Final report

Guideline for determining the Best Available Techniques at installation level

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SUMMARY

European and Flemish environmental regulations are based on the application of Best Available Techniques (BAT).

There are several possible reasons why an operator would carry out a company-specific BAT analysis. In order to offer a tool that enables company-specific BAT studies of that type to be carried out in line with the approach used in Flemish and European BAT sector studies, we have provided this Guideline.

A BAT study at installation level consists of the following 7 steps, which must be completed one by one. Depending on the complexity of the dossier, the available information and the degree of consensus between the government and the company, these 7 steps will be worked out qualitatively (expert estimate) or quantitatively and more thoroughly.

Step 1: Define the problem
Step 2: Draw up a list of "potential BAT"
Step 3: Evaluate the technical feasibility of the potential BAT
Step 4: Evaluate the environmental performance of the potential BAT. Two possible routes can be used to achieve this – a quantitative estimate or a qualitative approach. The quantitative approach may be used to supplement or replace the qualitative approach.
Step 5: Evaluate the economic feasibility of the potential BAT. Two possible routes can be used to achieve this – a qualitative estimate or a quantitative approximation of the cost price of the potential BAT, followed by an analysis of the profitability of the potential BAT and its feasibility for the company and by an analysis of the cost-effectiveness of the potential BAT and the reasonableness thereof. The quantitative approach may be used to supplement or replace the qualitative approach.
Step 6: Select the BAT
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CHAPTER 1. PURPOSE AND SCOPE OF THE GUIDELINE

European and Flemish environmental regulations are based on the application of Best Available Techniques (BAT).

For an operator, there are various possible reasons for carrying out a company-specific BAT analysis, whether or not this is linked to a Flemish or European BAT study. For example, an operator may find it desirable to substantiate the application of BAT, such as in the context of an environmental permit application or in order to apply for a specific derogation.

In order to offer a tool that enables company-specific BAT studies of that type to be carried out in line with the approach used in Flemish and European BAT sector studies, we have provided this Guideline. The Guideline can form a useful point of reference for the operator and the environmental coordinator of individual companies, whenever they wish to investigate what the BAT is in their particular situation. This Guideline can also be used as a manual by those conducting company-specific BAT studies (e.g. research institutions or engineering offices).

After all, this Guideline is not binding and does not need to be followed exactly. The Guideline must therefore also be regarded as a voluntary tool for operators.

The Guideline has been drawn up based on the experience gained during Flemish sectoral BAT studies, company-specific studies by VITO and experiences with European BAT studies (Best Available Techniques Reference Documents (BREFs)). The legal provisions of the Flemish (VLAREM) and European legislation (Industrial Emissions Directive - 2010/75/EU) will serve as a framework. This Guideline is distributed following approval by the BAT/EMIS/EP Steering Committee. The most recent version can be accessed at any time on the EMIS website (http://www.emis.vito.be , under the tab “BBT-kenniscentrum”, and “andere publicaties”).

CHAPTER 2. DETERMINING THE BAT AT INSTALLATION LEVEL

2.1. INTRODUCTION

A BAT study at installation level consists of the following seven steps, which must be completed one by one. Depending on the complexity of the dossier, the available information and the degree of consensus between the government and the company, these seven steps will be worked out qualitatively (expert estimate) or quantitatively and more thoroughly (see Figure 1).

Step 1: Define the problem
Step 2: Draw up a list of "potential BAT"
Step 3: Evaluate the technical feasibility of the potential BAT
Step 4: Evaluate the environmental performance of the potential BAT. Two possible routes can be used to achieve this – a qualitative estimate (Step 4a) or a quantitative approach (Step 4b). The quantitative approach may be used to supplement or replace the qualitative approach.
Step 5: Evaluate the economic feasibility of potential BAT Two possible routes can be used to achieve this – a qualitative estimate (Step 5a) or a quantitative approximation of the cost price of the potential BAT (Step 5b), followed by an analysis of the benefits of the potential BAT and its feasibility for the company (Step 5c) and by an analysis of the cost-effectiveness of the potential BAT and the reasonableness thereof (Step 5d). The quantitative approach (Steps 5b to 5d) can be used to supplement or replace the qualitative approach.
Step 6: Select the BAT
Step 7: Test the proposed BAT against sectoral BAT

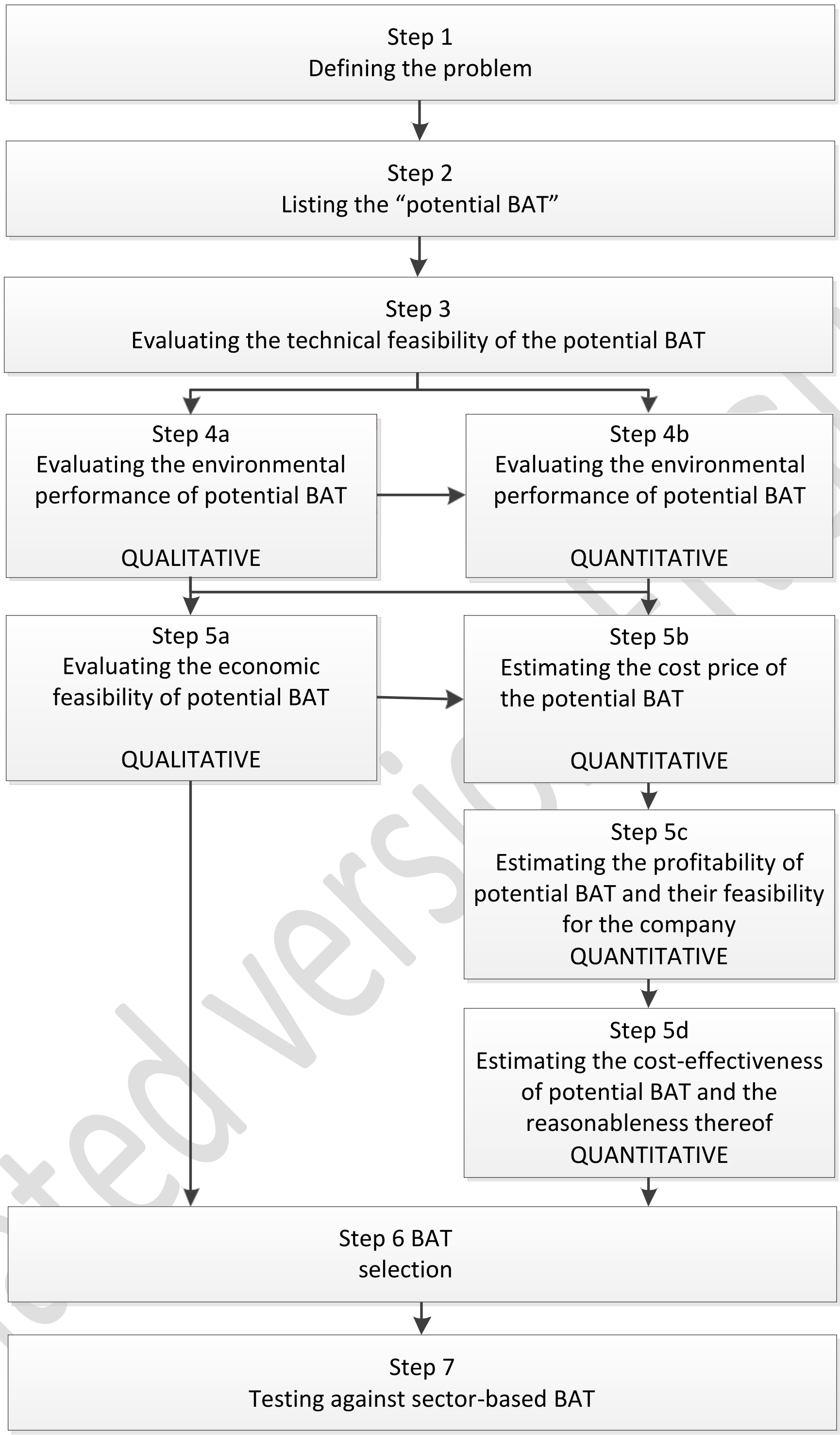

Figure 1. Schematic diagram of steps to be taken when carrying out a BAT analysis at company level

2.2. Step 1. Delineation of the study

The first step in such a study is, of course, to define the problem clearly. In the majority of cases, the licensing authority will not ask for the BAT in all processes in the company concerned, but will focus its demand, based on a particular environmental problem, such as odour nuisance, high concentrations of a specific pollutant in the wastewater or the off-gases, or the choice of a visually jarring installation, etc. It is clear that the predetermined framework in which the BAT study takes place determines the complexity of the BAT evaluation and the final result to a significant degree. If the starting and finished products have been less precisely defined (e.g. A = textile and B = coloured textile), the conclusions of the BAT analysis will be different and will be less specific than will be the case if those products have been defined in specific terms (e.g. A = wool from sheep breed X and raised on farm Y and B = carpet, type T, coloured with anthraquinone dye Z). A further example comes from the chipboard industry, which makes use of adhesives containing formaldehyde. In the context of chipboard production, the use of alternative (formaldehyde-free) adhesives must be included in the BAT assessment. In the context of chipboard production using formaldehyde-containing adhesives, the BAT will relate to the best variants and possible adjustments to the production process, in order to limit formaldehyde emissions. Switching to formaldehyde-free adhesives will not form part of the study. The person carrying out the study must provide a precise definition of this problem at the start of the study and possibly also in the title. For example: “BAT for the prevention and elimination of nitrogen compounds from the wastewater of company XYZ”. If a narrow delineation is preferred (such as: “BAT for the elimination of nitrogen compounds from the wastewater of company XYZ”), sufficient justification for this must be provided. After all, a delineation that is too narrow can result in potentially attractive measures (in the above example: preventive measures) being excluded from the scope of the BAT analysis before it is even carried out. However, a narrow delineation can, in some cases, be justified, for example if an earlier study has been carried out that was broader in scope.

When delineating the environmental problems, care should be taken to ensure that the integrated nature of the BAT analysis is not compromised. In accordance with the definition of BAT in VLAREM II (Article 1.1.2.), all environmental compartments, such as air, water, waste, soil, energy, raw materials, etc., must be taken into account when determining the BAT. Delineating the problem must not result in this integrated approach being compromised.

2.3. Step 2. Listing potential BAT

The person carrying out the study should draw up the broadest possible list of techniques that could be used to solve the environmental problem. These are then known as the “potential BAT”. As a minimum, these should include the techniques referred to in Flemish and European BAT studies involving the activities concerned or any related activities. This can easily be achieved by consulting the EMIS website (www.emis.vito.be/en), and selecting the pages Flemish BAT-studies and European BAT-studies, or by accessing the BAT database on EMIS.

Above and beyond those studies, or if it turns out that such studies are not relevant or not applicable, other audits of techniques may be consulted. The EMIS website provides a number of tools that provide an overview of existing techniques. These tools relate to the processing of waste and materials (AFSS), soil remediation techniques (BOSS), air and water treatment techniques (LUSS and WASS), and reduction techniques for diffuse particulate emissions during the storage and transhipment of dry bulk goods. These tools have been developed to support decision-making by the government, companies or environmental advisers. The purpose of the tools or selection systems is not to automatically propose the BAT based on the data entered, but to select a number of possible techniques from which the expert may then be able to select the BAT following a more in-depth analysis.

The techniques that the company has already tested itself or of which it is already aware will also be taken into consideration of course. In a number of cases, the person carrying out the study may contact suppliers of environmental technologies and other companies or federations from the sector concerned, in order to supplement this list.

When drawing up the list, it is important not to make a hidden selection (such as "we will not include that technique in the list, as it is too expensive"). The selection should only be made afterwards.

Some general rules when drawing up a list of potential BAT:

- Do not restrict the list to treatment techniques. The list should also include preventative and process-integrated measures.
- Do not restrict the list to technologies. Organisational measures should also be included.
- Define the techniques in terms that are as specific as possible. For example, it is better to write "separation using a centrifuge of type X", and not just "physical separation"

2.4. Step 3. Selecting a potential BAT that is technically feasible

In principle, the technical feasibility of a particular technique must be demonstrated (or refuted) on the basis of practical experience or on the basis of data in Flemish or European sectoral BAT reports. As a rule, techniques that have only been tested on a purely experimental scale can be excluded for this purpose. This does not mean, however, that the company cannot ultimately choose to introduce an experimental technique of that type. A good indication in terms of technical feasibility is if the technique has already been applied in other companies under comparable conditions. In that regard, it is not necessary for the technique to have been used or produced in Flanders, or in the industrial sector concerned. Amongst other things, the technical evaluation must focus on the following questions:

- Are there any technical constraints that prevent the potential BAT from being applied in the installation (such as the presence of specific contaminants that would poison a catalyst or a lack of available space)?
- Will the introduction of the potential BAT still allow finished products to be produced to the same level of quality (e.g. could the quality of the printed matter deteriorate as a result of switching to aqueous paint)?
- Will the introduction of the potential BAT not involve any unacceptable deterioration in working conditions?

The answer to these questions must be taken into account in the final decision regarding technical feasibility.

More specifically, the assessment of technical feasibility can be subdivided into the following categories:

- **Proven**. In this category, it is necessary to determine whether the technique has already proved its usefulness in industry on a practical level.[1]
- **Applicable**: In this category, it is necessary to examine whether there are any technical limitations that prevent the technique from being applied in the installation.

[1] In some cases, techniques that have not yet been proven can be regarded as an Emerging Technique. The term "emerging technique" is defined in the Industrial Emissions Directive (2010/75/EU) as follows: "a novel technique for an industrial activity that, if commercially developed, could provide either a higher general level of protection of the environment or at least the same level of protection of the environment and higher cost savings than existing best available techniques". Emerging techniques do not, by definition, form a BAT (as yet).

- **Safety**. Under this category, it is possible to evaluate whether, if appropriate safety measures are put in place, the technique will result in an increase in the risk of fire, explosion and occupational accidents in general.
- **Quality**. Under this category, it is possible to evaluate whether the technique has any influence on the quality of the end product and to what extent.
- **Overall**. This category summarises the preceding categories and assesses the overall technical feasibility of the technique.

In many cases, the evaluation of the technical feasibility can be based on the available information from companies, suppliers, literature, from the experiences of experts, etc. In other cases, it will be necessary to carry out practical tests, such as testing a pilot wastewater treatment plant using the wastewater from the company concerned.

In order to select a potential BAT that is technically feasible, sufficient technical background or support should be available to properly assess the value of data provided by a company or supplier and any other sources of information. If necessary, access to and experience with test installations will be required.

If a technique has already been evaluated as BAT for a certain sector or activity in a Flemish or European BAT study, it will, in principle, be considered technically feasible for any company that falls within the scope of the BAT study. Only if the company-specific situation is clearly different to that of other companies in the sector from a technical point of view will it be possible to deviate from this.

Techniques assessed at this stage to be “not technically feasible” in a company specific context will not, by definition, form a BAT for the company. Further assessment of environmental performance and economic viability can still be carried out, but this is not strictly necessary in order to draw conclusions regarding the BAT.

2.5. STEP 4A. QUALITATIVE ASSESSMENT OF ENVIRONMENTAL PERFORMANCE

As a minimum, it is necessary to indicate the environmental compartments on which the technique in question has an influence, and in what sense (positive/negative). The advantage of qualitative approaches is that they can provide a fairly rapid picture of the overall environmental performance of a large number of techniques. A disadvantage of these, however, is that they fail to reveal smaller differences in environmental performance. A qualitative analysis often involves awarding a score for the various environmental impacts. An approach used by the BAT knowledge centre when drawing up the Flemish BAT studies is the one in which various environmental compartments (air, wastewater, waste, soil, use of raw materials and auxiliaries, energy consumption, water use, noise nuisance and odour nuisance) are assigned the following scores:

--	Major deterioration in this compartment
-	Deterioration in this compartment
0	No effect on this compartment
+	Improvement in this compartment
++	Major improvement in this compartment
+/-	sometimes a positive effect, sometimes a negative effect

The assessment is an expert estimate that may be based on BAT studies, other literature data and on the experience of operators and suppliers. Taking an expert opinion as a starting point, an overall environmental assessment can be provided. To determine the latter, the following elements can be taken into account:

- if one or more environmental scores are positive and none are negative, the overall assessment is always positive
- if there are both positive and negative scores, the overall environmental score will depend on the following considerations:

shifting from a less controllable compartment to a more controllable one (from air to waste, for example) may be beneficial

  - a relatively greater reduction in one compartment compared to a limited increase in others may be beneficial
  - The desirability of a reduction based on policy, derived, for example, from a comparison of the environmental quality objectives for the receiving surface water, emission reduction objectives drawn up for Flanders in the context of acidification or eutrophication, etc. In many cases, the actual permit file will contain elements that can be used as a guide for this final assessment.
  - Even general rules of thumb, such as the "Lansink ladder" can provide guidance. Alternative qualitative approaches are possible, of course, e.g. one score per pollutant, per group of pollutants, etc.

A possible additional aspect when evaluating the environmental performance of a technique is its impact on the value chain. For each technique, a qualitative check is carried out to determine whether its implementation in the company has an effect on the environmental impact of the upstream and downstream chain. A given technique can have a positive influence on the environmental performance of a company, but can also lead to a significant effect (positive or negative) on the environmental impact of companies in the upstream or downstream chain (and this could take the form of one or more environmental aspects, such as air, wastewater, waste, soil, use of raw materials and auxiliaries, energy consumption, water use, noise nuisance, odour nuisance, etc.).

2.6. STEP 4B. QUANTITATIVE ASSESSMENT OF ENVIRONMENTAL PERFORMANCE

This approach sets out to quantify and weigh up the environmental benefits of the various techniques. In principle, figures are easier to calculate in company-specific BAT studies than in sectoral BAT studies, because the parameters of the former are better defined (e.g. 100,000 m^3 of wastewater per year containing X and Y). A quantitative approach is usually preferable but has the disadvantage that less quantifiable environmental impacts (e.g. odour) are less clearly visible in the final assessment.

If weighing up the various environmental compartments and/or pollutants is less important, a quantitative comparison of the reductions in emissions of the problem parameter may be sufficient on its own. For example, a technique that reduces heavy metals by 90% will score better than a technique that only achieves a 60% reduction. The technique providing a reduction of 90% can consume more energy or generate more waste, or can transfer the pollution to another installation. For that reason, such a comparison of the reductions in emissions will often need to be complemented by a qualitative assessment of the effects on other compartments (see Step 4a). If weighing up the various environmental compartments and/or pollutants is important, a more in-depth analysis will have to be carried out. That will particularly be the case whenever process modifications are concerned. In those cases, a life-cycle analysis (LCA) may be an option.

After the LCA, the various environmental topics (such as the greenhouse effect and effects on human health) will still need to be weighed up. An important aspect of an LCA approach is an effective and specific definition of the parameters of the environmental problem that one wishes to study. The availability of reliable figures is often a problem. The availability of such data is generally greater when using an installation-specific approach than when using a sector-based approach. When carrying out LCA studies, it is best that these be based on ISO standards 14040 and subsequent standards.

For an overview of methodologies that can be used in order to weigh up cross media aspects, see the REF economics and Cross-media Effects[2]. Examples of evaluation methods include:

- a simple comparison of the impact on each of the environmental themes involved
- standardisation aimed towards European totals
- standardisation against sectoral totals from the European Pollutant Release and Transfer Register (E-PRTR, http://prtr.ec.europa.eu/);
- a study into local environmental impacts

Quantifying emissions can sometimes be carried out using the measurement data available. In many cases, it will however be necessary to make prior measurements, such as on test installations, for example.

If a technique has already been evaluated in a Flemish or European BAT study as a BAT for a certain sector or activity, the environmental performance will, in principle, be assessed as positive. Only if the company-specific situation is clearly different to that of other companies in the sector from a technical point of view will it be possible to deviate from this.

Techniques assessed at this stage to be “not environmentally effective” in a company specific context will not, by definition, form a BAT for the company. Further assessment of economic viability can still be carried out, but this is not strictly necessary in order to draw conclusions regarding the BAT.

2.7. STEP 5: EVALUATION OF THE ECONOMIC FEASIBILITY OF THE POTENTIAL BAT

The evaluation of the economic feasibility of the potential BAT is based on the available cost data of the potential BAT and the financial data of the company, if available. For that purpose, it is important that the person carrying out this evaluation has a good sense of the scale of the costs, an objective attitude towards the specific dossier and experience with other environmental investments. In principle, such analyses can once again be carried out both on a qualitative and a quantitative basis. To carry out a more detailed quantitative analysis, experience with investment decisions and financial analysis will be necessary.

If a technique has already been evaluated as BAT for a certain sector or activity in a Flemish or European BAT study, it will, in principle, be considered economically feasible for the average company that falls within the scope of the BAT study. Generally, a specific (poor) economic situation does not, as such, constitute an argument to derogate from conclusions on BAT determined on a sectoral basis. Derogation is possible if it can be demonstrated that the costs are excessively high in relation to the environmental benefits and that this is the result of a specific (non-standard) technical situation, geographical location or local environmental conditions.

2.8. STEP 5A. QUALITATIVE EVALUATION OF THE ECONOMIC FEASIBILITY OF POTENTIAL BAT

An assessment of the economic feasibility of a potential BAT, seeks to provide an answer to two questions: (i) Can the company concerned bear the costs of the potential BAT and (ii) is the environmental benefit achieved outweighed by the costs? A thorough estimate of the costs therefore forms an important pre-requisite in that regard.

The qualitative approach gives scores for profitability (+ profitable investment, 0 costs and revenues in balance, - non-profitable investment but portable, -- neither profitable nor portable investment) and for cost-effectiveness (+ reasonable environmental benefit compared to costs, - unreasonably high cost compared to the environmental benefit achieved). Here too, the scores are assigned on the basis of expert assessment, supported by quantitative data and, as far as possible, by “objective” assessment frameworks.

2.9. STEP 5B. ESTIMATING THE COST PRICES OF THE POTENTIAL BAT

Costs should be estimated on the basis of the most appropriate sources. In installation-specific studies, cost prices will often be presented by suppliers in quotations that have been issued to the company. Cost prices from affiliated companies may also be available. In addition, cost prices mentioned in (recent) BAT studies, BREFs and other literature sources can be used. For specific guidelines regarding the proper documentation of cost price data, please refer to the Costing Methodology in the REF Economics and Cross-Media Effects[3].

In order to serve as a basis for estimating feasibility and cost-effectiveness, it is useful to convert the cost-price data into (i) annual costs and/or (ii) the net present value.

→ Annual costs

The investment costs are “spread” across the life of the technique examined and are expressed as an annual capital cost. The sum of that capital cost and the operational costs, minus the annual revenues and savings, indicates the total annual costs. This is often expressed using the formula below:

$$Total\ annual\ cost = I_0 \left[\frac{r(1+r)^n}{(1+r)^n - 1}\right] + OK$$

where:

- I_0 : total investment expenditure in the year of acquisition
- OK : annual net operating costs
- r : discount rate
- n : expected service life

[3] EIPPCB, 2006. http://eippcb.jrc.ec.europa.eu/reference/ecm.html

→ **Net present value (NPV)**

In this case, all proceeds and costs as indicated above are added together but back-calculated to the time of acquisition. The initial investment in the year of acquisition I_0 is deducted from this in order to arrive at the net present value. If the net present value is positive, the investment is regarded as profitable from a commercial point of view. That may be the case, for example, if savings are made on energy costs, and those savings compensate for the costs incurred.

The following formula is used:

$$NAW = \sum_{t=1}^{n} \frac{O_t - K_t}{(1+r)^t} - I_0$$

where:

O_t : proceeds and savings in year t
K_t : costs in year T

Bear in mind that there are many factors that determine the usability of the cost price data, such as:

- the origin of the data (e.g. suppliers may quote low cost prices for new techniques in order to open up the market)
- the background behind how the costs were calculated (e.g. what discount rate or what depreciation period was used)
- the recency of the data (techniques and their costs can evolve rapidly)
- the uncertainty of the data

2.10. STEP 5C. ESTIMATING THE ECONOMIC FEASIBILITY OF POTENTIAL BAT FOR THE INSTALLATION CONCERNED

If the technique(s) examined has/have been assessed as profitable (e.g. by a positive net present value), it will be assumed that feasibility is not a problem either. In order to decide which unprofitable techniques are still feasible for the installation concerned, a number of approaches can be followed:

1. testing against reference values
2. impact on the company's free cash flow
3. evaluating the company's financial ratios
4. calculating the cost price increase per unit of product

When assessing feasibility using these approaches, the market situation and the competitive pressure to which the company is subject must be taken into account. The framework set out in Michael Porter's 'Five Forces' is an excellent tool for this. M. Porter (1980, 1985) distinguishes between five sources of competition: competitive rivalry between companies, the power of suppliers, the power of customers, the threat of substitutes and the threat of new entrants. The essence of the theory and the way in which these sources of competition can influence the definition of BAT is described in the REF "Economics and Cross-media"[4].

→ Reference values

By relating the annual costs to reference values for a number of financial parameters, the economic feasibility of various techniques can be assessed. These reference values are presented in the following table (Vercaemst, 2002). They have been derived from practical data from previous studies and are therefore not the result of scientific research. The reference values are useful to perform a quick scan that can exclude techniques with clearly unrealistically high costs in relation to the financial performance indicator of the company. On the other hand, those techniques whose costs are very low can also be identified and it may be possible for them to be regarded as feasible without any further analysis.

In this method, the annual costs of the technique are analysed in relation to a number of key figures for the company: the turnover, the operating profit and the added value. The relationship between the absolute investment amount and the average investments of recent years is also analysed here. To average out variations, it is preferred to calculate an average for the past 4 to 5 years.

Table 1: Indicative reference values for the feasibility of environmental investments (source: Vercaemst, 2002)

Ratio	Acceptable	To be discussed	Unacceptable
Annual costs/revenue	<0.5%	0.5 – 5%	>5%
Annual costs/operating profit	<10 %	10 – 100%	>100%
Annual costs/added value	<2 %	2 – 50%	>50%
I_0/Investments	<10 %	10 – 100%	>100%

Each of these relationships can be classified in one of the three following classes: “Acceptable”, “To be discussed”, and “Unacceptable”. If the environmental investment falls within the acceptable zone, it can be stated that the investment is relatively small enough in relation to the key figures to be considered acceptable without further discussion. The class “Unacceptable” contains those investments that can be considered excessive in relation to the activities and company results. In between those is the ‘To be discussed’ category, in which no clear assessment can be given of the feasibility of the investment. In this case, the feasibility of the environmental investment is assessed based on additional elements such as the implementation period, the total environmental investment pressure and the current market and financial situation.

The advantage of this method is that it allows us to relate the costs of the environmental investment to the financial results (turnover, operating profit, added value) and size (turnover, added value, investments) of the businesses within a sector.

The largest number of environmental investments considered in previous studies, however, fall into the “To be discussed” category. This immediately indicates the most important shortcoming of this method – the “To be discussed” category forms, as it were, a large grey area, in which no conclusions can be drawn about the feasibility of the environmental investment. On the other hand, this approach in any case forms a *basis* for assessing feasibility and this must be combined with other considerations in order to arrive at a decision.

→ **Evaluating the financial ratios**

A financial analysis based on financial ratios is a familiar tool when it comes to supporting investment decisions in the world of business. The purpose of the analysis is to assess the financial situation based on mainly historical data from published annual accounts. In order to be able to assess the financial health of a company effectively, it is important to chart the changes in the ratios that took place over a period of 3 or 4 years. What is more, a comparison with sector averages can help to form an effective assessment of the financial health of the company and the impact this will have on the economic feasibility of the environmental investments intended. For example, the Central Balance Sheet Office of the National Bank of Belgium publishes annual statistics on the annual accounts of companies by sector of activity, in which a number of financial ratios are also included.[5]

The table below shows a number of ratios that can be used for the financial analysis. The majority of these can be found in the annual publications of the NBB. Below, we have provided a short description of those ratios and the calculation method, according to the codes listed in the annual accounts of companies[6]. For more background information, it may be useful to consult a financial analysis manual or to seek the involvement of a financial officer within the company.

The first two ratios are liquidity ratios that compare cash income with cash expenditure and reflect a company's short-term solvency (such as paying its debts on time). Liquidity in the broad sense or the current ratio is equal to the coverage of the short-term debt by the (limited) current assets. If that coverage is sufficient, the current ratio will be greater than 1. Insufficient coverage can lead to liquidity problems. The liquidity ratio in the strict sense takes account of the fact that not all current assets (such as stocks and contracts in progress) can be converted into cash in the short term. The numerator and denominator of this ratio are therefore limited to the most liquid elements and are therefore interpreted more strictly.

The profitability ratios make it possible to assess the company's results on a relative basis. The profitability of a company is a comparison of income and costs incurred as a result of the operation of the company over a given period of time. Sufficient profitability means that the difference between revenues and costs is sufficient in comparison to the invested capital, which can be found on the balance sheet. The table below shows two ratios that relate profitability to equity or assets. The net return on total assets before financial charges and taxes indicates the result obtained per 100 euros of invested capital. This is particularly important from the point of view of investment decisions, while the net profitability of equity after tax is particularly of interest to shareholders.

The solvency ratios reflect the extent to which a company is able to meet its long-term financial obligations (payment of interest and repayment of debts). The overall debt ratio can be calculated in different ways. In the current NBB publication, solvency is calculated by taking the ratio of equity to debt and is therefore a measure of financial independence

5 https://www.nbb.be/nl/balanscentrale/analyseren/statistieken/statistieken-van-de-jaarrekeningen-van-ondernemingen

6 See https://www.nbb.be/nl/balanscentrale

of the company. The coverage ratio of multi-year debts payable that are due within the year by the cash flow takes into account the debts that have to be repaid within a given year. This can be done on the basis of the historical data from the balance sheet, but can be calculated on the basis of the debts that will have to be repaid next year, including an additional loan for the environmental investment. In this way, the feasibility can be estimated, based on financial data.

Table 2: Selection of financial ratios to be used for financial analysis

Ratio	Codes
Liquidity in the broad sense (current ratio)[7]	(3 + 40/41 +50/53 + 54/58 + 490/1) **/** (42/48 + 492/3)
Liquidity in the strict sense (acid test)[5]	(40/41 + 50/53 + 54/58) **/** (42/48)
Net return on equity after tax[5]	9904 **/** 10/15
Net return on total assets before tax and debt charges[5]	(9904 + 650 + 653 – 9126 + 9134) **/** 20/58
Solvency (financial independence) [5]	10/15 **/** 10/49
The coverage ratio of multi-year debts payable that are due within the year by the cash flow (coverage ratio)[8]	70/67 - 67/70 + 630 + 631/4 + 635/7 + 6501 + 651 + 6560 + 6560 – 6561 + 660 + 661 + 662 + 663 + 680 – 760 – 761 – 762 – 780 – 9125 **/** 42

→ Calculating the cost price increase per unit of product

A third possibility is to calculate the increased cost price per unit of end product. This cost price increase can be compared with the customary margins in the sector concerned. For example, the BAT study on petrol stations states that the vapour recovery technique amounted to an increase in the cost price of the petrol of between 0.1 and 0.2 eurocents per litre. Compared to an operating margin of 12 eurocents per litre, it was decided that this cost was feasible in most cases.

→ Attention

Assessing the economic viability of investments at installation level is not without risk. If the capacity of a company turns out to be weak, this may also be due to poor management, a lax attitude in the past and so on. “Rewarding” that weakness by weakening BAT proposals does not seem justified in these cases, and may threaten the level playing field if other companies in the sector are required to apply those BAT. Evaluating the reasons for a possible weakness of capacity falls outside the scope of a BAT study at installation level. However, it may be important when interpreting the results of the study.

7 Definition and codes – NBB, 2015
8 Definition and codes – Ooghe et al., 2003

2.11. STEP 5D. ESTIMATING REASONABLE COST-EFFECTIVNESS

2.11.1. CALCULATING THE COST-EFFECTIVENESS

In order to determine whether the costs of certain techniques are still reasonable in relation to the environmental result achieved, a cost-effectiveness (CE) assessment is recommended. Cost-effectiveness is expressed as the cost per unit of reduction of a given pollutant and is generally calculated as follows:

$$KE = \frac{total\ annual\ cost\ (€)}{total\ annual\ emission\ reduction\ (kg)}$$

where the total annual cost is calculated using the procedure in Article 2.7. There are several options for assessing cost-effectiveness:

1. Evaluating the cost-effectiveness based on existing investments
2. Drawing up a cost-effectiveness curve for the technology and assessing where the specific application of the technology is located on that curve
3. Evaluating cost-effectiveness based on shadow prices

2.11.2. EVALUATING THE COST-EFFECTIVENESS BASED ON EXISTING INVESTMENTS

The cost-effectiveness of a given environmental technique can be compared to the cost-effectiveness of other investments aimed at reducing the same parameter (such as NO_X). Comparisons arising from this can be found in sectoral BAT studies or in other research reports into emission reductions. In addition, the cost-effectiveness of certain pollutants can be tested against reference values derived from real environmental investments. Cost prices that exceed those reference values are regarded as too expensive.

Based on indicative reference values, the Dutch Environmental Management Decree includes “assessment areas”, in which the cost-effectiveness of measures aimed at reducing emissions of VOCs, fine particulate, NO_X and SO_2 is to be assessed.

Table 3: Assessment area in which the cost-effectiveness of measures for VOCs, fine particulate, NO_X and SO_2 is to be determined (source: Activiteitenbesluit milieubeheer (Environmental Management Decree), Article 2.7[9])

Pollutant	Assessment area (€/kg reduction)
NO_x	5-20
SO_2	5-10
VOC	8-15
Fine particulate	8-15

A measure is considered not cost-effective if the cost effectiveness is higher than the highest value of the assessment area and is considered cost-effective if the cost-effectiveness is lower than the lowest value of the assessment area.

9 http://wetten.overheid.nl/BWBR0022762/2016-01-01#Hoofdstuk2_Afdeling2.3_Artikel2.7

2.11.3. DRAWING UP A COST-EFFECTIVENESS CURVE FOR THE TECHNIQUE

In specific and complex situations, VROM 2010 recommends that a CE curve be drawn up for the technique and that the specific situation be displayed on that curve. In this way, the CE in the installation-specific situation can be compared with the general CE of the technique and assessed in that way.

If the CE of a technique is plotted in relation to the input concentration, a graph is obtained as shown in the figure below. This shows that the CE initially decreases rapidly (lower cost per kg of pollutant avoided) when the input concentration increases. At higher input concentrations in the flat part of the curve, the technique is considered cost-effective for the installation's situation. In the steep part of the curve, the costs per unit of reduced emissions are not cost-effective. Between these two areas is a grey area in which the transition point between what can be considered as BAT and what can no longer be considered as BAT is located. More background and examples of these cost curves can be found in the report by the Netherlands Ministry of Housing, Spatial Planning and the Environment (VROM) 2010.

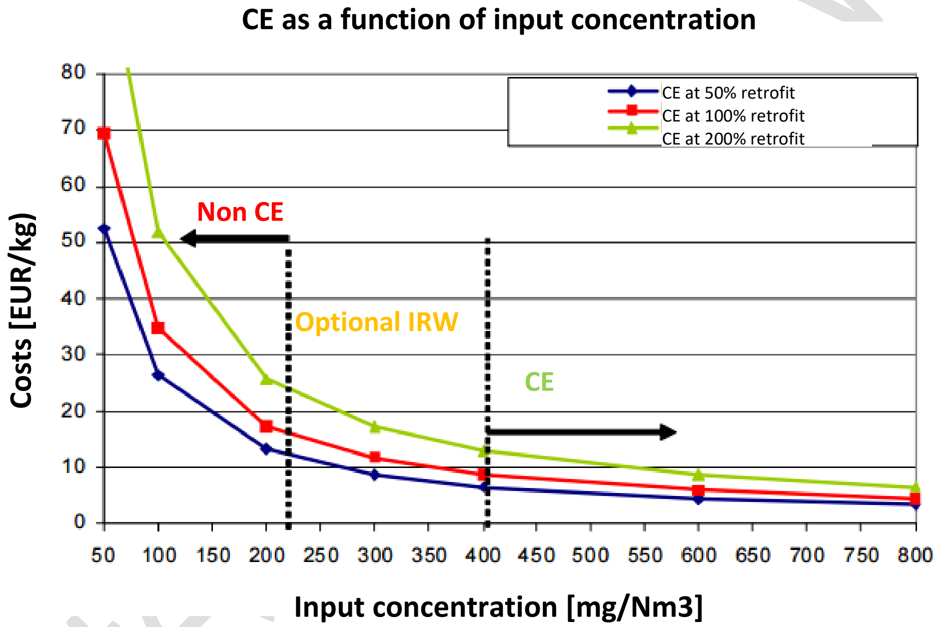

Figure 2: NO_x reduction by applying SCR at a refinery (source: VROM, 2010).

2.11.4. EVALUATING THE COST-EFFECTIVENESS BASED ON SHADOW PRICES

Shadow prices are defined as the prices that would apply if there were a market for environmental conservation. As no such market exists in reality, such prices have to be constructed. Any measure that costs less than the shadow price deserves to be taken, in principle. In addition, shadow prices can be used to weigh up emission reductions of substances that have an unequal environmental impact (Van Soest et al., 1997; de Bruyn et al., 2010; Debacker et al., 2012).

Shadow prices can be determined based (1) on prevention costs or (2) on the costs of damage. Prevention costs are calculated on the basis of the additional costs incurred by different sectors in order to reduce their contribution to a given environmental impact until it is line with the environmental objectives of the policy. This methodology is based on existing knowledge regarding the costs of emission reductions and assumptions about the emission reductions that the sectors should already be taking. When determining shadow prices based on the costs of damage, the shadow prices are estimated on the basis of the damage caused by emissions. The valuation is usually based on people's willingness to pay, in order to avoid a specific health or environmental problem. Both methods require an in-depth knowledge that is not available for all environmental impacts. That is why, in practice, the methods are often combined. The table below shows some of the most recent available shadow prices. Due to the high degree of uncertainty when determining the shadow prices, a low value and a high value are also shown between brackets. The estimates of MMG (Environmental Material Performance of Building Elements) are, in principle, valid for Belgium. However, the Dutch environmental price method (de Bruyn et. Al, 2017) covers more environmental themes.

Table 4: Shadow prices as indicative references for evaluating the cost-effectiveness of potential BAT.

Environmental theme	**Equivalent**	**MMG (VITO 2014)**	**Environmental price (CE Delft 2017, prices 2015)**
Global warming	kg CO_2 eqv.	0.1 (0.050-0.200)	0.057 (0.014 – 0.057)
Ozone layer depletion	kg CFC-11 eqv.	49.1 (25-100)	313 (99.6-336)
Photochemical oxidation	kg NO_X eqv.		34.7 (24.1-53.7)
	kg NMVOC eqv.	7.40 (1.85-29.6)[10]	2.1 (1.61-3.15)
Acidification	kg SO_2 eqv.	0.43 (0.22-0.88)	24.9 (17.7-38.7)
	kg NH_3 eqv.		30.5 (19.7-48.8)
Eutrophication	kg PO_4 eqv.	20 (6.6-60)	0.629 (0.156-1.22)
	kg N eqv.		3.11 (3.11-3.11)
Exhaustion of non-fossil (mineral) raw materials	kg Sb eqv.	1.56 (0-6.23)	
Fine particulate	kg PM10 eqv.		44.6 (31.8-69.1)
	kg PM2.5 eqv.	34 (12.7-85)	79.5 (56.8-122)
Noise	dB – transport by road		97 (21-138)
Land use	m^2 per year		0.026 (0.007-0.050)
Water scarcity	m^3 water eqv.	0.067 (0.022-0.20)	

In addition to the environmental prices shown in Table 4, environmental prices are determined in the Netherlands for a large number of important and frequently-occurring substances. These can be found in the tables in Annex I to the Handboek Milieuprijzen (Handbook on Environmental Prices) (de Bruyn et al., 2017): Table 63 (emissions to air), Table 64 (emissions to water) and Table 65 (emissions into the soil).

In order to bring the various substances that contribute to the same environmental problem or theme under a common denominator, equivalence factors are used. These can be found, for example, in the midpoint characterisation factors of ReCiPe 2008, which are also used in the LCA methodology (Goedkoop Mark et al. 2013) with the Excel attachment that can be downloaded from (http://www.lcia- recipe.net/file-cabinet). For example, the impact on global warming of 1 kg of fossil

10 From the version from MMG 2010

methane (CH_4) can equal that of 25 kg of CO_2. At a central value of €0.10/kg of MMG (2014), the shadow price of CH_4 comes to €2.50/kg.

2.12. Step 6. BAT selection

Based on the technical, environmental and economic evaluation (see Steps 3, 4 and 5), the BAT can be selected as follows:

- **BAT**, i.e. the technique or combination of techniques with the best environmental outcome that is technically and economically feasible. Multiple BAT can be selected if they have a similar environmental performance.
- **No BAT**, if the technique:
    - is not technically feasible or
    - is not economically feasible (either not feasible or its cost-effectiveness is too low), or
    - no other technique is available that offers a better environmental outcome overall

2.13. Step 7. Testing against sector-based BAT

After selecting the BAT at installation level, these techniques must be compared with BAT that may have been selected as BAT for the sector concerned in Flanders or Europe. If the installation-specific techniques deviate from the sectoral BAT and especially if the environmental outcome of the former is lower than that of the latter, justification must be provided. That justification may take the form of elements taken from previous analyses. A similar comparison can also be made in relation to the Flemish and European standards for these types of activities.

For an overview of the sectors in which a Flemish or a European BAT study is available, please visit the EMIS website:

- Flemish BAT studies: https://emis.vito.be/en/bat-studies
- European BAT-studies, BREFs:
  https://emis.vito.be/en/brefs or
  http://eippcb.jrc.ec.europa.eu/reference/

The sectoral BAT studies from Flanders and their associated recommendations have been drawn up as policy advice and may or may not be subsequently translated into VLAREM (VLAREM II, part 5 "Sectoral environmental conditions for assigned institutions"). The BAT conclusions in the European BAT studies, BREFs, are binding and will be transposed into VLAREM III.

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