instance, according to Silvo et al. (2009), an LCA-based method would provide further information on the intensity of the impact of various emissions and consumptions within the impact categories, but would not resolve the importance of the various types of impact.

It is important to clarify that the aim of this article is not to study the feasibility of the LCA or other well-known environmental assessment methodologies (such as Material Flow Analysis) to assess the performance of existing techniques against the performance of the best available techniques. As mentioned previously, the aim of this paper is to present the context and problem of BAT performance application and to fill the gap of appropriate methodology. Then an environmental performance methodology under the BAT concept is presented to help operators to diagnose the performance of their existing processes, practice and organizational measures, at plant level. Moreover, this will ensure the detection of weak points to take into account in order to improve their BAT performance. This step, which forms part of global measures, will enable operators to define a continuous improvement strategy to identify, select and implement BAT or a combination of BATs. This will necessitate a multi-dimensional methodology including technical feasibility, environmental performance and economic viability, not included in our diagnosis (Laforest, 2008).

### **Figure 1 : Identification of some BAT assessment methodologies at different levels**

The next section of this article includes a description of the general procedure of L-BAT methodology. This methodology is specifically adapted to face the difficulties encountered when implementing the IPPC directive through the BAT concept. It is based on the fact that BREFs specify the best combination of techniques to implement or key elements to help operators to compare the performance of their existing techniques with the performance of the BAT defined in the BREF. The application sector chosen is the surface treatment of metals, due to the environmental and economic issues involved and its historical regional implementation in the Loire Department.

### **3. The L-BAT methodology**

The general steps of L-BAT methodology and the main evaluation rules are presented in this third section.

It is important to underline that this original research project was supported by, and forms part of, the European Project Zero Plus (Life05/ENV/E/000256) which began in December 2005, as much as for the bibliography phase related to the IPPC European Directive stakes in Europe as for the development of the performance assessment method of techniques under the BAT concept. However, the steps undertaken in this context are manifold. First of all, a literature review was carried out to supplement the knowledge and to understand better the history, context, issues and challenges of the

IPPC Directive. Secondly, to give legitimacy to the proposed methodology, a voluntary working group consisting of several different participants (representatives of the French government, the environmental authority (DREAL), the water agencies, INERIS, and the technical center of the mechanical engineering industry) was created, meeting twice a year for 3 years. In addition, to support our research, we have been in contact with several experts. One of them was the European IPPC Bureau in Sevilla (Watson et al., 2007; Cikankowitz, 2008).

### **3.1.Objectives of the L-BAT methodology**

The aim of this methodology is to create a systematic approach and pragmatic tools for industries. This kind of tools needs to be familiar to the administrations; it will be easier both to understand and to put into practice the third part of the technical report, the diagnostic step under the BAT environmental performance (Watson et al., 2007; Arrete, 2006; Circulaire, 2006).

It is not a matter of choosing which technique could achieve the BAT performance, but on the contrary, an environmental diagnosis is to be completed: L-BAT provides a comparison between the performance of a company's existing techniques and the BAT performance from BREFs. This step is crucial because it identifies deviations in BAT performance. Moreover, in this way, it will be easier to determine specific measures of the utmost importance in reaching the level of performance required by the legislation. Besides, this method simplifies the use of BREFs. Finally, operators will be able to highlight, on the one hand, their strong points and their BAT compliance and, on the other hand, their weak points which require the planning of improvement initiatives with better environmental performance. Furthermore, if the results of the evaluation are argued and planned in great detail, it will be a significant advantage for operators faced with the strict and rigorous administration conditions that prevail.

### **3.2.Two kinds of analysis**

Two kinds of analysis were used to develop this methodology :

- A theoretical analysis of the 12 considerations defined in the IPPC directive to determine criteria, indicators and parameters adapted to the BAT concept (Laforest, 2008), and
- An *a posteriori* analysis based on feedback experiences and case studies. The techniques are observed within firms and assessed using technical and regulatory documents and with the participation of experts. Although relevant, some existing documents present weaknesses or deficiencies in terms of general framework or lack of information.

These approaches give many arguments to the operators when they must prove that they use techniques which could perform to the standard expected by BAT. The theoretical analysis can also be employed when operators decide which technique is the best BAT to be implemented.

Our methodology L-BAT was primarily built from case studies in order to produce simple and pragmatic tools which are adapted to their local conditions and expectations. The methodology has been tested for the metal finishing industry and specifically SME which are facing economical difficulties: experts and other stakeholders have participated in the L-BAT development. However, the *a priori* analysis has been initiated since 2003. The Zero Plus European project was inspired by this previous study based on the analysis of the twelve considerations of the IPPC directive (Laforest and Bertheas, 2004). In addition, the performance assessment of candidate techniques for BATs or other existing techniques will be discussed through the use of the twelve considerations in a further paper. It is a process-based approach which takes into account economic criteria, focuses on environmental performance through the definition of indicators and parameters adapted to plant level but not on environmental impacts.

### 3.3. General procedures of the methodology

The general approach adopted for the L-BAT methodology is made up of the four main steps shown in figure 2. Each assessment step is supported by a specific tool.

**Figure 2 : L-BAT : General steps for the assessment of environmental performance of an installation through BAT requirements**

In the first step, in order to assess the level of environmental performance of each technique, operators must refer to the relevant BREFs and regulatory texts. All information about environmental performance and prescriptions are gathered in the evaluation grid associated with this first step.

The second step is about the analysis of the performance level of management procedures associated with the techniques; to comply with this step, a thematically organized evaluation grid was established. The first two steps can be carried out simultaneously.

The combination of the two results (step 1 and step 2) enables to establish the global performance of the installation under BAT. Yet the assessment of the environmental impact of an industry is meaningless without taking into account the characteristics of the local conditions. Thus, the analysis of vulnerability (specificity of the local natural and human environments) is associated with the previous results in step 3 to get a representative level of performance (step 4). This fundamental step appropriately combines the characteristics of the local conditions with the environmental impact of industries. Indeed, environmental impact assessment tools are being increasingly developed and are required to take account of natural environmental sensitivity. In fact, an appraisal of the impact of industrial activity cannot be done without characterizing its close context. Regulations encourage taking into account natural environmental sensitivity but do not propose a framework, whereas the significance of the impact depends on where the installation is located (Faure-Rochet, 2005; ISO, 2006). In a recent paper, Cikankowitz et al., (2009a) sought to fill this gap by proposing a vulnerability assessment method. This method is based on the definition, identification and organization of elements that characterize this sensitivity. The proposed approach is a **qualitative** approach based on a “multi-media” questionnaire. The themes (water, air, soil, etc.) were identified via the meticulous analysis of the requirements of the impact study defined in the French regulation (ICPE), the IPPC directive, technical guides for producing the technical report and the “*Plan Environnement Entreprise*” developed by ADEME. The originality of L-BAT is based on the integration of close environmental sensitivity into an environmental performance assessment methodology.

#### 3.3.1. Definition of the performance levels

Six grades corresponding to five levels of control have been defined to assess the level of performance of techniques (step 1) or management procedures (step 2). They are presented in table 1.

**Table 1: Performance level of techniques and management systems against BAT defined performance**

These levels have been discussed and determined with metal finishing experts. The wording of each grade can combine them with the levels of control. Each level of control has one or more grades designated by one of the first six letters of the alphabet; A is the best level of control and F the worst.

It is important to mention that the level « good control » will be equally attributed to techniques even if they have grade A or B. In fact, there is no distinction between a technique with environmental performance described in the BREFs (grade A) or not mentioned in the BREF (grade B) from the time

the ELVs are in conformity with the legislation. Indeed, the BREF is an exhaustive technical document. If a technique does not appear in a BREF it can yet be considered as a BAT for an installation provided, when it is justified according to specific environmental performance criteria or terms adapted to the sector of activity concerned.

The level of sensitivity is evaluated independently of the intensity of the industrial impact. A specific qualitative evaluation in four levels from “very sensitive” to “very slightly or even not sensitive” is proposed (Cikankowitz et al., 2009b). A level of sensitivity is associated with each industrial environmental characteristic.

### **3.3.2. Global level of performances**

So as to define a more or less satisfactory level of performance of the global installation in relation to BATs, a ratio of IPPC conformity (CR(IPPC)) of techniques and environmental and risk management practices is specified by the following equation :

$$\text{CR (IPPC)} = \frac{\text{Number of actions of grades (A+B)}}{\text{Total number of actions}}$$

The global IPPC level of performance of an industrial installation should reach at least 75%. This arbitrary level was discussed and validated with experts. More precisely, if 75% of techniques are classified in the grade A or B, the firm gets a satisfying performance and can be considered “IPPC compatible”. It means that this firm has implemented BATs or techniques with equivalent performance.

## **3.4. Description of the environmental performance assessment tools applied to metal finishing industries**

The core of these tools relies on specific criteria adapted to IPPC constraints, the main environmental objectives defined in this text and the BREF recommendations while considering parameters related to the local context.

### **3.4.1. An evaluation grid for the production units (step 1)**

Regulations oblige enterprises to consult the BREFs, select the relevant paragraph(s) and depict their situation in order to show that existing actions implemented in their industrial site correspond to the BAT performances given by the BREFs (Dijkmans, 2000). Then, in a metal finishing workshop (using chromates, brighteners, cleaners, etc.), operators have to compare precisely the performance of each bath (treatment and rinse) of a production line with the BAT performance. For that, the EU STM BREF (surface treatment of metals and plastics) is declared to be the reference. However, it is organized according to environmental impact which is not helpful for users. This implies that a similar technique is often mentioned in various contexts. So the use of such a document is difficult for the operators. That is why a simplified version has been created to make the reference to the STM BREF easier. Our new structure was personalized to be useful for the metal finishing industry. This industry is rather complex, especially because of the many techniques and operations needed to produce various products (Rigaud et al., 2002). Thus, the simplified BREF reading grid for the metal finishing industry is organized by processes, while considering the production and manufacturing in a metal finishing workshop.

This kind of structure seems to be more appropriate for operators. It also highlights an integrated approach of the environmental impact and the cross-media effects. Moreover, the legitimacy of this project was recognized and justified through a survey, encouraged by the EIPPCB in Sevilla (Watson et al., 2007), on the use of BREFs by industries, competent authorities or other institutions in France.

In order to simplify the comparison, a registration sheet or evaluation grid (see table 2) will help to compile the characteristics of each bath, step by step. Then, in order to assess the BAT performance of each production line, the operators will attribute a level of control by providing information on 8 topics defined from the detailed study of the STM BREF and the requirements of the ministerial decree of June 0, 2006, relative to metal finishing workshops. Consequently, for each production line, eight environmental objectives, which correspond to BAT, have been analyzed to assess the level of IPPC compliance: (1) optimization of the bath functioning (duration) (2) reduction in the use of hazardous substances (3) drag-out reduction and control (4) reduction of heat losses (5) reduction of water losses (6) reduction of soil and subsoil pollution (7) wastewater management (8) air emission abatement.

Some technical parameters relative to the BAT concept for the metal finishing industry are associated with these eight environmental objectives.

To collect the data, the operator first catalogs the baths by production line. Secondly, for each bath he identifies one or many techniques which correspond to one of the eight objectives. Finally, he allocates the appropriate level of performance (grades) for each technique, bath by bath and objective by objective.

**Table 2: Extract of the registration sheet for process lines evaluation**

### **3.4.2. The Environmental and Risk Management System (ERMS) (step 2)**

This system is appropriate to the assessment of the performance of prevention and reduction actions or practices according to the environmental impact of a metal finishing workshop. To do this, a questionnaire has been created.

This system deals specifically with global issues or issues encompassing the entire production system which cannot be evaluated step-by-step at process level.

Fourteen themes based on the STM BREFs and the legislative prescriptions (June the 30<sup>th</sup>, 2006), have been identified and characterized as best for the environment and the risk aspects: (1) installation settlement, (2) decommissioning of the industrial site, (3) organization, implementation and installation development, (4) management of storage, (5) emissions monitoring/control of processes/cleaning/maintenance, (6) training/staff awareness, (7) waste production, (8) vibrations/noise/odors, (9) transportation of products, (10) management of wastewater emissions, (11) management of air emissions, (12) heat loss, (13) management of inputs, (14) fire risk and others.

The performance analysis of the ERMS is based on the following actions:

- Identification of the preventive measures in their entirety of the installation, based on a questionnaire,
- Comparison of the preventive measures of the industrial installation to the BREF STM and the French ministerial decree of June 30, 2006 (the ministerial decree of February 2, 1998 for other sectors of activity),
- Classification of these preventive measures according to the six levels of control (letter from A to F).

Table 3 is an extract of the ERMS assessment questionnaire for subjects (2), (7) and (8). Each subject consists of a list of questions. For example, subject (2) consists of 10 questions as follows:

- o B1: Are you planning adequate measures to decontaminate the soil?

- B5: Which measures are planned if the industrial site is definitely closed? For instance, during the dismantling of the production lines of metal finishing workshops (evacuation of baths, resale of tanks, rehabilitation of retention areas, etc.)

The user fills out the appropriate information in this evaluation grid.

In this way, the environmental practices of the company participating in this study are highlighted. Then, each practice defined in the grid, is evaluated by attributing a level of control (category A to F).

**Table 3: Extract of the ERMS questionnaire**

### 3.4.3. Systematic procedure

Figure 3 presents the procedure to be followed. This flowchart gives details of the general steps to be followed by users of L-BAT methodology to assess the BAT performance of different “operations” (processes of production and detoxication plants) of a metal finishing workshop (step 1 of figure 3). In the same way, this flowchart could be fully used or repeated for the second step (ERMS) of the general aforementioned procedure (figure 2).

The major questions are: « *Am I in compliance with the prescriptions of the IPPC directive? Finally, is my installation IPPC compatible?* ». To answer these questions, the operator is guided, step by step, by the procedure exposed in figure 3.

It is vital to emphasize the fact that a deviation from BAT compliance for one or more techniques does not affect the global IPPC compliance of the installation. To finalize the analysis and reach a global level of IPPC compliance (step 3 of the general procedure on figure 2), the operator has to take into account the level of performance of all the techniques, taking into account the cross-media effects of the environmental impact. The evaluation of the cross-media effects has not yet been studied.

**Figure 3 : The systematic procedure to assess the BAT environmental performance of a unit of production for a metal finishing workshop**

## 4. Case study

### 4.1.Introduction

According to appendix 1 of the IPPC directive, metal finishing workshops using an electrolytic or chemical process where the volume of the treatment baths exceeds 30m<sup>3</sup> is concerned by this regulation (Derden et al., 2002; Litten, 2002). This specific study encourages the realization of one subsection of the French technical report of company X. This real case study was tested and has taken part of the validation of the L-BAT methodology with its three tools:

- The Environmental and Risk Management System (ERMS)
- The evaluation grid or registration sheet consisting of eight parameters relative to the production unit evaluation of the metal finishing process line
- The determination of the vulnerability of the local context (not dealt with in this article) (Cikankowitz et al., 2009a)

This company X produces surface treatments of metal pieces for decoration, prevention of corrosion and improved hardness (resistance to damage and wear) to many industries: automotive, aerospace, electronics, medical supplies, domestic electrical appliances, telephony, plumbing fixtures, stamping, and cutting. Eight rack/jig process lines (two manual and six automatic) are implemented for these applications.

In the present article, the results from the performance analysis of the polishing process line and the ERMS are only graphically presented without firming up technical details. Therefore, our systematic and progressive approach for BAT assessment and the visual representation (drawing spider graphs) chosen are highlighted.

It will be easier for the operators to be transparent on the one hand, on their main strong points and compliance with the BAT and, on the other hand, on the barriers on which they have to focus to finally reach the BAT performance corresponding to the main IPPC requirements.

#### **4.2. Results of the performance analysis of the polishing line**

39 actions of the polishing line were counted (table 4). These actions are, for the most part, classified in grade A (27) and grade B (9), which correspond to a very high level of performance in relation to the Best Available Techniques. The circle chart (figure 4) points out that the level of control reaches a rate of 92% (69% for grade A + 23% for grade B).

**Table 4: Summary of actions**

**Figure 4 : Compliance rate (%) of the electrolytic polishing process line**

The spider chart in figure 5 indicates that company X should pay special attention to the objectives « **reduction in losses of raw materials (water)** » (objective 5) and « **reduction in air emissions** » (objective 8) in order to improve the BAT level of performance and plan an adequate business strategy. A third action is classified in level C. Moreover, the actions relative to objective 8 have been assessed in class D. It justifies the level of performance of this process line. For instance, concerning air emissions, there is no extraction above two hot baths of this process line. Objective 2 is not represented on this spider graph because company X is not involved in it.

**Figure 5: Levels of IPPC compliance by environmental objectives of the preventive measures of the electrolytic manual polishing lines**

This step-by-step procedure is repeated for all eight process lines. Thus, analysis of the level of control of abatement and prevention techniques implemented in these production lines shows that a majority of these techniques are classified in grades A and B (95%). The performance of each process line can be compared to the BAT performance.

#### **4.3. Results of the performance analysis of the ERMS combined with the local context**

In the same manner as for the performance analysis of the environmental impact of the prevention and reduction measures, the chart and diagrams indicate that about 95% of actions reach grades A and B. This is a good level of control compared to the Best Available Techniques (figure 6). Indeed, the rate of compliance is at least 75% or higher for each objective (CT (IPPC) > 75%), except for waste. Company X applies preventive techniques with a good level of control. No techniques are classified in grades E and F.

### **Figure 6 : Position to prevention techniques compared to BAT**

The results of the ERMS analysis are represented on a spider graph (figure 7). This spider graph shows the level of performance of each issue (security – risk – fire, implantation and development, training and maintenance, etc.).

### **Figure 7 : Representation of the environmental and risk management system compliance as regards the IPPC directive, taking local conditions into account (Cikankowitz, 2008; european, 2009**

The study of the local environments (natural and human) showed that the soil and groundwater were very sensitive in the area surrounding the industrial installation. The air was a « fairly sensitive » area. On figure 7, it is shown that the topics regarded as at least « fairly sensitive » are drawn by a line which is superimposed on the graph on one or several criteria that could have an effect on these environmental areas (water, air, soil, and groundwater). Thus, the depiction of both results together on the graphic (environmental performance and sensitivity of the environments) facilitates visualization of the industrial installation's performance, and defines criteria upon which it is crucial to focus in order to reduce the intensity of the impact on the sensitive area (figure 7).

Furthermore, actions of the utmost importance can be planned to improve the level of performance according to an evaluation rule: the most important action to implement depends on the worst criterion of performance which has the highest environmental intensity impact in relation to the level of sensitivity assessed. Considering figure 7, the previous evaluation rule adopted suggests that the actions are organized into a hierarchy as followed: (1) reduction and minimization of waste production impact (2) loss reduction: water consumption, (3) reduction and minimization of atmospheric impact, (4) Risks/accidents and (5) Training and maintenance.

This spider graph provides an effective and relevant profile of the enterprise. With this kind of visual representation, the operators identify the priority axis of progress contingent on the sensitivity of the local context.

#### **4.4.Results synthesis and interpretation**

As a result of this study, the operators discuss the performance of the processes and management procedures corresponding to the industrial activity of the installation. For that, spider graphs draw both ERMS and production units' levels of performance, taking into account the characteristics of the local context, the BREFs performance objectives and regulatory constraints. Moreover, the barriers which need to be improved are presented transparently to define a continuous improvement plan.

It is essential to keep in mind that this case study constitutes the performance evaluation diagnosis of company X. The purpose is not to solve the identified barriers, but to provide a decision-making tool which will facilitate the definition of an environmental management strategy or plan. In fact, company X has to envisage an improvement program for actions classified in grades C and D in order to get a better level of control compared to the Best Available Techniques. To conclude, the global environmental performance evaluation shows that for the majority of actions (ERMS and process lines) at 95%, company X is in compliance with the BAT and *a fortiori* with the IPPC directive. No action is located in grades E and F.



A feedback mechanism has been conducted in this firm. It appears that, by using this L-BAT methodology, the results obtained reflect the level of performance of this company. Moreover, it has been noticed that this methodology does not penalize the industries, unlike the poor image promoted by the metal finishing industry with regard to pollution; this approach will nevertheless focus on a set of “green” practices in the light of regulatory constraints (O’Malley, 1999).

## **5. Discussion**

### **5.1. Advantages of the L-BAT methodology**

The L-BAT methodology is essentially down-to-earth, simple to use at plant or local level and accessible to non-experts. It presents several advantages at different levels.

This methodology provides a relevant approach which will help industries to comply with the IPPC directive and work more easily with the BREF. Comparatively to other tool developed which help to choose a technical alternative (best qualified techniques) to pollutant ones (Samindi et al., 2011; Goldstein et al., 2011; Fijal, 2007), our methodology aims at a global assessment of a factory. However, outside the environmental regulatory context, this methodology helps operators to regularly monitor the environmental performance of the plant’s activities. This opportunity ensures a better knowledge and a better technical awareness of current industrial processes. Furthermore, there will be better data acquisition and a better recording and processing system.

At a strategic level, the methodology is interesting for the Sevilla Process, because collecting data and experiences encourages the process of BREFs review and *a fortiori* their updating. Besides, this methodology, with the BAT reference documents, made up of specific terms or the tools that have been created provide an opportunity for discussion between industries and authorities that is unusual, original and relevant. For example, it could be a good way of developing voluntary and participatory approaches in France that is not yet common. In fact, it would help industries to be better prepared for regulatory constraints, which are becoming ever more stringent.

From an operational perspective, the L-BAT methodology is original in the sense that the type of visual representation of results selected (spider) draws the enterprise performance profile according to BAT indicators and criteria. It also specifies an appropriate program of remedial actions by taking into account its local context.

Finally, from a practical point of view, our methodology may reconcile industries with such approaches and tools because of its simplicity of use and because it has been developed from an industry-wide experimental approach. Indeed, we would point out that the feedback from industries showed that the results were in accordance with the level of performance of their industrial activities.

### **5.2. Points to improve in the L-BAT methodology**

Nevertheless, within the scope of the fundamental research, it would be interesting to adopt a more quantitative approach, like the LCA methods, from the analysis of the twelve considerations of the IPPC directive defined to determine a technique candidate for BAT. Indeed, the L-BAT methodology is supported by a qualitative approach: the level of performance and the evaluation rules are mainly defined thanks to a list of questions with an undeniable element of subjectivity from the users.

There is no indicator or environmental weighting in the L-BAT methodology. However, it should be emphasized that the weighting of the impact of the various emissions is not easy, for the importance attached to each natural and human environment might change in time and also according to local priorities (Monzain, 2001).

Besides, other kinds of weaknesses arising from our method could be solved by:

- ✓ Introducing economic criteria in the assessment methodology, because the concept of BAT depends on it. After the diagnostic phase, the methodology should evolve and be improved by proposing to operators of metal finishing the opportunity of BAT selection in a continuous way of enhancement. At this stage, it should be possible to combine our methodology with the LCA methodology in order to identify cross-media effects generated by new change.
- ✓ Carrying out further case studies for metal finishing industries. This activity is bound by the increasingly strict regulatory context, and comprises several different treatments (paint application, chemical conversion, diffusion treatment, etc.) (ISO, 1998) whose characteristics are not integrated into our tools.

Moreover, some case studies have to be carried out for other sectors of activity in order to extend the scope of our methodology, to allow an appraisal of its reproducibility and thus to identify other possible limits. In this, our method is currently specific for one type of treatment (aqueous mode of treatment) for an activity sector.

### **5.3. Position of the L-BAT methodology compared with other types of assessment methodology**

The application of the L-BAT methodology (figure 8) effectively encompasses all the processes of a production line in a workshop, taking into account the relevant procedures. In this sense, the L-BAT methodology underlines both its « vertical » and « horizontal » approach compared to the « horizontal » approach of the EMS and the EPE of the ISO standard.

Figure 8 illustrates the application of some environmental assessment methodologies: the « EPE: environmental performance evaluation » defined by the standard ISO 14031 (Jasch, 2000; Personne, 1998), LCA, and L-BAT. This figure emphasizes the position of L-BAT compared to these methodologies.

#### **Figure 8 : Scope of L-BAT compared to other environmental assessment methodologies (EMS, LCA & EPE) (ISO, 1998)**

First of all, like an EMS, the L-BAT methodology facilitates the identification of ways of moving forward to reach the performance objectives defined in the official company policy. However, instead of having a global approach, our methodology is focused on the specificity of production. For instance, its main purpose is not to evaluate the in-house organization performance of the enterprise via a « horizontal » approach, but to assess the level of performance of « production units » by zooming vertically, step by step, in the processes (production and decontamination) and in the associated management procedures.

Then, unlike an LCA, its application is restricted to the physical limits of a company. Moreover, its evaluation takes into account the sensitivity of the local context and the concept of risk, which is not the case in the LCA methodology (Aissani, 2008). Nevertheless, LCA is the only existing quantitative methodology that brings together a set of impact analysis methods (CML, impact 2002+, etc.) which quantify different forms of global environmental impact like the greenhouse effect, acidification, and the ozone layer (ISO, 2006). Further developments of the LCA have been launched to achieve a more contextualized methodology (Aissani, 2008). What about combining a quantitative and qualitative approach to improve the L-BAT methodology and reduce the lack of the LCA methodology based on the local impact which is not yet quantified? In addition, the contribution of action on global

environmental issues is only evaluated according to its significance. Moreover, investigation or deep analysis carried out within the L-BAT methodology, focused on a step or a sub-step of the life cycle of a product or a system, could provide relevant information to a wider system assessment such as the LCA.

Finally, at first sight it seems that the EPE and the L-BAT methodology are similar. Both of them are applied to a plant site but L-BAT follows a « site » approach. L-BAT focuses on all of the operations, whereas the field of vision of the EPE is more extended, and also encompasses the managerial aspect, namely, human resources management, information management and general plans. Compared to the EPE, L-BAT suggests carrying out an elaborated environmental diagnosis, according to a progressive and organized approach, which will help the operators to define a program of actions to reduce performance deviations. In addition, whereas the EPE involves drawing up specific assessment indicators (Jasch, 2000; Personne, 1998; El Bouazzaoui, 2008), L-BAT leads to an evaluation based on a list of questions linked to a set of subjects relative to the global and local impact (ERMS), as well as specific criteria and parameters describing the industrial activity studied (process of production).

#### **5.4. New change due to the coming industrial emissions directive (IED)**

Companies have still many efforts to undertake before the total IPPC directive compliance at local level, but before the deadline (October 2007) the text has been undergoing already some significant adjustments at the European level. At the end of the year 2007, feedback from various sources led to the proposal of a new directive on industrial emissions, known as IED (European, 2007). This new regulation deals mainly with strengthening the BAT concept, the requirement to refer to the BREFs document and the importance of continuous and open communication between industry operators and government legislators. This latter statement was underlined by Silvo et al. (2009), when he declared that the efficiency of the IPPC directive in improving the environmental performance of industrial installations depends most certainly on this factor among others.

The IED directive will bring together the IPPC directive and six other sectoral directives, such as directive 2000/76/EC on the incineration of waste, directive 1999/13/EC on the limitation of emissions of volatile organic compounds (VOC), etc.

Moreover, this latter pays particular attention to the obligation for operators to use the BREFs for the BAT selection for the permit to operate and when updating periodically the environmental performance of existing techniques after a BAT diagnosis, which also necessitates a reference to the BREFs. On top of that, after a BREF updating the terms of the initial permit, conditions will be compulsorily reevaluated. This highlights the importance of the diagnosis phase and the need of a practical and simple methodology, for operators at a local plant, which enable the BAT environmental performance assessment of techniques and management procedures.

Besides, monitoring emissions is a central idea in the IED directive. Installations using, producing or releasing hazardous substances have requirements to control and reduce the risk of soil and groundwater contamination.

Thus, in comparison to the IPPC directive, the new regulation seems to be clearer and to have eliminated difficulties, mainly those concerning the relationship with other environmental legislation.

To conclude, in view of this situation, namely the complexity of this legal and regulatory framework on perpetual change, the SMEs are faced with more and more difficulties as they attempt to comply with new environmental requirements (Franchi, 2006). These difficulties are due to a lack of current environmental regulation knowledge, inconsistent or nonexistent access to information (Gondran, 2001; Perrin et al., 2010) and a lack of methodologies adapted to local conditions for operators (Cikankowitz and Laforest, 2010).

## 6. Conclusion and perspectives

The BAT concept is the key principle of the IPPC directive. This is brought to mind in many studies mentioned previously. Industries have to apply such techniques. On the one hand, the regulation does not dictate a specific one because a BAT depends on the local context. A technique with BAT equivalent performance for one company is not inevitably a BAT for another company in the same branch of activity. On the other hand, the main element is that the legislation does not provide the means to reach this objective. In spite of considerable progress in the application of the IPPC directive, almost two years after the deadline (October the 30<sup>th</sup>, 2007), France has not yet completed the process of transposition into national legislation. In February 2009, the national rate of IPPC compliance rose to 65%, against that of 58% for the Rhône-Alps region. Feedback mechanisms from stakeholders underline that each sector of activity does not reach the same difficulties in meeting the requirements of the IPPC directive (Laforest, 2008).

We must emphasize the stakes of the IPPC directive, which are a challenge and a real opportunity for industrial installations. Indeed, it helps industries to reach a high level of environmental protection, taking account of local conditions (technical, geographic and economic) in the evaluation of performances. After more than ten years of implementation, despite difficulties, recent literature proposes an assessment of the efficacy of the IPPC directive implementation in some industrial activities in terms of environmental performance, such as the steel and glass industry (Rave and Triebswetter, 2008), the Finnish pulp and paper industry (Silvo et al., 2009) and pharmaceutical manufacturing installations (Styles et al., 2009b). Moreover, measurement of the environmental performances of IPPC industry and evolution of implementation of techniques in the IPPC context seems to rise (Styles et al., 2009b; Karavanas et al., 2009). Nevertheless, it also gives an incentive for the development of a progressive and systematic evaluation approach as well as a continuous improvement approach in environmental performances. Lopez-Gameo et al. (2010) confirms that fact and affirms that industries must take the IPPC as an opportunity to develop an approach of enhancing the company. IPPC is an opportunity to undertake in an environmental management system by having a better master of the company and the possibility to forecast the future in a sustainable development strategy.

Earlier, before 1996 in Europe, the emission limit values were the main regulatory constraint, but this is no longer enough to reach an adequate level of environmental performance. The regulatory control policy leads to an « integrated » regulatory policy after the BAT concept, with the objective of taking into account not only the regulatory constraints but also economic and strategic issues. Therefore, this BAT concept might reconcile industries with regulatory requirements, because thanks to the principle of flexibility defined in the IPPC directive, operators are able to promote their prevention or risk reduction actions and negotiate with the competent authority regarding their level of performance according to the local context.

Our L-BAT methodology takes into account these characteristics and the evolution of the issues initially linked to the regulatory policy. Furthermore, for economic and strategic reasons, curative approaches are in favor of proactive actions regarded as clean technologies, or more generally as a cleaner production strategy. The IPPC legislation confirms this trend by laying out the application of BAT, or techniques with equivalent performances that gather clean and detoxication technologies in order to assure better environmental impact management from the source.

This evaluation methodology is a first step towards a better understanding of the fundamental BAT concept and also the technical documents, the BREFs, which seem to be increasingly important in environmental legislation.

Performance is evaluated via a progressive and systematic approach. The operator is able to analyze both the performance of the management procedures and the entire process lines. A score is attributed to each action belonging to the process line (technology by technology) and the environmental and

risk management system. Then, the results of these two studies highlight the overall level of performance of the installation in compliance with the IPPC directive. The evaluation of the sensitivity of the surrounding environment is taken into account and juxtaposed on a spider graph with the environmental impact. This gives a more precise indication of the overall level of performance. In addition, a minimal rate of IPPC conformity of 75% was arbitrarily defined.

Three tools have been devised: (1) an evaluation grid for the production line, (2) a thematic evaluation questionnaire for the environmental and risk management system and (3) an overall and cross-media evaluation grid focusing on the sensitivity of the environmental area surrounding the installations.

Finally, the contribution of the L-BAT methodology and the associated tools is:

- ✓ A comprehensive or integrated approach of the environmental impact,
- ✓ A comparative analysis of the processes' environmental performances and the BAT performance at local level,
- ✓ A flexible, customized approach, suitable for the actual situation on the ground,
- ✓ Communication, ease of discussion and opportunities between institutions and industries,
- ✓ Anticipation of regulatory prescriptions and,
- ✓ Comment on the elaboration of a methodology for the analysis of the cross-media aspects.

Through the L-BAT methodology, the operator is able to highlight on the one hand strong points and compliance with BAT, and on the other hand, weak points where special attention is required to reach the BAT performance. Carrying out part 3 of the French ministerial order of June the 29<sup>th</sup>, 2004 (modified in 2006 and 2009) relative to the decennial technical working reports, ensures initial validation of this L-BAT methodology. This gives operators the opportunity to promote a set of eco-friendly existing practices in the eyes of the law.

Moreover, the originality of this methodology is based on the fact that it has benefited from the participation of voluntary stakeholders with the application of the IPPC directive: industries, technical centers, administration and institutions. This methodology is especially expected to support positive negotiation for industries and the administration.

By ensuring the durability of the methodology, it would be possible to create a common database for the metal finishing activity, which would on the one hand complement our qualitative approach by a quantitative approach and, on the other hand, update the BREFs. Nowadays, these documents only include heterogeneous and generally qualitative data.

From a theoretical point of view, the comparison of the characteristics and the scope of the L-BAT methodology with other existing assessment methodologies allow us to affirm that the L-BAT methodology is consistent with the LCA and the EPE. These methodologies complement each other; they converge towards the same environmental performance improvement goal. Furthermore, concerning the L-BAT methodology, concrete tools that meet industrial requirements and incorporate legislative prescriptions (notably the IPPC directive) are developed. That is why it is possible to consider this methodology as a decision support tool (O'Malley, 1999).

Moreover, it will be interesting to transfer the know-how gained through our approach to other activities such as textiles or paper mills: how will the tools be adapted in the regulatory and technical context of these industries? A specific method which completes the L-BAT methodology, the "*focus L-BAT*" is currently in development to make the step-by-step evaluation of processes easier (Perrin et al., 2010).

To conclude, with the launch of the European industrial emission directive, the BAT concept is reinforced. Thus, the need for methodology such as L-BAT to evaluate technical performances is increasing all the time.

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## Figures

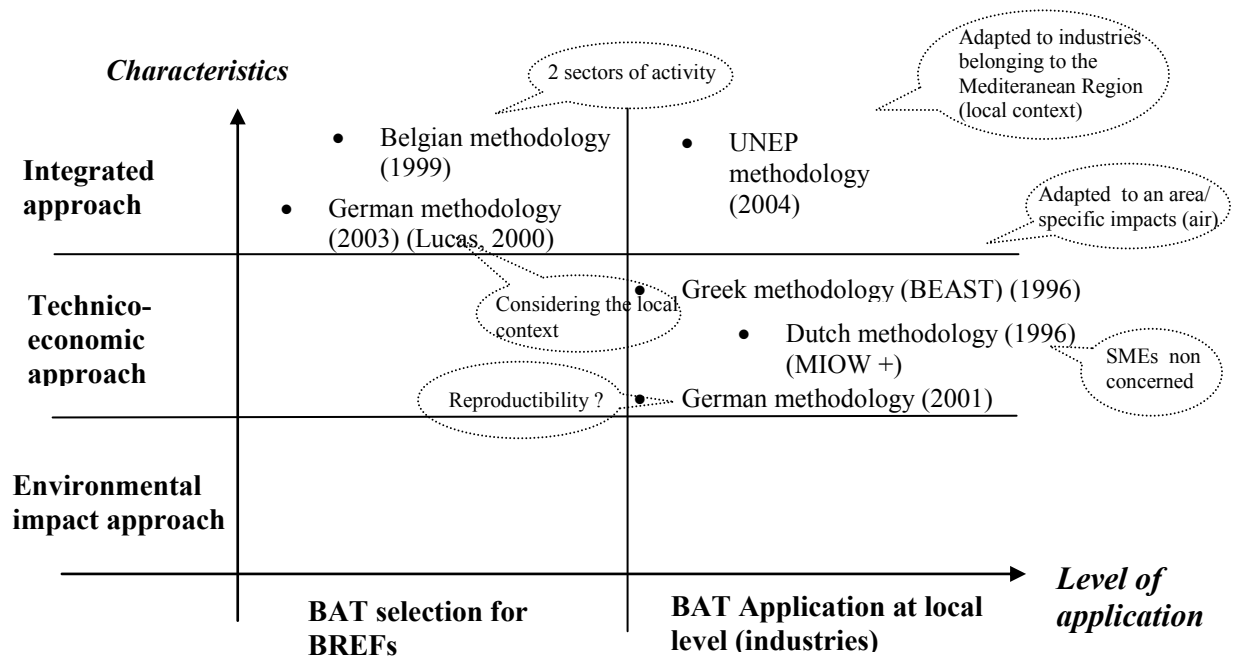


Figure 1: Identification of some BAT assessment methodologies at different levels

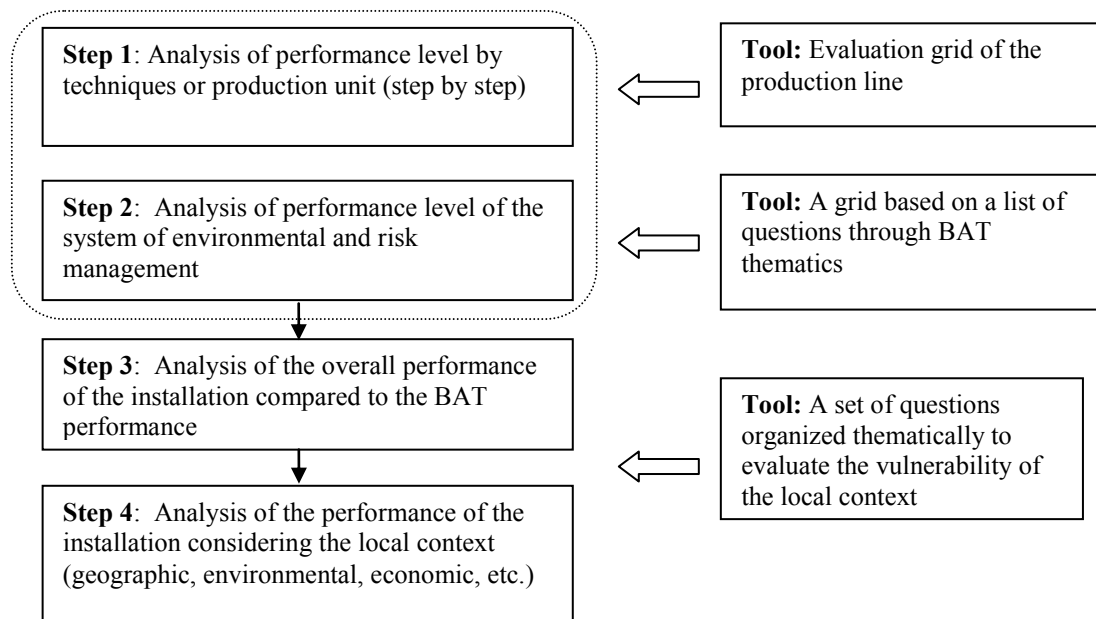


Figure 2: L-BAT : General steps for the assessment of environmental performance of an installation through BAT requirements

Grades	Specifications	Levels of control
A	Existing BAT in the BREF and in compliance with ELV	Good control
B	Action not classified in the BREF but in compliance with the ministerial decree of the February 2, 1998 or the specific decree of the industrial sector (« IPPC compatible ») (for example : ministerial order of the June 30, 2006 for the metal finishing industry)	
C	BAT under implementation and in compliance with ELV	Lower control
D	Technique with BAT from BREF equivalent performance but ELV deviation ( <i>to justify absolutely</i> ) or Solution not in compliance with regulations and/or security but in compliance with ELV	Insufficient control
E	BAT under implementation and ELV deviation ( <i>to justify absolutely</i> )	Very insufficient control
F	Overall non-compliance in terms of regulatory constraints, security and ELV	No control

**Table 1: Performance level of techniques and management systems against BAT defined performance**

OBJECTIVES	Bath functioning optimization		Use of hazardous substances reduction		Reduction of heating losses		Air emissions reduction	
	Temperature - chemical solution - Viscosity	grades	Recent substitution and/or hazardous substances control ?	grades	Means ?	grades	What kind of air emissions reduction techniques ?	grades
STM BREF reference and ministerial decree of June 30th 2006	«5.1.1.2.3.1.7; 5.1.6.1.5.1.4.4» 5.1.4.4.8) "prevent over-cooling by optimising the process solution composition and working temperature range. Monitor temperature of previous and control bath flow optimized process ranges, see Sections 4.1.1 and 4.1.17"		«5.2.5 (F4.9); 5.2.7 (5.2.7.2)» 5.2.5: Substitution for, and/or control of, hazardous substances "Where a hazardous substance has to be used, techniques for minimizing the use of the hazardous substance and/or reducing its emissions are described below: 5.2.5.1 to 5.2.5.7) for example: -> to avoid the use of EDTA (5.2.5.1) (for example using biodegradable substitutes such as those based on gluconic acid (see Section 4.9.1)) -> to avoid the use of PFOS (5.2.5.2) -> cyanide degreasing is not BAT (5.2.5.3) -> [...] Substitution for hexavalent chromium (5.2.5.7)		«5.1.4.3» 5.1 BAT to reduce heating losses by: "4- insulating heated solution tanks by one or more of the following techniques: o using double-skinned tanks o using pre-insulated tanks o applying insulation"		«5.1.18» "When extraction is applied, BAT use the techniques described in Section 4.18.4 to minimize the amount of air to be discharged"	
	5.1.7 "It is BAT to increase the process bath life as well as maintain output quality, particularly when operating around start up, or at the closing of the material loop (see Section 5.1.8.3)".		5.2.7: Substitution and choices for degreasing		5- "insulating the surface of heated tanks by using floating insulation sections such as splines or hexagons. The options are where: o rectangular sections are used, light and may be displaced by the insulation o rectangular sections are sufficiently large to keep the insulation sections (such as vehicle bodies) o the insulation sections can stack or otherwise interfere with the treatment in the tank"			
Batch 1 (degreasing)								
Batch 2 (rinse)								
Batch 3 (pickling)								
Batch 4 (rinse)								
Batch 5 (oil plating)								

**Table 2: Extract of the registration sheet for process lines evaluation**

Themes	ACTIVITIES	OBJECTIVES	Identification of pollution reduction measures	REGULATION	BREF	EVALUATION : BAT level of control											
				Prescriptions of the ministerial order of the june 30, 2006 concerning surface treatment	Surface treatment for metals and plastics	A	B	C	D	E	F	NC	Justifications				
B	Decommissioning of the site	Limitation of the soil contamination and reduction of underground water pollution	Do you plan measures of soil decontamination ?	article 38	5.1.12 "take remedial action for potential contamination of groundwater or soil (see 4.1.1)"												
			Is there an appropriate monitoring of the soil pollution ? (frequency and type of analysis)	article 37	5.1.2.1 "avoid the contamination of soil and water environments from spillages and leakages of chemicals"												
			What kind of measures are planned in case of permanent cessation of activities ?	- production line of metal finishing disassembly --> bank evacuation ?	article 38	5.1.12 "use the information acquired to assist with installation shutdown, removal of equipment, buildings and residues from the sites (see 4.1.1)" and "giving consideration to possible decommissioning during the design or upgrading of the installation (see 4.1.1)"											
				--> area reformation rehabilitation ?													
				--> vats rental ? (Cleaning and in treatment of wash water)													
				--> residue of chemicals products evacuation in an authorized treatment office?													
				--> realization, if necessary, of soil study ?													
				--> other ?													
G	Waste production	Reduction of waste production impacts	Is the industrial waste as a majority recycled/ upgraded ?	article 27, 28, 29	5.1.6 "BAT is prevention, reduction, re-use, recycling and recovery"												
			If industrial waste is disposed and not upgraded, will this management provide the best warranty and results in terms of environmental protection ?	article 28 - §2	not referenced												
H	Vibration, noise, odor	Reduction of noise	If there are sources of odor that are hard to confine (mill pond, etc.), are there, appropriately embedded in order to limit inconvenience for the neighbourhood ?	article 24 - §1	not referenced												
			Are you equipped with reducing noise (material) means or control measures ?	Are there a plan of closure bay doors ?	not referenced	5.1.11 "it is BAT to reduce noise [...] closure of bay doors"											
				Are there silencers or acoustic enclosures for large fans or equipment with high or tonal noise levels ?	not referenced	5.1.11 "engineered controls such as installation of silencers on large fans [...]"											

Table 3: Extract from the ERMS questionnaire

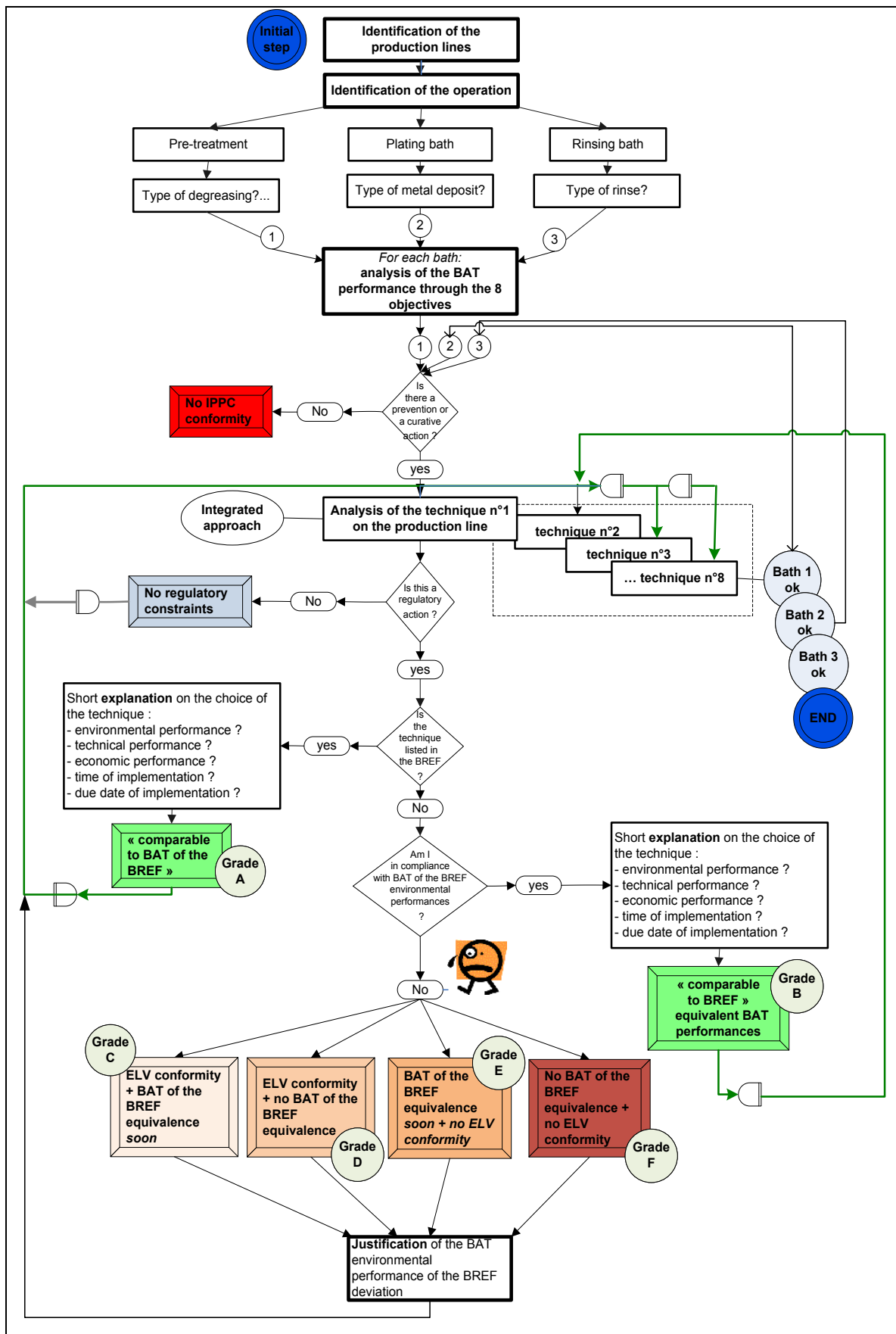
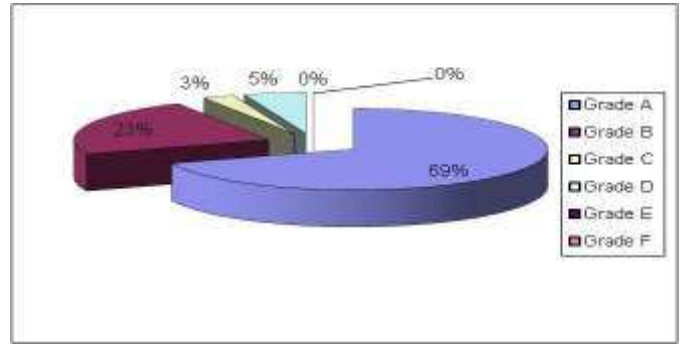


Figure 3: The systematic procedure to assess BAT environmental performance of a unit of production for a metal finishing workshop

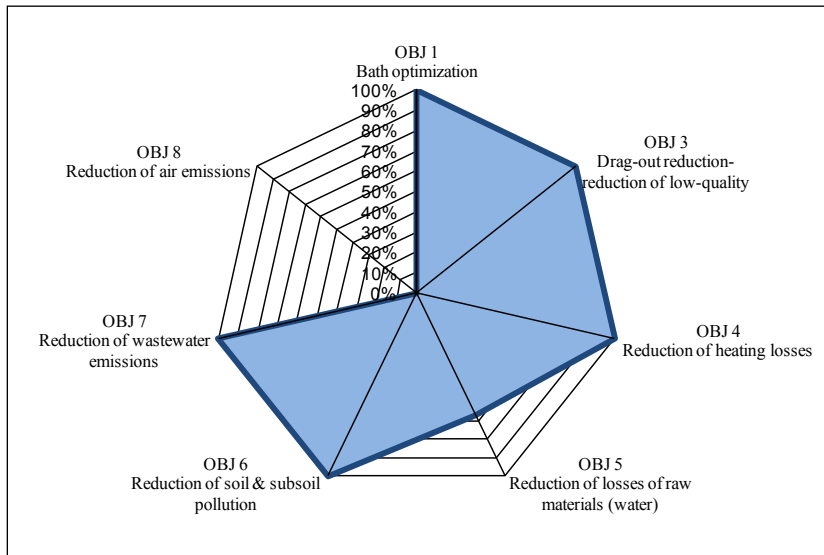
	Obj. 1	Obj. 2	Obj. 3	Obj. 4	Obj. 5	Obj. 6	Obj. 7	Obj. 8	Number of actions sum-total
Grade A	6	nc	9	3	2	0	7	0	27
Grade B	0	nc	0	0	0	9	0	0	9
Grade C	0	nc	0	0	1	0	0	0	1
Grade D	0	nc	0	0	0	0	0	2	2
Grade E	0	nc	0	0	0	0	0	0	0
Grade F	0	nc	0	0	0	0	0	0	0
	6	nc	9	3	3	9	7	2	39

nc : non concerned

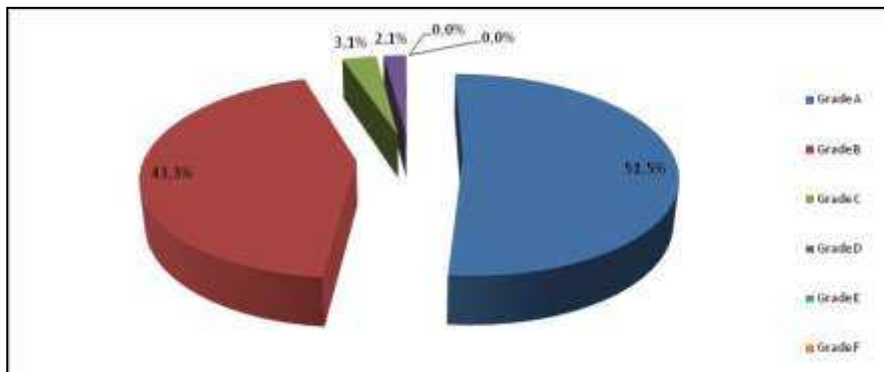
**Table 4: Summary of actions**



**Figure 4: Compliance rate (%) of the electrolytic polishing process line**



**Figure 5: Levels of IPPC compliance by environmental objectives of the preventive measures of the electrolytic polishing manual lines**



**Figure 6: Position of preventive techniques compared to BAT**

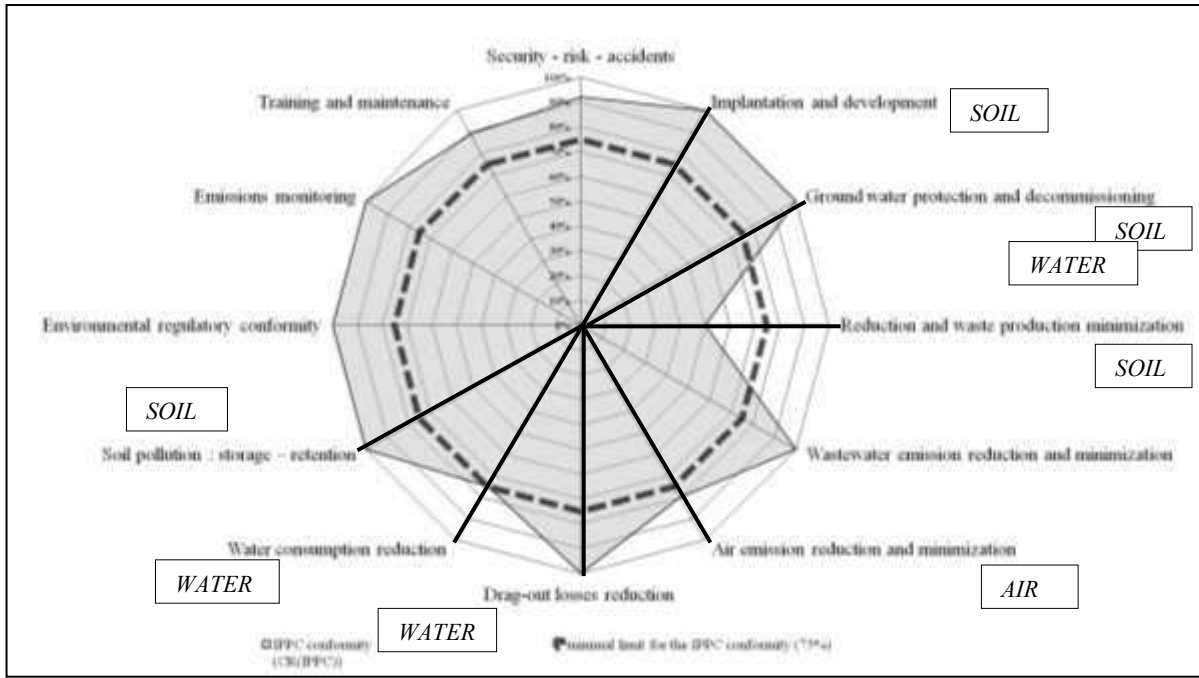


Figure 7: Representation of the environmental and risk management system compliance as regards the IPPC directive, taking local conditions into account (Cikankowitz, 2008; European, 2009)

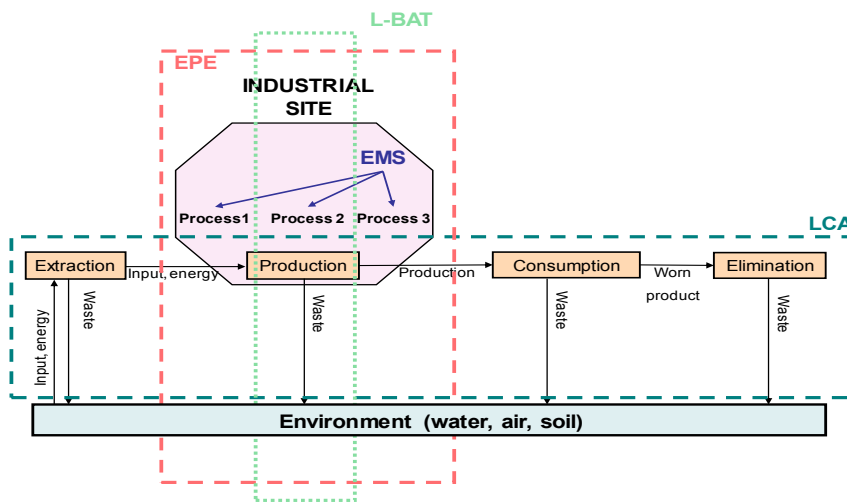


Figure 8 : Scope of the L-BAT compared to other environmental assessment methodologies (EMS, LCA & EPE) (ISO, 1998)