UNITED NATIONS

EP

UNEP(DEPI)/MED WG.436/3

UNEP

UNITED NATIONS
ENVIRONMENT PROGRAMME
MEDITERRANEAN ACTION PLAN

6 March 2017
Original: English

Meeting of the Mediterranean Informal Network on Compliance and Enforcement

Greece, 6-7 April 2017

Agenda item 4: Strengthening the Inspection and Permitting Systems to promote the use of Best Available Techniques (BAT)

Guide on the Selection of Best Available Techniques (BAT) in Industrial Installations

UNEP/MAP
Athens, 2017

Explanatory Note by the Secretariat

1. Several articles to the Protocols under the Barcelona convention refer to the obligations to ensure implementation and law enforcement. In particular the Land based Sources and Activities Protocol as amended in 1996, under its Article 6 on authorization or regulation system provides for:

"Point source discharges into the Protocol Area, and releases into water or air that reach and may affect the Mediterranean Area, as defined in article 3(a), (c) and (d) of this Protocol, shall be strictly subject to authorization or regulation by the competent authorities of the Parties, taking due account of the provisions of this Protocol and annex II thereto, as well as the relevant decisions or recommendations of the meetings of the Contracting Parties.

To this end, the Parties shall provide for systems of inspection by their competent authorities to assess compliance with authorizations and regulations.

The Parties may be assisted by the Organization, upon request, in establishing new, or strengthening existing, competent structures for inspection of compliance with authorizations and regulations. Such assistance shall include special training of personnel.

The Parties establish appropriate sanctions in case of non-compliance with the authorizations and regulations and ensure their application"

2. In the framework of MED POL programme of UNEP/MAP, an informal network on enforcement and compliance had been established which meets on regular basis and aims at sharing relevant best practices with the view to support the Contracting Parties to comply with the obligations under Article 6 above.

3. One of the activities approved under the MAP PoW 2016-2017, COP 19, Athens, Greece, 2016, is related to the preparation of guide documents to facilitate both the identification or selection of BAT during the authorization (permit) process as well as and the environmental inspections of facilities in view of BAT implementation.

4. The present document represent a practical and simple guidance tool to support the relevant national authorities in promoting BAT assessment and application.

5. This Guide aims to assist the permitting authorities of the Contracting Parties to extract and evaluate the necessary information contained in the complex literature in order to assess the information provided by the applicants for permits concerning BAT introduction in industrial installations. As literature is mainly meant the complex and extensive (>500 pages each) BAT Reference documents (BREF) produced by the European Union (EU) institutions for the implementation of the Industrial Pollution Prevention and Control (IPPC) Directive and the Industrial Emissions Directive (IED). These BREF contain all available data about BAT in each industrial sector and are used worldwide as the most reliable source of information. It must be noted that not only European BAT are contained there but also techniques applied elsewhere in the world.

6. An additional purpose of this Guide is also to assist the operators who apply for a permit to better document the selection of the BAT options they propose in their application so that a better cooperation and communication with the permitting authorities can be established.

7. It is based on a methodology for BAT assessment which contains 5 phases/15 steps to be followed in order to justify the finally selected BAT for each industrial process (unit operation).

8. Phase 1 (4 methodological steps: 1 – 4) provides a baseline analysis of the existing situation in an industrial installation by assessing the priority pollutants and the “weak spots” where these pollutants are generated from. This first analysis gives an insight into the environmental “importance” of the installation as a whole and of the respective unit operations in particular.

9. Phase 2 (3 methodological steps: 5 – 7) is focused on the preparation of a list of candidate BAT according to their environmental performance (emitted pollutants, less resources consumption) which will be further analyzed in order to compare the expected reduction of emissions/use of resources to those of the conventional process. The purpose is to perform an effective search in the complex BREF documents in such a way that the most appropriate BAT for each “weak spot” can be found and duly described in order to be a candidate for the final selection. As “appropriate” are defined those BAT which seem to fit better into the respective industrial production process – unit operation (UO), namely that, by applying them, a considerable reduction of emissions (outputs) and of the resources (inputs) can be expected.

10. Phase 3 (3 methodological steps: 8 – 10) aims to define the expected environmental benefits (reduced emissions/use of resources) coming out from the application of candidate BAT options to the conventional process: a comparative analysis is performed where the existing and the expected outputs and inputs are benchmarked to each other in order to verify whether the respective candidate BAT can be a reliable alternative to the conventional process. In this context the compliance of the emissions of the candidate BAT with set Environmental Quality Standards (EQS) plays an important role in this analysis.

11. Phase 4 (2 methodological steps: 11 – 12) is analyzing the technical characteristics of the candidate BAT options in order to find out whether the proposed technique is technically mature to be implemented on a wide industrial scale.

12. Finally Phase 5 (3 methodological steps: 13 – 15) consists of the assessment of the viability/ sustainability of the proposed BAT options by comparing the investment/operational costs needed for the implementation of the candidate BAT to the expected savings in raw materials and resources.

13. The whole exercise i.e. the application of the Guidance in practical situation is an interactive process which has to be based on mutual agreements and compromises. For sure the industry has to realize that the process does not end with the submission of the application and its approval: it is for the industry’s own interest to find ways for the modernization of its equipment which, sometimes, starts and ends with simple good housekeeping measures. Even in cases of larger investments there will be substantial benefits if the BAT to be selected are resource effective and pollution preventive.

Guide on the Selection of Best Available Techniques in Industrial Installations

Table of Contents

Table of Contents (continued)

Tables

Figures

List of Abbreviations /Acronyms

AEL	Associated Emission Limit
BAT	Best Available Techniques
BREF	Bat Reference Document
CE	Cost Effectiveness
EEA	European Environment Agency
EIPPCB	European Ippc Bureau
ELV	Emission Limit Value
EQS	Environmental Quality Standards
GHM	Good Housekeeping Measure
IED	Industrial emissions directive
IPPC	Industrial Pollution Prevention & Control
O/M	Operating Maintenance (Costs)
TOR	Terms of Reference
UO	Unit Operation
WHO	World Health Organization

Introduction

1. This Guide on BAT assessment aims to assist the permitting authorities of the UNEP/MAP contracting parties to extract and evaluate the necessary information contained in the complex BREF documents in order to assess the information provided by the applicants for IPPC permits concerning BAT introduction in industrial installations. On the other hand the guide will also help the applicants to justify in their IPPC application the reasons why they have selected the respective BAT for each case.

2. It is based on a methodology for BAT assessment and contains 5 phases/15 steps to be followed in order to justify the finally selected BAT for each industrial process (unit operation).

3. At the end of the description of each phase of the methodology (1 – 5) a "checklist" of tasks to be performed by the operator (submitting the application) and the permitting authorities summarizes the "things to do".

4. The Guide should be seen as a "pathway" to be followed when the information contained in a submitted application has to be checked by the permitting authorities in order to understand why/in which way the applicant (i.e. the industrial operator) has proposed specific BAT; on the other hand it will help the operators to select from various complex literature sources those BAT which apply best for their specific situation without losing too much time by examining the vast number of BAT contained in these sources. In this context it must be mentioned that the main literature source about BAT are the BAT Reference Documents (BREF) prepared by the European IPPC Bureau (EIPPCB).

Phase 1 - Framework of BAT analysis (baseline)

Step 1 – Inventory of main pollutants

Rationale

5. Potentially harmful substances emitted into the environment from each unit operation of an industrial installation have to be classified and estimated. This first analysis gives an insight into the environmental "importance" of the installation as a whole and of the respective unit operations in particular.

6. It is important to allocate the emissions from all production steps; therefore an analysis of the emissions of **each separate** Unit Operation (UO) **and not of the installation as a whole** (cumulative emissions) has to be elaborated and the relevant emissions registered.

7. As **main (priority) pollutants** are meant those main parameters which are classified as **air emissions** and **wastewater discharges**. In cases where the prescriptions of local Environmental Quality Standards (EQS) ask for additional parameters, these ones have also to be considered as priority pollutants. Additionally **solid waste quantities** generated during a production process are also considered as priority pollutants.

8. Necessary data for the inventory of the main pollutants.

9. In the following tables examples of priority pollutants (air emissions, effluent discharges) and the data needed are listed. Solid waste types depend entirely on each industrial production process and have to be listed accordingly whereas the parameters for air emissions/effluent discharges are mostly common in all processes.

10. The notations “Before Treatment (BT)” and “After Treatment (AT)” respond to situations where either treatment facilities already exist or are planned to be installed. These treatment facilities should not be connected with BAT: they are considered as “end-of-pipe” techniques in existing industrial installations (wastewater treatment plants, filters/cyclones etc.).

11. For new (planned) installations which are subject to a permit, the notation AT is not applicable at this stage: Step 1 aims to find out which UO contribute more to the installation’s pollution loads emitted/discharged into the environment without any “intervention” (i.e. end-of-pipe treatment) so that these UO have to be prioritized for BAT selection (Steps 4 + 5).

Table 1: Emissions to air

UO name	**UO number**	**Duration of operation: daily/annually (h)**	**Pollutant**	**Concentration BT / AT (mg/m^3)**	**Quantity BT / AT (g/s) / (t/year)**
			SO_2		
			Other S compounds		
			NO_x		
			Other N compounds		
			CO		
			VOC		
			Metals		
			Metals compounds		
			Fine particulate matter		
			Asbestos suspended particulates		
			Asbestos fibers		
			Cl		
			Cl compounds		
			F		

UO name	**UO number**	**Duration of operation: daily/annually (h)**	**Pollutant**	**Concentration BT / AT (mg/m^3)**	**Quantity BT / AT (g/s) / (t/year)**
			F compounds		
			As		
			As compounds		
			CN		
			Substances / mixtures possessing carcinogenic/ mutagenic properties		
			Polychlorinated dibenzodioxins		
			Polychlorinated dibenzofurans		

Table 2: Effluent discharges to surface/ground water

UO name	UO number	Point of discharge (SW, S/GW,TP)*	Wastewater quantity (m^3/day)	Pollutant	Concentration BT / AT (mg/l)	Quantity BT / AT (kg/day)
				Organohalogen compounds		
				Organophosphorus compounds		
				Organotin compounds		
				Substances / mixtures possessing carcinogenic/mutagenic properties		
				Persistent hydrocarbons and persistent and bioaccumulable organic toxic substances		
				CN		
				Metals		
				Metals compounds		
				As		
				As compounds		
				Biocides		
				Suspended solids		
				Nitrates		
				Phosphates		
				BOD_5		
				COD		

*SW = Surface Water, S = Soil, GW = Ground Water, TP = Treatment Plant

Table 3: Waste quantities

UO name	UO number	Waste generated (description)	Waste classification	Hazardous / non-hazardous	Quantity (kg/day)	Disposal / Recycling (according to Annex I + II of the Waste Framework Directive)

How the pollutants quantities/concentrations will be assessed?

12. For the most effective selection of BAT (Steps 5, 6 and 7) it is preferable, at this stage, to leave aside from the analysis any “end-of-pipe” techniques which are already used in **existing** installations: their inclusion and the related quantitative assessment of the finally released waste streams (after treatment) can mislead the decisions to be taken at a later stage (for BAT introduction) because the problem of the “in-situ” generation of waste streams (i.e. by the production process) will not be revealed to its full extent if they will be pre-treated at any stage before being finally emitted into the environment.

13. For **existing** installations the monitoring records for air emissions, wastewater discharges and solid waste give reliable information about the quantities and the pollutants released into the environment in both cases (before/after treatment). In cases where monitoring/treatment devices are installed at the exit of some UO (e.g. if significant air emissions are channeled via a bag filter through a chimney in the atmosphere) then the **inputs** to the monitoring/treatment devices will be considered as UO’s **outputs**.

14. For **new** installations where monitoring records do not exist yet, load coefficients (kg and m^3 of pollutants/kg of product) for several industrial sectors can be applied for a first approximation of the relevant quantities. The produced values are obviously not as accurate as those coming out from the monitoring records; however they allow a good insight into the magnitude of the environmental emissions **(rapid assessment)** and the prioritization of those UO which are of high environmental “importance”.

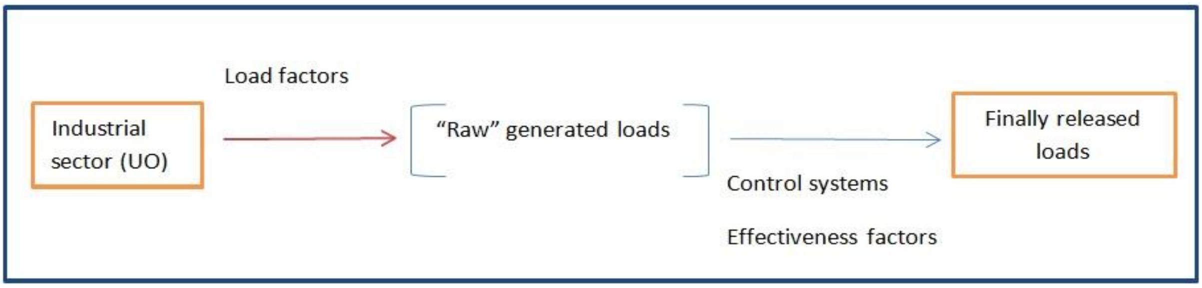

Figure 1: Rapid assessment scheme

15. The World Health Organization (WHO) has produced sets of pollution load factors for several industrial sectors (Rapid Assessment of sources of air, water and land pollution, World Health Organization, 1993) which can be used as a basis for the calculation of the estimated quantities of air emissions, effluents and solid waste quantities coming out from the relevant sectors.

16. Alternatively the technical prescriptions of the equipment of each UO, except of the basic parameters (water/energy usage, temperature, chemicals, raw materials), shall include information about its environmental performance, so that the operator knows by purchasing the equipment what is expected to be emitted into the environment. The provision of this information is an important criterion to be considered during the market research for the equipment purchase.
An industrial production process is schematically presented in figure 2.

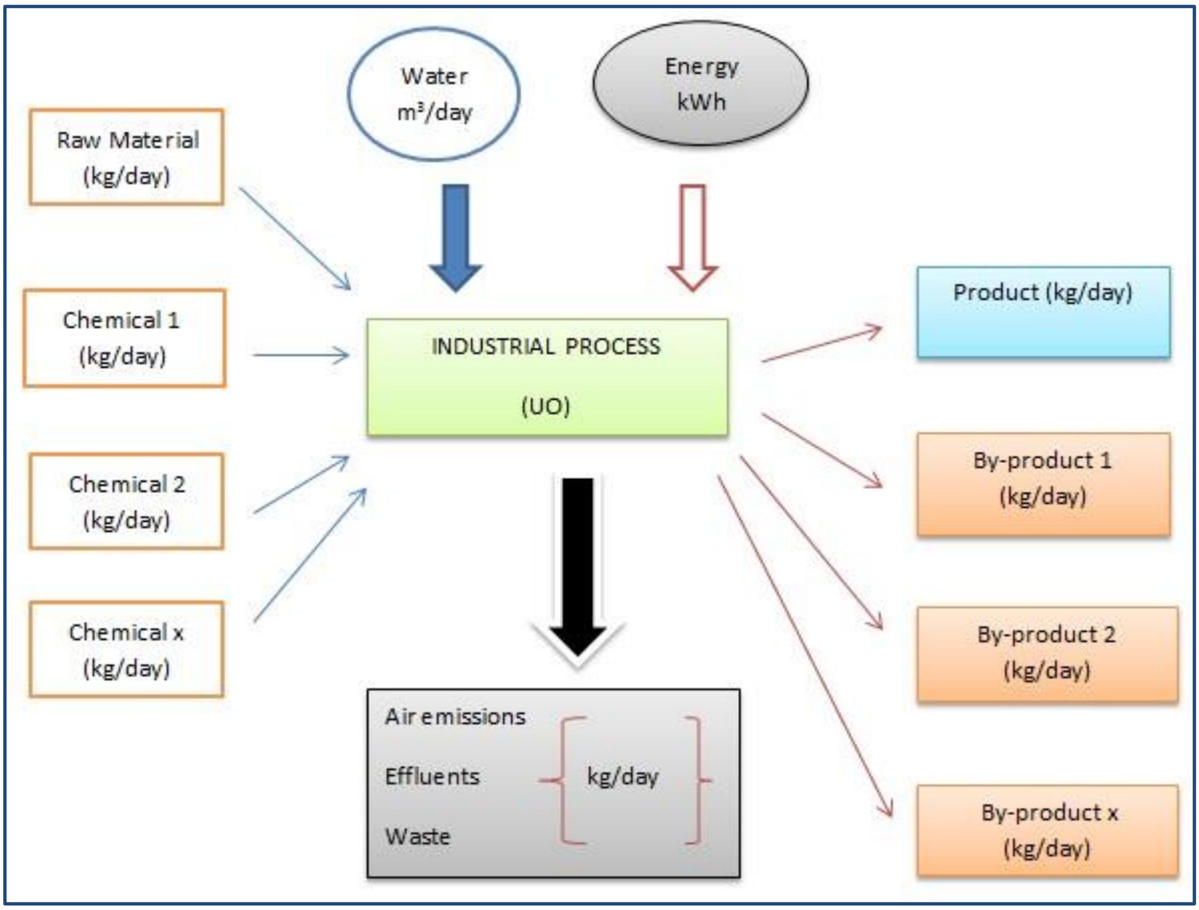

Figure 2: Scheme/flow diagram of an industrial production process/UO

17. A **mass balance flow** will allow the definition of quantities which leave the production process as a pollution stream (air emissions, effluents, waste).
Example:

Total inputs = mass $_{\text{raw material}}$ + mass $_{\text{chemical 1}}$ + mass $_{\text{chemical 2}}$ + mass $_{\text{water}}$

kg/day = 10,000 + 500 + 300 + 1,000

= 11,800 kg/day

Total outputs = mass $_{\text{product}}$ + mass $_{\text{by-product1}}$ + mass $_{\text{by-product2}}$ + mass $_{\text{wastewater}}$

Kg/day = 8,000 + 300 + 100 + 800

= 9,200 kg/day

Total quantity of pollutants (air emissions, effluents, waste) produced:

Total inputs – total outputs = 11,800 – 9,200 = 2,600 kg/day

(Note: The calculation of the effluents quantity occurs by multiplying the concentration of pollutants expressed as mg/l with the wastewater quantity expressed as m^3/day).

18. This mass balance analysis gives a reliable first assessment of the "intermediate" emissions by each UO: inputs/outputs for this mass balance analysis are measureable and can be quantitatively assessed.

Step 2 – Assessment of the Environmental Quality Standards (EQS) in the region

Rationale

19. Local factors, such as proximity of the installation to particularly sensitive receptors, existing air/water quality standards and the conditions of the water resources in the area can have a significant influence on the BAT techniques and options to be chosen and on the level of pollution control required for the industrial activity concerned. The aim of Step 2 is to identify whether there are any local sensitivities to emissions from the industrial installation although at this stage only a qualitative response is needed. Further scientific investigation may be carried out (Step 10 – BAT options) depending on the magnitude of risk to the receiving environment.

20. Existing EQS (ambient air standards, quality of water recipients, underground water quality, soil conditions) in the region where the installation is operating should be reviewed in order to assess which of them are in danger to be negatively influenced by the various discharges from the installation.

21. At this level the EQS and the associated Emission Limit Values (ELV) will not be reviewed and eventually modified; they are taken as granted and as basis for the prioritization of those pollutants emitted from an installation which, in addition to existing emissions from other installations in the same geographical area, can negatively affect the environmental quality of the water recipients, the soil, the ambient air.

Actions to be taken

22. Existing EQS and the related ELV for the area will be reviewed by the permitting authorities in order to list those pollutants emitted by the installation which as first priority have to be reduced. This review should be accomplished in light of the **actual situation** namely whether, in the time elapsed between initially setting the EOS, some more industrial facilities (and other pollution sources such as agricultural farms etc.) have been installed in the area and the cumulative quantities emitted/discharged by them will in the near future endanger the maintenance of the quality of the ambient air, water bodies and soil even if the set ELV are met: it is possible that, due to many activities in the area, the ELV for the particular installation has to be more strict (compared to those ones for the other installations in the area).

23. Actions to be taken by the **permitting authorities**:

Water

1. Assessment of the monitoring records (from the monitoring stations) in the particular geographical region where the **effluents** of the industrial installation are supposed to be discharged:

For

Water recipients (rivers, lakes, ground water)

Resulting in

EQS + ELV inventory in the area

2. Inventory of existing industrial and other sources of water pollution in the area

3. Priority pollutants as potential risks (generated by the candidate installation) **- Water**

Air

4. Assessment of the monitoring records (ambient air monitoring stations) in the particular geographical region where the industrial installation is/will be located
5. Review/evaluation of the ELV of all stationary air emission sources in the area

6. Priority pollutants as potential risks (generated by the candidate installation) – **Air**

Soil

7. Review/assessment of any studies (scientific, technical) prepared by institutions/universities on soil conditions in the area where the industrial installation is/will be located
8. Inventory of the conditions of waste disposal (controlled/uncontrolled landfills) in the area
9. Assessment of eventual risks to the soil quality if the installation's waste quantities are disposed in the area

24. Setting of priorities for waste types to be treated/disposed – **Soil**

Tasks to be performed by the **operators** are summarized in table 4. The submitted information will be validated by the permitting authorities and taken into consideration when the existing EQS are evaluated (underlined text describes needed amendments of the application form).

Table 4: Operators' tasks for Step 2

Recipient	Action
Water (surface/ground)	1. Presentation of the situation of the surface/ground water quality (incl. the hydrological conditions) 2. Comparative review of the prescribed allowed concentrations for each polluting substance in the ground and surface water 3. Cumulative list of the points of discharge, together with the maps, drawings and the adjoining documentation 4. Detailed list of hazardous substances to be discharged into ground and surface water 5. Cumulative data and impact assessment of the existing or proposed emissions into the aquatic environment i.e. surface and/or ground water 6. Full data on the assessment and other relevant information on the recipient as well as the usual water quality analyses at the recipient point, i.e. the water body.
Air	1. Presentation of the situation of the air quality (including the meteorological conditions and factors) 2. Comparative review of the prescribed allowed concentrations for each polluting substance in the air 3. Cumulative list of point source emissions 4. Full data on atmospheric dispersion modelling of the emissions 5. Cumulative data on fugitive sources of pollution, the control measures and information on their environmental impact 6. Control measures that planned in the future (equipment, control parameters, limit values, types of measures, validity, time of measurement, sampling, measurement points distribution, frequency, method of analysis etc.).

Soil	1. Comparative review on the presence of hazardous and harmful substances in the soil, as well as morphological characteristics of the superficial soil layer including current/potential emissions from the installation 2. Comparative review of the prescribed allowed concentrations for each polluting substance in the soil according to existing standards (legislation) 3. Cumulative overview of data on superficial and ground contamination on the location or under it (including data sets of research studies, assessments or reports, monitoring results, location and measuring equipment, plans, drawings and other adjoining documentation) 4. Cumulative data on all direct emissions of hazardous substances on land/soil 5. Full data on the location of discharge (including maps, drawings and the adjoining documentation) 6. Information about the type of processing and the waste quantities and location of deposition in the geographical area concerned 7. Description of existing controlled or uncontrolled landfills in the area where the installation's waste quantities will be disposed.

For the qualitative assessment of the potential risks for the local environment a checklist of basic questions/responses should be finally prepared by the **authorities** as follows:

Table 5: Checklist (authorities)

Local environment	Question	Response (YES/NO)
Air quality	Are there any Environmental Quality Standards relating to substances released from the installation which may be at risk due to additional contribution from the installation?	
	Are there any sensitive groups of population e.g. schools or hospitals in the area?	
Water quality	Are there any Environmental Quality Standards relating to substances released from the installation which may be at risk due to additional contribution from the installation?	
	Is the installation located in a groundwater vulnerable zone?	
	Are groundwater reservoirs used for drinking water uptake in the area which can be affected from the installation's activities?	
Soil conditions	Are there any sensitive agricultural areas or wildlife habitats, e.g. Special Areas of Conservation, or Special Protection Areas, likely to be affected by releases from the installation?	
	Are there any controlled/ uncontrolled landfills which will be used for disposal of solid wastes from the installation?	

25. On the basis of the collected and revised information and the responses of this checklist a **qualitative** assessment of the risks for the local environmental conditions is possible which allows the permitting authorities to set the priorities for the reduction of the pollutants generated by the installation. At this stage the above mentioned analysis is focusing on the current status of the emissions from existing installations i.e. without any BAT implementation so far (Step 10).

Step 3 – Prioritization of pollutants and emissions

Rationale

26. Based on the outcomes of Steps 1+2 a list of "priority" pollutants (**emission indicators**), which have the potential to break existing or envisaged EQS, will be established. These pollutants will be correlated with the relevant sources (UO) in the production process ("weak spots").

27. This list will give an insight into those UO which have to be prioritized for BAT introduction thus enabling primarily the permitting authorities to focus on those spots in the production process which cause the major environmental concern; on the other hand the operators will be able, on the basis of this "weak spot prioritization" to plan the necessary investments as well as to negotiate with the authorities a gradual adoption of the prescribed Emission Limit Values (ELV) if necessary.

Actions to be taken

28. Tables 1, 2 and 3 (Step 1) have to be re-arranged in such a way that the priority pollutants in qualitative (hazardous substances) and quantitative (volume of emissions/wastewater, quantities of emitted substances) terms are listed in a descending order. The dominating factor to prioritize the pollutants will be their **cumulative quantity emitted:**

Quantity (tn/day) = Volume (m^3/day) X Concentration (kg/m^3)

29. The priority list of pollutants will be given to the operators by the **authorities** and its correlation with the relevant UO will be performed by the **operators.**

Step 4 – Analysis of each production process/unit operation (UO)

Rationale

30. For each unit operation – "weak spot" an analysis of the production process will be conducted in terms of **process design** (e.g. needs for changes or replacements of processes/equipment), **selection of inputs (**e.g. raw materials, water/energy usage), **process control (**e.g. process optimization), **good housekeeping type measures (**e.g. cleaning regimes, improved maintenance), **non-technical measures (**e.g. organizational changes, staff training, introduction of environmental management systems), **emitted pollutants.** This analysis will show the potential for improvement of each UO and consequently where/how to search in the relevant BREF to find the most appropriate BAT.

31. This analysis is the most important step towards the introduction of BAT in an industrial installation and it is of the operator's own interest to perform it because it helps allocating those production units which generate "pollution": one must be aware that pollutants emitted into the environment are, to a large extent, raw materials/chemicals/water/energy which could not be fully used in the manufacturing process and therefore they comprise "lost money"…

Points of analysis of an industrial process – UO

32. Industrial **processes** are procedures involving chemical or physical steps needed for the manufacture of a product, usually carried out on a large scale.

33. This Step 4 is entirely relying on the competences of the **operators** who know best the respective production processes, the equipment/devices applied, the process arrangements etc. Therefore only some general “hints” can be given here which can be used as **starting points** for the further investigation of the industrial processes. In doing so and for the purposes of this Guide an analysis of the basic features of each process/UO has to be accomplished in terms of:

- Equipment used for the production
- Civil/mechanical engineering devices
- Quality/quantities of raw materials and chemicals
- Water quantity used in the process (industrial water)
- Energy input and types of energy sources used.

34. As basic tools for this analysis the **mass balance flow** (see Figure 2 in Step 1), the **equipment’s technical specifications** and **literature references** (see Figure 1 in Step 1) should be taken into consideration. In any case however, the operator’s **own experience** is the most important “tool” for the assessment of the processes’ technical performance**.**

1. The focus of this analysis will be the allocation of those points in each process where pollutants are generated **(waste streams).** These waste streams can either be:
- Further processed (downstream) or
- Inevitably released into the environment (air emissions, effluents, waste)

2. For the most effective selection of BAT (Steps 5, 6 and 7) it is preferable, at this stage, to leave aside from the analysis any “end-of-pipe” techniques which are already used in **existing** installations: their inclusion and the related quantitative assessment of the finally released waste streams (after treatment) can mislead the decisions to be taken at a later stage (for BAT introduction) because the problem of the “in-situ” generation of waste streams (i.e. by the production process as such) will not be revealed to its full extent if they will be pre-treated at any stage before being finally emitted into the environment.

Tasks of operators

3. The following checklist (Table 6) can be used by the **operators** for each UO. The pollutants (types, quantities) emitted have to be registered for those responses where an assessment of the pollutants is feasible.

Table 6: Checklist for operators ("weak spots")

Question	Response (YES/NO)	Comments / Explanations	Pollutants generated (air emissions, effluents, waste)	Quantity of pollutants – measured/estimated (kg/day)
Is the configuration of the process’ modules arranged according to the manufacturer’s instructions?				

Question	Response (YES/NO)	Comments / Explanations	Pollutants generated (air emissions, effluents, waste)	Quantity of pollutants – measured/estimated (kg/day)
Have any design's modifications occurred? If YES, for which reasons?				
Are there any improvements occurred from these modifications?				
Are there any corrective measures planned to overcome any malfunctions of the process? If YES, specify the achieved improvement of the process features (in environmental terms i.e. less use of water/ energy)				
Has the equipment being installed/ operated according to its technical specifications?				
Any changes/ modifications occurred? If YES, specify the achieved improvements				
Is the equipment regularly checked for defects, leakages?				
Is maintenance performed regularly according to the				

Question	Response (YES/NO)	Comments / Explanations	Pollutants generated (air emissions, effluents, waste)	Quantity of pollutants – measured/estimated (kg/day)
equipment's specifications?				
Are the quantities of raw materials, water, chemicals, energy introduced in the production process **(inputs)** according to the technical prescriptions? If NO, specify the reasons and the achieved improvements in the production process				
Are measured/ weighted quantities of raw materials, chemicals, water registered? If NO, specify why				
Is the less polluting energy source used for the production e.g. natural gas? If NO, specify why				
Is the energy input measured? If NO, specify why				
Which process **outputs** (products, by-products, air emissions, effluents, waste) are measured? If NO, specify why				
Is there any management system (i.e. EMAS, ISO				

Question	**Response (YES/NO)**	**Comments / Explanations**	**Pollutants generated (air emissions, effluents, waste)**	**Quantity of pollutants – measured/estimated (kg/day)**
14000) applied in the industry?				
Is regular training of the process personnel organized?				

35. The responses to be listed above will help the operators to allocate potential points of process improvement which can be simple, low-cost but effective e.g. detection of leakages, possibilities of cooling water recycling. It is advisable that these "small-scale" **good housekeeping measures** should be implemented immediately namely before searching for greater process interventions i.e. BAT introduction.

Phase 1 – Summary of tasks (Steps 1 – 4)

36. The tasks for the authorities and for the operators are summarized in table 7.

Table 7: Tasks for operators/authorities - Summary (Phase 1)

Step	**Operators**	**Authorities**
Inventory of main pollutants + prioritization of pollutants/ emissions + correlation with UO **(Steps 1 + 3)**	Prepare tables 1 + 2 + 3	1. Check If all expected priority pollutants for air emissions and effluent discharges are included in the tables submitted by the operator 2. Cluster the air emissions/effluent discharges/waste quantities in a descending order (quantities/hazardousness of pollutants) 3. Correlate UO with the clustered pollutants 4. Prepare a priority list of UO according to point 2

Step	Operators	Authorities
Review of Environmental Quality Standards (EQS) in the region **(Step 2)**	Prepare table 4	1. Evaluate monitoring records (ambient air + water quality) 2. Review existing ELV for air emissions + effluents from all pollution sources in the area 3. Make an inventory of all pollution sources in the area 4. Review of any studies on soil conditions in the area where the industrial installation is/will be located 5. Assess the conditions of waste disposal (controlled/uncontrolled landfills) in the area 6. Assessment of eventual risks to the soil quality if the installation's waste quantities are disposed of in the area 7. Make a list of priority pollutants (air, water) as potential risks for EQS 8. Set priorities for waste types to be treated/disposed of
Analysis of each production process /unit operation **(Step 4)**	Prepare table 6	Prioritize those UO which are "weak spots" and should be subject for BAT introduction

Outputs of Phase 1

4. By completion of Phase 1 the following outputs will be produced:
1. A list of priority pollutants which can endanger the local EQS
2. A priority list of UO for BAT introduction which generate high pollution loads
3. A set of information of "weak spots" in each UO e.g. high energy consumption/water usage
4. Based on 1-3, a set of intervention points (BAT search)

5. Phase 1 is considered as the **baseline** for the BAT assessment and gives the necessary information for a targeted BREF search.

Phase 2 – List of candidate BAT

Step 5 - Correlation of candidate BAT with "weak spots"

Rationale

37. The aim of Step 5 is to perform an effective search in the BREF documents in such a way that the most appropriate BAT for each "weak spot" can be found and duly described in order to be a candidate for the final selection. This search will allow the operators to find from the extensive BREF information those BAT which fit into their own requirements and leave aside incomplete, badly documented or very sophisticated techniques/technologies which, although technically "correct", do not respond in the simplest possible way with the needs and actual conditions prevailing in each industry: it must be clear that the selection of candidate BAT without taking into consideration the local circumstances can end into a failure of the BAT operation when installed.

38. Step 5 is the basis for the further "downstream" analysis (Steps 6 to 10) because it will provide the "matrix" for the evaluation of each BAT technical, economic and environmental characteristics and thus its viable/sustainable introduction in the industrial production processes.

Find the "weak spots" of a UO in the BREF documents

39. Although there is no standard form of information in all BREF the following major chapters are at least contained:

1. Industry overview
2. Environmental issues
3. Applied production processes (UO) and techniques
4. Associated emissions into the environment from each UO
5. Techniques to consider in the determination of BAT
6. Environmental and technical characteristics of proposed BAT (sometimes economic issues are also included).

40. In each BREF the relevant unit operations (UO) of the industrial sector concerned are described in the first chapters (before embarking to BAT description at a later stage); therefore each operator can find if the particular UO is included in the BREF. This first insight into the BREF (and the allocation of the UO) will be the "road map" for the further BREF investigation.

41. BREF chapters 1 – 4 define the UO and the associated air emissions, effluents and wastes. The operator can then verify to which extent the UO -"weak spot" is matching with the usual emissions generated in similar cases.

List the candidate BAT for each UO

42. BREF chapters 5 and 6 are focusing on the candidate BAT for each UO and comprise the "heart" of the BREF by delivering various **BAT options** to mitigate the emissions from each particular UO. Therefore, after having found that the sequence of UO is described in these BREF chapters, the relevant BAT should be listed.

43. At this stage a first "screening" of the candidate BAT according to some qualitative criteria can be done (Step 6).

44. This basic information can be summarized in Table 8 and has to be undertaken by the **operators**. The respective citation in the BREF chapter should also be included so that the **authorities** can track the "logic" behind τηε selection of the final BAT options. If for each UO more than one

BAT options exist the relevant cells of the following tables have to be modified accordingly by adding the needed rows.

Table 8: List of candidate BAT options

Source (UO) of pollutants (name, number)	Pollutants (kg/ton)	Candidate BAT (BREF citation: chapter/page)	BAT-associated emission limit (AEL) (kg/ton, mg/Nm^3)	Reduction of emissions expected if BAT is applied (%)
UO 1				
UO 2				
UO x				

Step 6 – Clustering of candidate BAT

Rationale

45. Having in mind that the criteria for BAT selection are aiming at the use of pollution prevention measures instead of end-of-pipe technologies, the candidate BAT should be clustered according to these criteria as well as to the extent of the reduction of the "priority" pollutants.

46. Therefore this BAT clustering allows the grouping of BAT options according to their preventive nature, simplicity, use of less resources and the envisaged reduction of the "priority" pollutants.

47. Step 6 is closely related with Step 5, both can be combined in one common Step.

How to cluster/group the candidate BAT

48. A checklist (Table 9) will allow the **operators** to group the BAT according to:

- The relevant UO where the BAT is applicable
- The types and quantities of emissions (air, water, waste) expressed as BAT- AEL
- The achievable reduction of the "priority" and other (if applicable) pollutants
- The preventive nature (resource consumption, low-waste production)
- The simplicity for installation/operation (e.g. good housekeeping measures)
- The related environmental impacts and eventual trans-boundary effects after BAT introduction

49. At this stage a rather **qualitative** approach is preferable because it gives the ”flavor” of the possible interventions without a lengthy analysis of all BAT options and eventually will allow the ”screening-out” of those options which, from a first insight, do not meet the set requirements or does not match the local conditions (e.g. BAT is too complex). The **quantitative** analysis of the BAT environmental parameters, which is the major factor to decide about the applicability of a BAT, will follow at a later stage (Steps 7 – 8).

50. BAT clustering can be accomplished in 2 ways:

For each UO (table 9) or

For each “priority” pollutant emitted from all UO if those pollutants are emitted from different UO (table 10)

51. The candidate BAT (and the associated emission limit – AEL) should be in both cases listed in a descending order according to the expected reduction of the “priority” pollutants (column 7 in tables 9 and 10).

Table 9: Clustering of candidate BAT - UO

UO	**Candidate BAT**	**Good housekeeping measure (GHM)/major intervention**	**Preventive / End-of-pipe**	**Emissions expected (air, water, waste)**	**BAT-AEL (kg/ton, mg/Nm^3)**	**Reduction of emissions expected if BAT is applied (%)**
UO 1						
UO 2						
UO x						

Table 10: Clustering of candidate BAT - "Priority" pollutants

"Priority" pollutants	UO	Candidate BAT	Good housekeeping measure (GHM)/major intervention	Preventive / End-of-pipe	BAT-AEL (kg/ton, mg/Nm^3)	Reduction of emissions expected if BAT is applied (%)
Air emissions						
SO_2						
Other S compounds						
NO_x						
Other N compounds						
etc.						
Wastewater discharges						
Organohalogen compounds						
Organophosphorous compounds						
Organotin compounds						
etc.						
Waste generation						

Step 7 – Assessment of inputs/outputs of candidate BAT

Rationale

52. After the completion of the preparatory Steps 5 and 6 the relevant inputs/outputs for each candidate BAT will be assessed, prioritized and registered. This final Step of Phase 2 completes the assessment of candidate BAT by giving a **quantitative** basis for the final evaluation of their environmental performance which will follow (Steps 8 + 9) and allows a first insight into the expected achievements, in terms of environmental benefits (resource conservation, reduced emissions into the environment), if the BAT will be introduced in the industrial production processes. Figure 2 can be taken as a "guide" for this analysis.

Which inputs should be assessed

- ✓ Raw materials (ton/day)
- ✓ Chemicals/other additives (kg/ton of raw material)
- ✓ Water consumption (m^3/day)
- ✓ Energy usage (kWh/day)

Which outputs should be assessed

- ✓ Air emissions (mg/Nm^3)
- ✓ Wastewater (effluents) discharges (kg/ton of raw material or mg/l)
- ✓ Waste (kg/ton)
- ✓ Products (ton/day)
- ✓ By-products (ton/day)

53. The above mentioned information is summarized in table 11 (for each UO).

Table 11: Candidate BAT - Inputs/outputs

UO				
INPUTS	**BAT 1**	**BAT 2**	**BAT 3**	**BAT X**
Raw materials (ton/day)				
Chemical 1 (kg/ton of raw material)				
Chemical 2 (kg/ton of raw material)				
Chemical x (kg/ton of raw material)				
Water (m^3/day)				
Energy (kWh/day)				
OUTPUTS				
Products (ton/day)				

UO				
By-product 1 (ton/day)				
By-product 2 (ton/day)				
By-product x (ton/day)				
	BAT 1-AEL	**BAT 2-AEL**	**BAT 3-AEL**	**BAT x-AEL**
Air emissions **(kg/ton, mg/Nm^3)**				
SO_2				
Other S compounds				
NO_x				
Other N compounds				
etc.				
Wastewater (kg/ton, mg/l)				
Organohalogen compounds				
Organophosphorus compounds				
Organotin compounds				
etc.				
Wastewater quantity (m^3/day)				
Waste (kg/ton)				

Phase 2 – Summary of tasks (Steps 5 - 7)

6. The tasks for the authorities and for the operators are summarized in table 12.

Table 12: Tasks for operators/authorities - Summary (Phase 2)

Step	Operators	Authorities
Correlation of candidate BAT to each UO **(Step 5)**	Prepare table 8	Check BAT-AEL for each candidate BAT according to BREF citations (provided by the operator – table 8)
Clustering/grouping of candidate BAT **(Step 6)**	Prepare tables 9 + 10	
Registration of inputs/outputs of each candidate BAT **(Step 7)**	Prepare table 11	

Outputs of Phase 2

54. By completion of Phase 2 the following outputs will be produced:

1. A list of candidate BAT for all "problematic" UO aiming at the reduction of the respective "priority" pollutants containing
   - BAT-AEL
   - Level of reduction of the "priority" (and other) pollutants and
   - Inputs (raw materials, chemicals, water, energy) for each candidate BAT
   - Outputs (products, by-products, air emissions, effluents, waste quantities) for each candidate BAT

Phase 3 – Evaluation of environmental performance of candidate BAT

Step 8 – Comparison/benchmarking of BAT outputs to "old" emissions

Rationale

55. The assessment of the achievable reduction of the pollutants of the conventional ("old") production processes-UO has to be documented in order to find out to which extent the introduction of the respective BAT would significantly (or not) reduce the emissions of the existing/non-BAT process: the analysis performed so far (Steps 5 – 7) has allowed a first "screening" of possible candidate BAT whereas Step 8 will document the achievable results by detailed comparison of the existing processes to the envisaged BAT so that the prioritization of the candidate BAT according to their "capability" to reduce the "priority" and other pollutants to the desirable level can be accomplished.

How to compare "new" with "old" emissions

56. The BAT-AEL stated in the relevant BREF citations have to be compared with any monitoring records (for existing installations) or figures derived from load coefficients referred in the literature (for new installations).
In doing so, the tables 9, 10 and 11 have to be re-shuffled accordingly so that the indicated expected reduction of the emissions (Steps 5 and 6) can be now documented for each UO (table 13). BAT-AEL are usually expressed in ranges (lower – upper figures), therefore the "conventional" emissions should

be expressed either as average or as maximum/minimum values (deriving from existing monitoring results).

Table 13: Comparison of existing emissions to BAT-AEL

UO	Value	BAT 1-AEL	Reduction (%)	BAT 2-AEL	Reduction (%)	BAT X-AEL	Reduction (%)
Air emissions (kg/ton, mg/Nm^3)							
SO_2							
Other S compounds							
NO_x							
Other N compounds							
etc.							
Wastewater (kg/ton, mg/l)							
Wastewater quantity (m^3/day)							
Organohalogen compounds							
Organophosphorus compounds							
Organotin compounds							
etc.							
Waste (kg/ton)*							

*State any recycling options for solid waste quantities

57. After having completed this Step a clear picture of those candidate BAT will arise which allows the pre-selection of those BAT by which the highest possible reduction of emissions can be achieved. Within this context a **combination** of candidate BAT by which several emissions from one UO can be reduced (or the same pollutants from more than one UO) is possible.

A **ranking** of all available BAT options shall now be established **preferably referring to the "priority" pollutants** instead to the UO (where the BAT will be applied to). This ranking is presented in table 14.

Table 14: Ranking of BAT options according to outputs

"Priority" pollutant	Ranking	Candidate BAT option (name, number)	UO (name, number)	Achieved reduction of pollutants (%)
Air emissions (kg/ton, mg/Nm^3)				
SO_2				
Other S compounds				
NO_x				
Other N compounds				
etc.				
Wastewater (kg/ton, mg/l)				
Wastewater quantity (m^3/day)				
Organohalogen compounds				
Organophosphorus compounds				
Organotin compounds				
etc.				
Waste (kg/ton)*				

*State any recycling options for solid waste quantities

Step 9 – Comparison/benchmarking of BAT inputs to the conventional process

Rationale

58. By applying some of the candidate BAT high environmental performance can be achieved by reducing the consumption of water/energy, the use of chemicals etc.: as a matter of fact, pollution is to a large extent loss of resources which were not used in the production process.

Therefore a thorough investigation of the inputs prescribed for each BAT is of high interest for the **operators** because, besides the good environmental results (expected), the lower consumption of resources leads to cost savings; on the other hand this perspective is interesting also for the **permitting authorities** because they can assess whether some preventive criteria (use of low-waste technology, the consumption and nature of raw materials/water used in the process and energy efficiency) has been duly addressed by the operators in order to apply an economically sustainable BAT: obviously BAT using less resources are economically more sustainable than other techniques which are not associated with this aspect.

59. Therefore the analysis of BAT inputs is important allowing putting those candidate BAT which achieve good AEL results combined with the rational consumption of the resources (inputs) on a high priority.

How to compare BAT inputs to those of the conventional process

60. The first part of table 11 has to be re-shuffled accordingly (Table 15). As a change/modification is meant any reduction of quantities used in the conventional process and/or change of raw materials/chemicals etc. It should be expressed in % of reduction and/or description of the new materials used (if any).

Table 15: Comparison of inputs (conventional process – BAT)

UO	Value	BAT 1	Change/ modification	BAT 2	Change/ modification	BAT X	Change/ modification
Raw materials (ton/day)							
Chemical 1 (kg/ton of raw material)							
Chemical 2 (kg/ton of raw material)							
Chemical X (kg/ton of raw material)							
Water (m^3/day)							
Energy (kWh/day)							

Steps 8 + 9 Formation of BAT options

Rationale

61. It is obvious from the above analysis that both aspects (reduction of emissions + reduced use of resources) are quite important, so that they have to be compared and, if possible, combined.

Therefore the results of the analysis in Steps 8 and 9 have to be assessed by trying to formulate those BAT options which primarily reduce significantly the releases into the environment and secondly are using less resources/produce less waste quantities. As a matter of fact those BAT which use less resources most probably generate less emissions: **both aspects, reduction of emissions (outputs) and of the use of resources (inputs), form the core of the BAT selection process.**

How to rank BAT options

62. In table 16 the final ranking of the BAT options ready for pre-selection is presented (ranking criteria: 1 - reduction of emissions, 2 - reduction of inputs). BAT options which combine **both criteria** are ranked on the 1st place followed by those causing less environmental emissions without any significant changes concerning inputs.

Table 16: Ranking of BAT options – environmental performance

Ranking	BAT	Pollutants reduced (name, % of reduction)	Raw materials savings (type, % of reduction, substitution of materials)	UO (1 or more UO addressed by the respective BAT)

Step 10 – Assessment of the potential risk to harm EQS

Rationale

63. The conclusions from Step 2 (affordable pollutants' concentrations to maintain the existing EQS) will be taken into consideration when the candidate BAT's outputs will be evaluated, namely to which extent existing EQS are better served when the respective BAT will replace/supplement the conventional production process and allow the emission of less quantities of pollutants.

64. This analysis will provide a clear picture of the environmental performance of all candidate BAT and distinguish those which achieve the best results.

65. This Step can become very complex since, from a scientific point of view, a quantification of the environmental impacts (to be caused by the emitted pollutants) should be undertaken
The BREF on economics and cross-media effects gives an insight on methodologies for the quantification of the environmental impacts.

66. Having in mind that this Guidance document aims to describe a simple/comprehensive methodology on how BAT can be selected (by the operators) and evaluated (by the permitting

authorities), the analysis on BAT impacts is kept to a minimum level: the same tasks as in Step 2 will be undertaken by the operators and the authorities by highlighting only those changes in emissions which are eventually caused by the candidate BAT i.e. if a pollutant emitted so far will be “replaced” by another one.

How the potential risks will be assessed when BAT options will be applied

67. The tasks described in Step 2 for the **operators** will be supplemented for the emissions coming out from all those BAT options deriving from the analysis of Steps 8 + 9. Therefore table 4 has to be modified as follows (in bold letters):

Water

Point 3

- List of **new** points of discharge **(where BAT are installed)** together with the maps, drawings and the adjoining documentation

Point 4

- Detailed list of hazardous substances **(if others than those emitted from the conventional processes)** on discharge into ground and surface water

Point 5

- Cumulative data and impact assessment of the **BA**T emissions to the environment i.e. surface and/or ground water – **BAT process contribution compared to the conventional process (% of increase/decrease of emitted pollutants)**

Air

Point 3

- Cumulative list of **BAT** point source emissions **- BAT process contribution compared to the conventional process (% of increase/decrease of emitted pollutants)**

Point 4

- Full data on atmospheric dispersion modelling of the **BAT** emission

Point 6

- Control measures that planned in the future (equipment, control parameters, limit values, types of measures, validity, time of measurement, sampling, measurement points distribution, frequency, method of analysis etc.) **for the BAT emissions**

Soil

Point 4

- Cumulative data on all direct **BAT** emissions of hazardous substances on land/soil

Point 5

- Full data on the location of discharge **of BAT waste quantities** (including maps, drawings and the adjoining documentation)

Point 6

- Information about the type of processing and the waste quantities and location of deposition **of BAT waste quantities** in the geographical area concerned.

In table 17 these changes (bold) are summarized.

Table 17: Operators' tasks for Step 10

Recipient	**Action**
Water (surface/ground)	1. Presentation of the situation of the surface/ground water quality (incl. the hydrological conditions) 2. Comparative review of the prescribed allowed concentrations for each polluting substance in the ground and surface water 3. List of **new** points of discharge (**where BAT are installed)** together with the maps, drawings and the adjoining documentation 4. Detailed list of hazardous substances **(if others than those emitted from the conventional processes)** 5. Cumulative data and impact assessment of the **BA**T emissions to the environment i.e. surface and/or ground water – **BAT process contribution compared to the conventional process (% of increase/ decrease of emitted pollutants)** 6. Full data on the assessment and other relevant information on the recipient as well as the usual water quality analyses at the recipient point, i.e. the water body.
Air	1. Presentation of the situation of the air quality (including the meteorological conditions and factors) 2. Comparative review of the prescribed allowed concentrations for each polluting substance in the air 3. Cumulative list of **BAT** point source emissions **- BAT process contribution compared to the conventional process (% of increase/decrease of emitted pollutants)** 4. Full data on atmospheric dispersion modelling of the **BAT** emissions 5. Cumulative data on fugitive sources of pollution, the control measures and information on their environmental impact 6. Control measures that planned in the future (equipment, control parameters, limit values, types of measures, validity, time of measurement, sampling, measurement points distribution, frequency, method of analysis etc.) **for the BAT emissions**.
Soil	1. Comparative review on the presence of hazardous and harmful substances in the soil, as well as morphological characteristics of the superficial soil layer including current/potential emissions from the installation 2. Comparative review of the prescribed allowed concentrations for each polluting substance in the soil according to existing standards (legislation) 3. Cumulative overview of data on superficial and ground contamination on the location or under it (including data sets of research studies, assessments or reports, monitoring results, location and measuring equipment, plans, drawings and other adjoining documentation) 4. Cumulative data on all direct emissions of hazardous substances on land/soil

	5. Full data on the location of discharge (including maps, drawings and the adjoining documentation) 6. Information about the type of processing and the waste quantities and location of deposition in the geographical area concerned 7. Description of existing controlled or uncontrolled landfills in the area where the installation's waste quantities will be disposed.

68. The tasks of the **authorities** will be to compare the data of table 17 with those of table 4 and to review table 5 to check whether the introduction of BAT in an installation has significantly altered the prevailing environmental conditions in the geographical area concerned.

Phase 3 – Summary of tasks (Steps 8 – 10)

69. The tasks for the authorities and for the operators are summarized in table 18.

Table 18: Tasks for operators/authorities - Summary (Phase 3)

Step	**Operators**	**Authorities**
Comparison of existing emissions to BAT-AEL **(Step 8)**	Prepare table 13	
Ranking of BAT according to outputs **(Step 8)**	Prepare table 14	
Comparison of inputs of conventional process to BAT **(Step 9)**	Prepare table 15	
Ranking of BAT options **(Steps 8 + 9)**	Prepare table 16	Check the compliance of BAT ranking (table 16) to the data of tables 13, 14, 15.
Assessment of potential risks of BAT emissions to EQS **(Step 10)**	Prepare table 17	Compare table 4 to table 17 to assess the expected changes of emissions according to the proposed BAT options.

Outputs of Phase 3

70. By completion of Phase 3 the following outputs will be produced:

1. A list of candidate BAT options pre-selected according to their environmental importance (reduction of emissions, reduced use of resources)
2. A list of the UO which the candidate BAT options can be applied to
3. A report about the expected impacts of BAT emissions to the environment (water, air, soil)

In figure 3 a summary of the procedures presented so far (Phase 3) for the pre-selection of the candidate BAT is schematically presented.

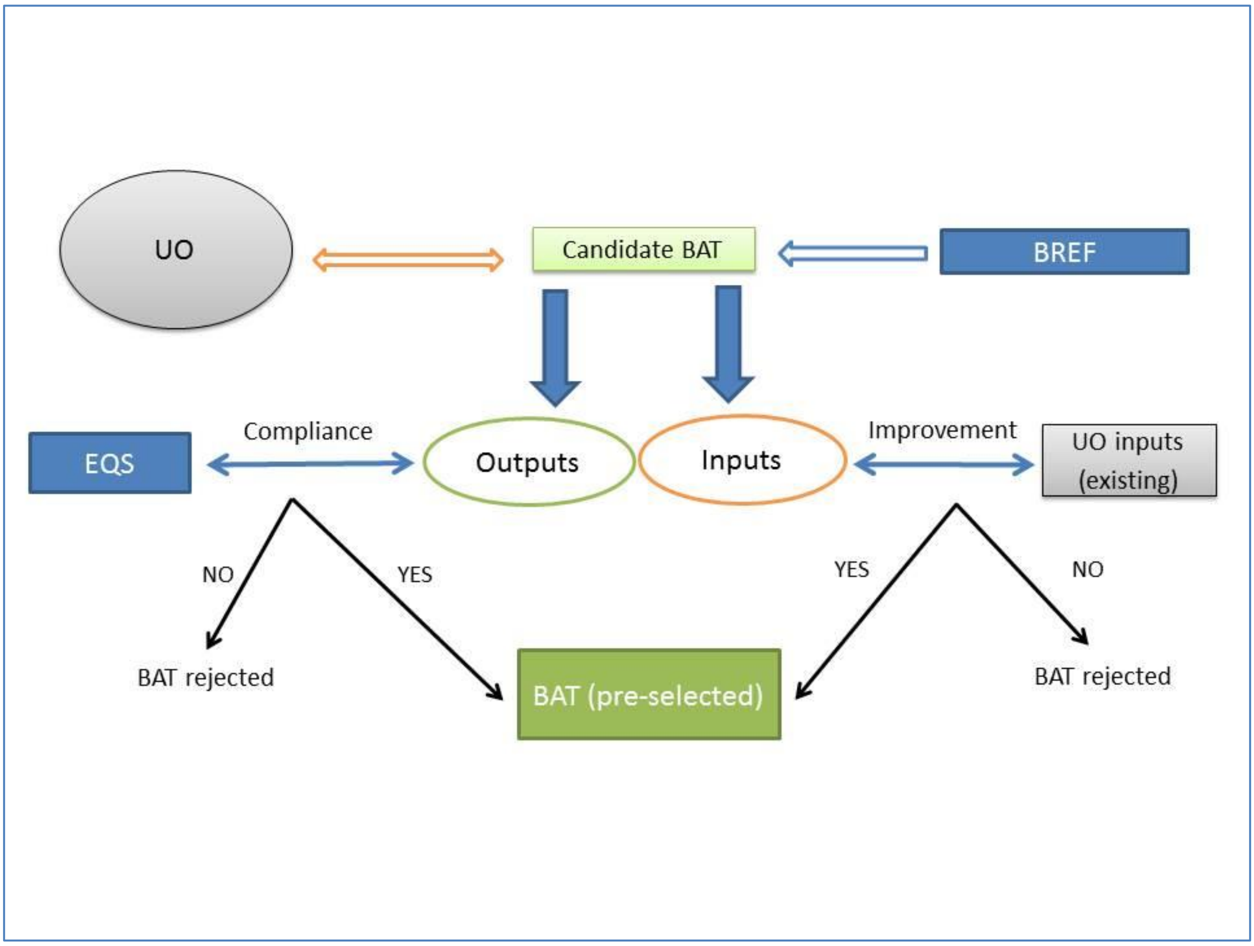

Figure 3: Pre-selection of candidate BAT

Phase 4 – Evaluation of the technical performance of candidate BAT

Step 11 – Analysis of the technical characteristics of candidate BAT

Rationale

71. Any technique can be easily rejected and not considered as a BAT if, despite its excellent environmental characteristics (i.e. reduction of outputs/inputs), it is not technically mature to be adopted by an operator: the danger that it will not perform properly in a large industrial scale is a major constrain for any final decision about BAT selection.

72. Therefore only those candidate BAT have to be adopted for further investigation which can prove their technical sustainability.

73. In this Step an assessment of the technical characteristics of each candidate BAT has to be performed in order to get a first insight about the technical character of the BAT e.g. whether it is simple/complex in operation or whether major technical interventions are needed for its introduction in the existing production process.

74. This analysis is important for **existing** as well as for **new** installations: whereas in the first case (existing installations) the technical modifications needed for replacing/supplementing existing equipment are crucial since they define the magnitude of interventions/investments, for new installations a clear picture of the BAT technical characteristics allows the operators to plan the whole production chain (i.e. the sequence of the UO) in advance of any other technical (or other) interventions (e.g. construction works, setting of canalization devices etc.).

Which technical characteristics must be examined

75. Besides the process inputs/outputs which have already been examined (raw materials, chemicals, water, energy/products, environmental parameters, heat release) the following technical characteristics of the candidate BAT have to be described:

- ✓ Process flow/parameters (hydraulic flow, temperature/heat exchange, cooling devices etc.)
- ✓ Types of equipment
- ✓ Type/magnitude of technical modifications in the existing production process needed for BAT introduction (mechanical/civil engineering issues)
- ✓ Operational requirements (manpower, training, recruitment of new personnel, any changes in the daily work, safety considerations)

76. This is an “internal” task of the **operators**: it is in their own interest to find out whether the candidate BAT can perform the assigned technical requirements in a full scale operation and under the “classical” industrial conditions (non-stop operation, alterations in process feeding, exploitation of full capacity of equipment over long/short periods etc.).

77. For the analysis of the technical characteristics a checklist has to be prepared by the operator which will be used as a general “guide” for the examination of the technical characteristics of the envisaged BAT options. In doing so, any technical description mentioned in the relevant BREF/literature will be the starting point whereas additional inquiries may be needed by direct correspondence with the BAT inventors and/or users.

Table 19: BAT technical characteristics - Checklist for operators

Analysis of: (sections - tables of application form)	Question	Response (YES/NO)	Description/Comments
Process design	Is the BAT configuration (i.e. sequence of UO) different in comparison to the conventional process?		
	If YES, describe the new configuration of UO (process flow)		
	Basic BAT technical features (describe if different of the conventional process - NEW installations: describe accordingly)		
	Heating/cooling system?		
	Feeding devices of inputs (raw materials, chemicals)?		
	Special storage devices for raw materials/chemicals needed?		
	Water feeding system?		
	Energy source?		
	Collection, treatment/ recycling of wastewaters?		
	Collection, treatment/ recycling of solid waste?		
Equipment	**BAT Equipment (describe if different of the conventional process –NEW installations: describe accordingly)**		
	Major devices?		
	Major auxiliary equipment (e.g. pumps)?		
	Electro-mechanical modifications?		
	Civil engineering interventions?		

Analysis of: (sections - tables of application form)	Question	Response (YES/NO)	Description/Comments
Operation	**BAT operational requirements (describe if different of the conventional process - NEW installations: describe accordingly)**		
	Training needs of equipment's operators?		
	Monitoring requirements of emissions?		
	New staff needed?		
	Safety requirements?		

Step 12 – Assessment of the technical viability of candidate BAT

Rationale

78. After the technical characteristics of the candidate BAT are assessed (Step 11) a further analysis is needed in order to find out whether the proposed BAT are technically viable or not.

79. This assessment is important not only for the **operators** (for obvious reasons) but also for the **permitting authorities**: it is in their interest to secure that the BAT will continuously be operated and not that, after some time, it will be left aside due to malfunctioning, technical complexity etc.

How the technical viability of candidate BAT will be assessed

80. The operator has to prepare a summary on the technicalities associated with each candidate BAT highlighting the major technical features (as described in table 19) and defining the "character" of each one of them. The following criteria should be taken into consideration in order to convince the permitting authorities that the proposed BAT are technically mature and ready for application:

1. The use of low-waste technology
2. The use of less hazardous substances
3. The potential for recovery and recycling of substances generated and used in the process and of waste, where appropriate
4. Comparable processes, facilities or methods of operation which have been tried with success on an industrial scale
5. Technological advances and changes in scientific knowledge and understanding
6. The nature, effects and volume of the emissions concerned
7. The commissioning dates for new or existing installations

8. The length of time needed to introduce the best available technique
9. The consumption and nature of raw materials (including water) used in the process and energy efficiency
10. The need to prevent or reduce to a minimum the overall impact of the emissions on the environment and the risks to it
11. The need to prevent accidents and to minimize the consequences for the environment
12. Information published by public international organizations
13. The simplicity of operation (e.g. good housekeeping measures) if applicable.

81. The major technical features assessed during the implementation of Step 11 (table 19) will be the "inputs" for checking the compliance of each candidate BAT with the above mentioned criteria (table 20).

Table 20: Technical viability of candidate BAT

Candidate BAT	Advantages (in comparison to the conventional process)	Disadvantages (in comparison to the conventional process)	Comments/Conclusions
Process design			
BAT configuration (i.e. sequence of UO)			
Heating/cooling system			
Feeding devices of inputs (raw materials, chemicals)			
Specific storage devices for raw materials/chemicals			
Water feeding system			
Energy source			
Collection, treatment/ recycling of wastewaters			
Collection, treatment/ recycling of solid waste			
BAT Equipment			
Major devices			

Candidate BAT	**Advantages (in comparison to the conventional process)**	**Disadvantages (in comparison to the conventional process)**	**Comments/Conclusions**
Major auxiliary equipment (e.g. pumps)			
Electro-mechanical modifications			
Civil engineering interventions			
BAT operational requirements			
Training needs of equipment's operators			
New staff needed			
Monitoring requirements of emissions			
Safety requirements			

Table 21: Ranking of BAT options - technical viability

Ranking	**BAT**	**Compatibility with the simplicity criterion (installation/operation)**

Phase 4 – Summary of tasks (Steps 11 – 12)
The tasks for the authorities and for the operators are summarized in table 22.

Table 22: Tasks for operators/authorities - Summary (Phase 4)

Step	Operators	Authorities
Analysis of the technical characteristics of each candidate BAT **(Step 11)**	Prepare table 19 for each candidate BAT	
Assessment of the technical viability of each candidate BAT **(Step 12)**	Prepare table 20 for each candidate BAT	
Ranking of BAT options on the basis of technical characteristics **(Step 12)**	Prepare table 21	Check tables 20 + 21 to assess the compatibility of the proposed BAT with set criteria

Outputs of Phase 4

82. By completion of Phase 4 the following outputs will be produced:

1. A list of pre-selected BAT containing the main technical characteristics of each one of them
2. A "preference" list of those BAT which show the best compatibility with the set criteria i.e. simplicity of operation, use of low-waste technology etc. (ranking of BAT).

Phase 5 – Evaluation of the economic viability of candidate BAT

Step 13 – Calculation of investment costs for the introduction of candidate BAT

Rationale

83. The selection of a BAT inevitably goes finally through a thorough investigation of the associated costs for its introduction in an existing industrial process or when a new installation is planned: in many cases high investment costs can prohibit the introduction of a very promising BAT (from the technical and environmental point of view). Therefore the assessment of the costs related to the investment needed for the introduction of a BAT is, to a certain extent, the most decisive factor for the final selection of a BAT.

84. Although this analysis has to be performed entirely by the **operators**, its outcomes cannot be overlooked by the permitting **authorities** since in most cases this point is the most difficult issue to be tackled when BAT-AEL (and consequently ELV) are proposed by the operator (and accepted by the permitting authorities) for a specific industrial process: usually operators refer to the high investment costs of associated with a BAT introduction in the production process which would endanger the economic sustainability of the industry when they have to negotiate with the authorities about the introduction of "strict" ELV. Therefore a solid analysis of the economical parameters is needed so that the relevant arguments can be subject of a well-documented discussion.

85. It must be pointed out that within the framework of this Guide, only indications and general instructions on how to proceed with cost estimations are given since a detailed economic/cost analysis is beyond the scope of this document. More detailed information dealing with cost validation, pricing of equipment, documentation about data uncertainty etc. can be found in various literature sources and especially in the BREF on Economics and cross-media effects and in the EEA report Guidelines for defining costs of environmental protection measures.

Which costs can be considered as investment costs

86. As investment (or capital) costs are meant the costs for **the purchase of equipment, construction of devices (civil/mechanical engineering services) and the modification of existing unit operations** (not relevant for new installations). When these costs have to be calculated a list of the relevant items has to be conducted as follows:

Major components

- ✓ Reactor vessels
- ✓ Furnaces boilers
- ✓ Turbines
- ✓ Treatment plants

Intermediate components

- ✓ Heat exchangers/cooling systems
- ✓ Filters
- ✓ Handling equipment
- ✓ Other pollution control equipment

Minor components

- ✓ Motors
- ✓ Drives
- ✓ Burners

Buildings/construction (civil engineering)

- ✓ Building where the BAT should be placed
- ✓ Storage devices for raw materials and chemicals (buildings, coverage etc.)
- ✓ Site preparation (e.g. excavations)
- ✓ Arrangements on existing devices (floors, coverage of equipment, canalization etc.)

Other components

- ✓ Purchase of land
- ✓ Land clean-up (if appropriate)
- ✓ Design/planning of works/hiring of consultants

87. Cost data can be obtained from a variety of sources but whatever the source, the user (operator) needs to think critically about the validity of the data since costs/prices can vary over time and location of the installation. In any case the cost data has to be as representative as possible for the specific case (industrial process – BAT concerned). In any case the data should be well documented and their sources registered and reported. In this context it must be pointed out that **confidentiality** of information must be always secured in any case of information exchange e.g. between the operator and the permitting authorities.

88. Possible sources of cost data can be:

- Industry (i.e. installations which have applied the same/similar BAT), e.g. construction plans, documentation of industrial projects, permit applications of similar BAT, cost estimates for comparable projects in other industries or sectors
- Technology suppliers, e.g. catalogues, tenders of BAT manufacturers/suppliers
- Consultants specialized in BAT assessment
- Research groups, e.g. demonstration programs of BAT applications in similar industries
- Published information e.g. reports, journals, websites, conference proceedings.

Which factors have to be considered when investment costs are evaluated/assessed

89. Some important factors which have to be considered when the investment costs of a BAT option will be calculated are given below as indication/advice to the operator for further and more detailed investigation of cost factors:

- Technological solutions **already available on the market** are easier to be economically assessed and evaluated from those which are still on a semi-industrial scale development level or implemented in a specific geographical area). In the latter cases a direct contact with the BAT suppliers/users have to be envisaged in order to understand the specific circumstances and conditions associated with the BAT applications and to carefully evaluate whether the costs estimations can be also applied in their own case.

- The **base case** namely the existing industrial production system (i.e. UO, equipment, buildings, existing pollution abatement systems etc.) has to be the reference on which all cost comparisons should be based when the costs for the introduction of a BAT option are evaluated: As a matter of fact all costs should be measured in relation to an alternative. The alternative most commonly employed is a projection of the existing situation, i.e. the situation in which the BAT option has not been yet installed (base case):

    - Will there be additional costs in the future for the modernization of the installation (e.g. because some of the equipment has to be replaced or new end-of-pipe treatment facilities have to be installed)?
    - Can any forthcoming environmental standards be met by the existing installation without any change of the process?
    - Are there any plans for new products? And if yes, is the existing production process capable to fulfill the relevant quality standards?

90. Therefore, the additional costs actually incurred relative to the base case should be compared with the costs needed to apply the proposed BAT and thus form the decisive factor to understand the magnitude of the investment costs required.

- The **life time** of facilities and of main/auxiliary equipment is an important factor to be considered when cost estimations are made. This factor defines the physical but also the economic life (i.e. depreciation) of buildings, equipment etc. so that any cost calculation should not exceed this time frame. Some indications about life time of facilities/equipment are given in table 23.

Table 23: Life time of facilities/equipment

Facilities/equipment	Life time (years)
Buildings	20
Major components (e.g. reactor vessels, furnaces, boilers, turbines, effluent treatment plant)	15
Intermediate components (e.g. heat exchangers, filters, handling equipment)	10
Minor components (e.g. motors, drives, burners)	5

- The **base year** namely the year when the BAT investment will be implemented has also to be defined. This year will define on the one hand the prices/costs for equipment purchase and the construction works as well as the level of depreciation of the "base case".

- **Discounting** is another factor to be taken into consideration by economic calculations: it is the mechanism whereby costs that accrue at different points in time are weighted to facilitate comparison (EEA report Guidelines for defining costs of environmental protection measures p. 20, BREF on economics and cross-media effects p.46). It states for example that the value of EUR 1 today will be different to the value of that same EUR 1 in one years' time due to inflation and prices changes. A discount rate has to be defined (usually based on official economic/statistical figures) which will be used as basis to calculate the "discounted" capital cost. It should be as close to the reality as possible and the information source where the discount rate is derived from has also to be stated. A simple example of the meaning of discount is presented in table 24.

Table 24: Discount rates (Example)

Year	**0**	**1**	**2**
Capital expenditure (€)	2000	2000	2000
Discount rate (%)		10	10
Value today (€)	2000	2000 x 0.9 = 1800	2000 x 0.9 x 0.9 = 1620

- **Inflation/interest** rates and **taxation** are factors which have also to be taken into consideration by a serious economic analysis of investment costs. Usually they are considered at the final stage of the economic analysis.

91. A checklist of the investment (capital) costs is given on table 25. It has to be prepared for each pre-selected candidate BAT option for which the environmental performance and technical viability have been proven so far (up to Step 12).

Table 25: Checklist - capital costs of a BAT option

COST COMPONENT	Included in capital costs (YES/NO)	Costs (€/$/national currency)/ % of capital costs	Year of purchase
Major equipment			
Reactor vessels			
Furnaces			
Boilers			
Turbines			
Pollution control equipment			
Instrumentation			
Installation costs			
Land purchase			
Site preparation			
Buildings and civil works (e.g. foundations, piping, canalization etc.)			
Labor and materials (engineering, construction and field expenses)			
Other capital costs			
Project definition, design and planning			
Testing and start-up costs			
Contingency			
Working Capital			
Clean up costs			
TOTAL CAPITAL COSTS		**€/$/national currency**	

Step 14 – Calculation of the operational costs for the introduction of candidate BAT

Rationale

92. The whole concept of BAT introduction is focused, besides the better environmental performance, in the possibility of cost savings through reduced inputs in the production process. It is expected that they are lower than those of the conventional process and can be reflected as cost savings in the operating costs component. Therefore the calculation of the operating and maintenance costs is a crucial factor for the final selection of the relevant BAT options by giving a first insight into the cost saving potential of the candidate BAT option and the possibility for the investment's amortization in the (near) future.

Which are the operational costs of a BAT?

93. An indicative list of the main items defining the **operating and maintenance (O/M) costs** is given below:

Energy costs - purchase and use of

- Electricity
- Petroleum products
- Natural gas
- Coal or other solid fuels

Materials and services costs

- Replacement (spare) parts
- Chemicals
- Water usage
- Environmental services such as waste treatment and disposal services

Labor costs

- Operating, supervisory, maintenance staff
- Training of the above staff

Fixed O/M costs

- Insurance
- License fees
- Emergency provisions
- Other general overheads

How O/M costs should be classified and calculated

94. In table 26 a checklist of the O/M costs is given. The checklist should be prepared by the operators for each pre-selected candidate BAT option for which the environmental performance and technical viability have been proven so far (Step 12).

Table 26: Checklist - operating costs of a BAT option

COST COMPONENT	Included in O/M costs (YES/NO)	Quantity - Unit (No of staff/man-hours, tons of water etc.)	Costs/unit (€/$/national currency)	Total Cost (€/$/national currency) per year/% of total operating cost	Year
Existing situation					
Labor costs					
Operating, supervisory, maintenance staff					
Training of the above staff					
Energy costs					

COST COMPONENT	Included in O/M costs (YES/NO)	Quantity - Unit (No of staff/man-hours, tons of water etc.)	Costs/unit (€/$/national currency)	Total Cost (€/$/national currency) per year/% of total operating cost	Year
Existing situation					
Electricity					
Petroleum products					
Natural gas					
Coal or other solid fuels					
Materials and services costs					
Replacement (spare) parts					
Chemicals					
Water usage					
Environmental services such as waste treatment and disposal services					
Fixed O/M costs					
Insurance					
License fees					
Emergency provisions					
Other general overheads					
TOTAL O/M COSTS (without savings/revenues)			**€/$/national currency**		
Existing situation			**€/$/national currency**		
Cost savings/revenues (in					

COST COMPONENT	Included in O/M costs (YES/NO)	Quantity - Unit (No of staff/man-hours, tons of water etc.)	Costs/unit (€/$/national currency)	Total Cost (€/$/national currency) per year/% of total operating cost	Year
Existing situation					
comparison to the conventional process)					
Energy savings					
Reduced water usage					
By-products recovered/ sold					
Reduced environmental tax/ charge					
Savings on labor costs					
Savings on the operation of pollution control equipment					
Savings on the monitoring of emissions					
Savings on maintenance					
Savings on disposal costs					
Savings on capital due to more effective use of plant					
Other savings (specify)					
TOTAL SAVINGS/REVENUES			**€/$/national currency**		
NET O/M COSTS (total O/M costs – savings/revenues)			**€/$/national currency**		

Step 15 – Assessment of the break-even point of the investment

Rationale

95. This is the final Step of the overall analysis which allows the operator to see whether the BAT investment will be somehow paid back due to the expected O/M cost savings (in comparison to the conventional process). This will be the case only if, by introducing one or more BAT in an industrial installation, savings of raw materials/chemicals/energy/water as well as less environmental remediation devices are needed. This is usually the case for BAT of preventive nature which consumes fewer resources, is simple and consequently cheap.

96. This is finally the most important consideration in the whole economic analysis performed so far: it reflects the full extent of the usefulness of the BAT introduction and can convince the investor about the necessity to introduce one or more good BAT options into the industrial production process. Within this context the calculation of the investment and O/M costs aim to act as "inputs" for this final Step which practically will demonstrate whether the introduction of a BAT option in a production process is economically feasible. This analysis however is not only useful for the operator but also for the permitting authorities in their discussions/negotiations with the operator about the conditions of a permit: they can understand the prospects of a smooth operation of the BAT in the daily process and the interest of the operator to apply the BAT in a full extent (because there will be potential benefits) and consequently the fulfilment of the permit's conditions.

97. It must be pointed out that the **ideal** situation would be that a BAT investment can be paid back during its life time from the cost savings of the O/M costs; however this is not always feasible. In any case the introduction of BAT leads to clear cost savings which principally contribute positively to the economic results of a company to a small or large extent.

How the amortization of a BAT investment can be assessed

98. The calculation of the annual costs is the starting point for the assessment of the duration of the amortization period of the BAT investment.

99. This calculation can be expressed by the following equation:

Annual Costs = capital cost (annual depreciation plus interest) + annual operating costs **-** annual savings

The following points are a summary of how the cost information should be processed and presented:

- Express the original cost data in the price level of a common year
- The discount or interest rate used should be clearly stated
- The 'real discount rate' and 'real prices' should be used
- The basis of the rate used should be explained, as well as any underlying assumptions made
- If the actual rate used is country/sector/company specific then this should be stated and the source of the rate should be referenced
- Discount and interest rates should be applied before any tax consideration
- Cost data are preferably calculated and presented as annual costs

100. Although it seems most appropriate to express cost data as annual costs for the assessment of industrial pollution control systems, there are other common and useful ways to express the data, such as:

- **The cost per unit of product**

101. This may be useful for assessing the affordability of the technique in comparison with the market price for the goods produced. The cost per unit can be calculated from the annual cost divided by the best estimate of the yearly average production rate during the period being considered.

- **The cost per unit of pollutant reduced or avoided** (annual costs per annual reduction of emissions)

102. This may be useful as a basis for analyzing the cost-effectiveness (CE) of the technique

103. It is up to the operator to choose the way he thinks that reflects better the calculations made and can be the whole economic process understandable to the industry's stakeholders as well as to the authorities.

How the economic attractiveness of a BAT investment can be described

104. There are no general economic rules or indicators which can numerically define whether an investment is attractive to be undertaken. Some **viability indicators** however can give an indication to decision makers about the fate of the BAT investment (table 27).

Table 27: Viability indicators for BAT investment

Annual BAT cost related to:	Acceptable	To be discussed further	Unacceptable
Turnover	< 0.5 %	0.5 – 5 %	> 5 %
Gross profit	< 10 %	10 – 100 %	>100 %
Added value	< 2 %	2 – 50 %	>50 %
Total investments	< 10 %	10 – 100 %	>100 %

105. A simplified example of application of the above mentioned considerations is presented in table 28 in order to explain how the savings in O/M costs can lead to acceptable economic results related with the BAT application. For reasons of simplicity not all economic factors have been taken into consideration and some simple assumptions have been made such as:
Interest rates = constant over the time period

Discount rate = not considered

O/M costs = constant over the time period

Table 28: Pay back of BAT investment (Example)

Year	0	1	2	3	4	5
Interest rate		5 %	5 %	5 %	5 %	5 %
Costs (€)						
Investment expenditure	**200,000**	**10,000**	**10,000**	**10,000**	**10,000**	**10,000**
Equipment	150,000					
Installation of equipment	50,000					
O/M costs (before BAT introduction)		**60,000**	**60,000**	**60,000**	**60,000**	**60,000**
a) Energy		15,000	15,000	15,000	15,000	15,000
b) Water		5,000	5,000	5,000	5,000	5,000
c) Materials		7,000	7,000	7,000	7,000	7,000
d) Labor		30,000	30,000	30,000	30,000	30,000
e) Other (insurance etc.)		3,000	3,000	3,000	3,000	3,000
Total annual costs (before BAT introduction): O/M costs + annual expenditure		**70,000**	**70,000**	**70,000**	**70,000**	**70,000**
O/M costs (after BAT introduction)		**25,000**	**25,000**	**25,000**	**25,000**	**25,000**
a. Energy		5,000	5,000	5,000	5,000	5,000
b. Water		1,000	1,000	1,000	1,000	1,000
c. Materials		3,000	3,000	3,000	3,000	3,000
d. Labor		14,000	14,000	14,000	14,000	14,000
e. Other		2,000	2,000	2,000	2,000	2,000
Savings (O/M costs)		**35,000**	**35,000**	**35,000**	**35,000**	**35,000**
Total annual costs (after BAT introduction): O/M costs + annual expenditure		**35,000**	**35,000**	**35,000**	**35,000**	**35,000**
Pay back of investment (from O/M cost savings)		**5.7 years**				

Phase 5 – Summary of tasks (Steps 13 – 15)

106. The tasks for the authorities and for the operators are summarized in table 29.

Table 29: Tasks for operators/authorities - Summary (Phase 5)

Step	Operators	Authorities
Assessment of BAT investment costs **(Step 13)**	Prepare table 25 for each candidate BAT	
Assessment of the BAT O/M costs **(Step 14)**	Prepare table 26 for each candidate BAT	
Calculation of break-even point of BAT investments **(Step 15)**	Assess when a BAT investment is economically feasible - consider examples (tables 27 + 28) – prepare a list of candidate BAT for final selection	Discuss with operator about the economic viability of selected BAT options

Outputs of Phase 5

107. By completion of Phase 5 the following outputs will be produced:

1. A list of pre-selected BAT containing calculations about expected investment and O/M costs
2. A "preference" list of those BAT which show a certain economic "attractiveness" i.e. seem to be economically viable.

Final selection of BAT

108. Having taken into consideration all the above mentioned factors a list of "most favorable" BAT for each production process (unit operation) will be compiled.
The final selection of BAT will be done on the basis of the following main criteria:

- Meeting of environmental targets (set by the authorities) in a "sustainable" way (emission of less hazardous substances)
- Preventive nature (low consumption of resources)
- Potential of recycling of waste
- Simplicity (technical/economical sustainability)
- Cost effectiveness (costs related to the reduction of environmental emissions)
- Operational health and safety considerations

Conclusions

109. This Guidance document on BAT selection is providing to the **authorities** and the **operators** through a rather simple systematic way a "roadmap" on how to select the most appropriate BAT for each industrial process which needs environmental improvement. Its philosophy is to help its users to find the most suitable environmental, technical and economic data in the literature (i.e. BREF and elsewhere) by applying a targeted search into a rather complex documentation so that the collected information can lead to reasonable decisions.

110. This methodological approach, inevitably, has to be tested in practical life. In doing so, a close and fruitful cooperation between the national/regional/local authorities and the industry is crucial for the actual testing of the methodology and the respective guidance document when IPPC applications will be submitted for approval.

111. This is an interactive process which has to be based on mutual agreements and compromises. For sure the industry has to realize that the introduction of one (or several BAT) does not end with the submission of the application and its approval: it is for the industry's own interest to find ways for the modernization of its equipment which, sometimes, starts and ends with simple good housekeeping measures. Even in cases of larger investments there will be substantial benefits if the envisaged BAT are resource effective and pollution preventive.

112. It should be clear that pollutants are "lost" raw materials/resources, therefore their prevention saves money on both sides: fewer costs for material/chemicals purchase, less treatment of pollutants.

References

Guidelines for defining costs of environmental protection measures – Technical Report No. 27, EEA (1999)

BREF **on Economics and cross-media effects**, 2006

Horizontal Guidance Note IPPC H1, Environment Agency/Scottish Environment Protection Agency/Environment and Heritage Service – United Kingdom

BAT: when do Best Available Techniques become Barely Affordable Technology?, Vito (Flemish Institute for Technological Research) – Belgium (Flanders)

Using BAT performance as an evaluation method of techniques, Ecole des Metiers de l'Environement (EME) – France

Multi-criteria group decision support for integrated technique assessment, French -German Institute for Environmental Research (DFIU)/University of Karlsruhe (TH) - Germany