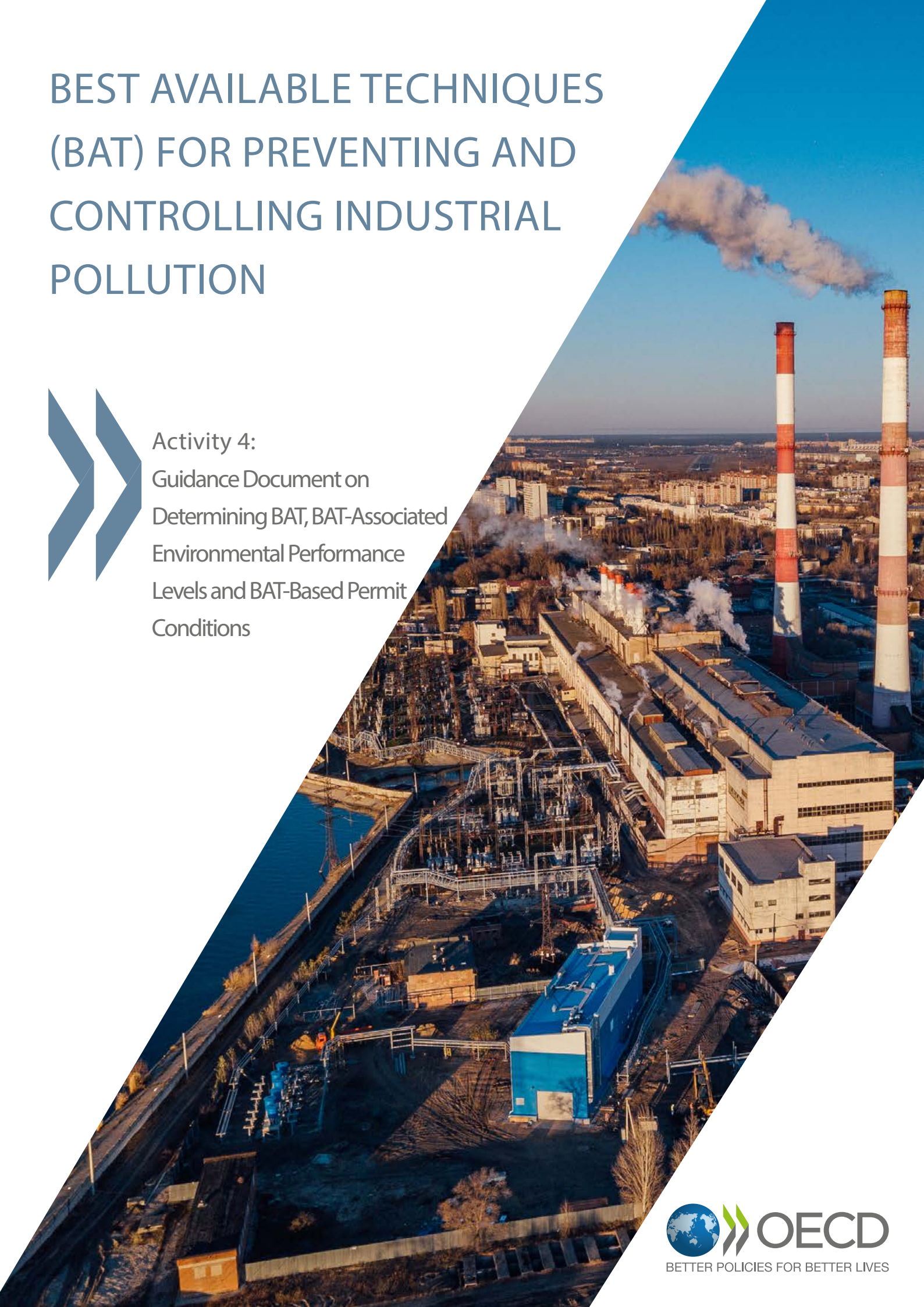
BEST AVAILABLE TECHNIQUES (BAT) FOR PREVENTING AND CONTROLLING INDUSTRIAL POLLUTION

Activity 4:
Guidance Document on Determining BAT, BAT-Associated Environmental Performance Levels and BAT-Based Permit Conditions



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BETTER POLICIES FOR BETTER LIVES

Best Available Techniques (BAT) for Preventing and Controlling Industrial Pollution

Activity 4:
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OECD

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IOMC

INTER-ORGANIZATION PROGRAMME FOR THE SOUND MANAGEMENT OF CHEMICALS

A cooperative agreement among **FAO, ILO, UNDP, UNEP, UNIDO, UNITAR, WHO, World Bank and OECD**

Foreword

A growing number of governments seek to adopt an approach based on Best Available Techniques (BAT) as part of the regulatory framework to prevent and control industrial emissions. There is value in supporting their efforts with guidance on how to identify and establish BAT, BAT-associated emission levels (BAT-AELs) and other environmental performance levels (BAT-AEPLs), as well as BAT-based permit conditions, including emission limit values. The OECD was tasked in 2018 by the 58th Joint Meeting of the Chemicals Committee and the Working Party on Chemicals, Pesticides and Biotechnology to develop such guidance, in order to provide support to countries that wish to set up, or strengthen, their BAT-based policies. More information on how the OECD works on BAT is provided in Box 1.

Providing guidance on BAT-based permitting is, in the short term, a means to strengthen policy in individual countries. In the long term, it might facilitate greater international harmonisation of procedures to establish BAT, and BAT-AE(P)Ls. This would assist efforts to protect human health and the environment across countries, and expand the level playing field for industry. The document presents a high-level overview of each step of the process to determine BAT, BAT-AE(P)Ls and permit conditions, including information on the principles and factors that should be considered in this process, based on best practices from OECD member and partner countries. It provides references to more detailed information from countries where such approaches are employed, and includes a range of elaborate examples from national and supra-national jurisdictions as well as international conventions. The document promotes an integrated approach to BAT-based environmental permitting.

This document primarily addresses regulators and competent authorities that would be interested in, and responsible for, introducing BAT-based permitting. It may also be a useful source of information for other stakeholders involved in the process to establish BAT and BAT-AE(P)Ls, including environmental NGOs, industry, equipment/service providers and consultants. The document applies to all interested countries and should have value both for those looking to update their existing regulatory regimes, as well as those seeking to introduce BAT-based permitting for the first time.

The guidance document does not aim to prescribe specific techniques. Instead, it focuses on the *processes* to establish BAT, BAT-AE(P)Ls and permit conditions. Further, it is not limited to new or existing industry, but covers both categories.

In the future, countries may consider elevating the status of this document by developing an OECD Council Act on BAT. However, this would require further analysis on the scope covered, the adequate level of prescription, and how a possible Act would integrate with other Council Acts, e.g. those concerning Pollutant Release and Transfer Registers (PRTRs) (OECD, 2018[1]), the Polluter Pays Principle (OECD, 1974[2]) or Integrated Pollution Prevention and Control (IPPC) (OECD, 1991[3]).

Box 1. How does the OECD work on BAT?

The OECD is leading a project on BAT to aid in the prevention and control of industrial pollution. Started in 2016, the project aims to identify and exchange best practices amongst countries that already have a BAT-based policy in place, and to assist those that are considering adopting this approach for the first time. The project is also relevant to the United Nations' Sustainable Development Goals (SDGs), as it contributes to activities intended to achieve some of the SDGs and the respective targets that speak to reductions in emissions of harmful chemicals, particularly Target 12.4 on the environmentally sound management of chemicals, which relates to SDG 12 on ensuring sustainable consumption and production patterns.

The OECD's BAT project runs until the end of 2021. The project is overseen by the OECD's international Expert Group on BAT, which consists of more than 90 members from governments in OECD member and non-member countries, in addition to environmental nongovernmental organisations (NGOs), industry, academia and inter-governmental organisations. The Expert Group is a fruitful platform for frequent exchanges of expertise and experiences across countries.

As of June 2019, the BAT project has developed three publications, which are available free of charge on oe.cd/bat:

i. Policies on BAT or Similar Concepts Across the World (OECD, 2017[4]), describing how BAT are defined and embedded in national legislation in different countries and regions;

ii. Approaches to Establishing BAT Around the World (OECD, 2018[5]), presenting various jurisdictions' procedures to determine BAT; and

iii. Measuring the Effectiveness of BAT Policies (OECD, 2019[6]), analysing methodologies and data for the evaluation of the effectiveness of BAT-based policies in a range of countries and regions.

The 58th Joint Meeting of the Chemicals Committee and the Working Party on Chemicals, Pesticides and Biotechnology (in November 2018) approved a new work plan for the BAT project, defining three activities for the period 2019-21:

iv. Develop a guidance document on determining BAT, BAT-associated emission and environmental performance levels, and BAT-based permit conditions, in order to provide a user-friendly tool to countries that are seeking to adopt a BAT-based approach for the first time, notably countries with developing and emerging economies;

v. conduct a study on value chain approaches to determining BAT for industrial installations, in order to identify and address the potential challenges and opportunities related to considering environmental implications across different stages of the value chain when determining BAT for a given industrial activity; and

vi. carry out cross-country comparisons of BAT and BAT-associated emission and environmental performance levels for selected sectors, in order to assess the differences and similarities across countries, with a long-term objective to explore opportunities for pursuing harmonisation amongst OECD countries.

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Acronyms

BAT	Best Available Techniques
BAT-AEL	BAT-Associated Emission Levels
BAT-AEPL	BAT-Associated Environmental Performance Levels
BAT-AE(P)Ls	BAT-Associated Emission Levels and/or Environmental Performance Levels
BEP	Best Environmental Practice
BREF	BAT Reference Document
CBA	Cost-Benefit Analysis
DEFRA	Department for Environment, Food and Rural Affairs (UK)
DG ENV	Directorate-General for Environment
DMR	Discharge Monitoring Report Database
EC	European Commission
EIPPCB	European Integrated Pollution Prevention and Control Bureau
EU	European Union
ELV	Emission Limit Value
EPA	Environmental Protection Agency
EPEP	Environmental Performance Enhancement Programme
GATPPC	Guidelines of Available Technologies for Pollution Prevention and Control
HAP	Hazardous Air Pollutant
IMPEL	European Union Network for the Implementation and Enforcement of Environmental Law
IPPC	Integrated Pollution Prevention and Control
KEI	Key Environmental Issues
MACT	Maximum Achievable Control Technologies
NESHAP	National Emission Standard for Hazardous Air Pollutants
OECD	Organisation for Economic Co-Operation and Development
SAB	Science Advisory Board
SDG	Sustainable Development Goal
NGO	Nongovernmental organisation
PRTR	Pollutant Release and Transfer Registers
TWG	Technical Working Group
US	United States
VOC	Volatile organic compounds

Chapter 1. Introduction to BAT

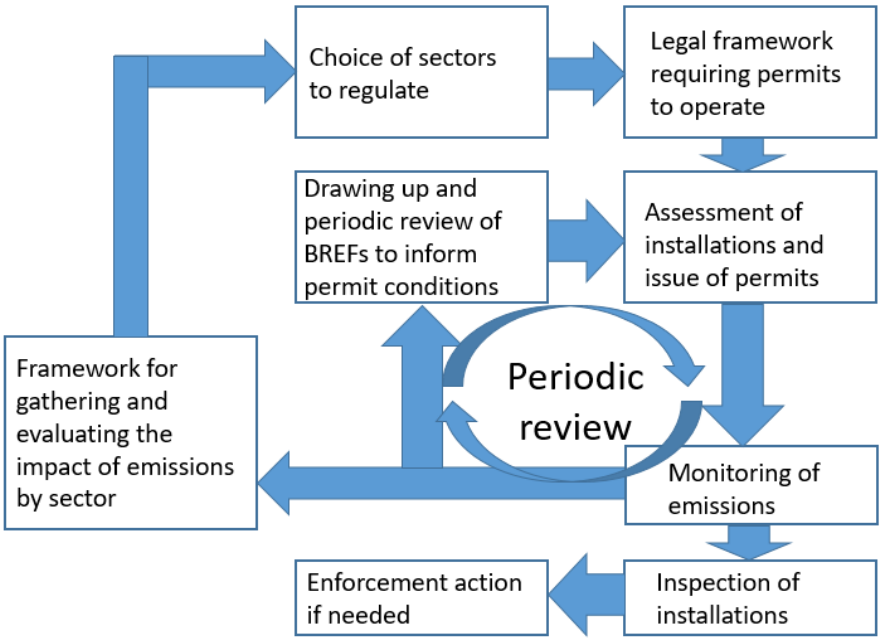
1.1. How does BAT fit in a regulatory framework?

Large industrial and agro-industrial installations are responsible for a significant share of total human environmental impacts. They can use large amounts of material, chemicals, energy and water. They can emit significant amounts of pollutants to the air, water and soil and generate substantial shares of hazardous and non-hazardous waste.

These environmental impacts vary by type of activity and can be very specific to the type of installation or the processes incorporated in a given site. These rather varied impacts as well as varying local conditions where such installations are subject to a regulatory regime, generally necessitate site-specific requirements.

Given the diversity of installations, establishing the environmental limits for each is challenging for regulatory officials. This can be compounded by frameworks where permits are granted at a local level and officials do not have experience of dealing with multiple installations of a similar type. The use of BAT reference documents (BREFs) is a solution that has been employed in a number of jurisdictions around the world to support the setting of permit conditions for industrial sites. Figure 1.1 shows how they fit in the regulatory framework and illustrates the main aspect of the overall regulatory regime covered by this document. The choice of sectors to regulate and the development of permit conditions are also reflected in this document.

Figure 1.1. Simplified flowchart illustrating how BREFs fit in a regulatory regime for environmental impacts of industry



Source: DG ENV, European Commission

1.2. What is BAT?

Best Available Techniques (BAT) are advanced and proven techniques for the prevention and control of industrial emissions and the wider environmental impact caused by industrial installations, which are developed at a scale that enables implementation under economically and technically viable conditions. A growing number of governments use BAT or similar concepts as a means to identify and set technically driven emission limit values (ELVs) and other conditions in environmental permits for industrial installations. Using BAT allows establishment of permit conditions that are rooted in techno-economic evidence and based on a participatory approach, thus to help achieve a high level of human health and environmental protection. BAT-based permit conditions can include ELVs, technical and management requirements, and monitoring requirements relating to emissions, consumption and/or waste generation.

Some OECD member countries and related organisations have already used BAT requirements for prevention and control of industrial pollution for several decades. The European Union (EU) is an international frontrunner, with more than 30 years of experience taking a BAT-based approach to establishing environmental permit conditions. More recently, an increasing number of non-EU countries have adopted BAT as a means to regulate emissions from industrial installations. While the BAT concept is interpreted differently across jurisdictions, the EU's definition of BAT, as presented in Box 1.1, remains the most widely referenced one.

Box 1.1. The European Union's definition of BAT

The European Union's Industrial Emissions Directive (EU, 2010[4]) defines Best Available Techniques (BAT) as "the most effective and advanced stage in the development of activities and their methods of operation, indicating the practical suitability of particular techniques for providing the basis for emission limit values and other permit conditions designed to prevent and, where this is not practicable, to reduce emissions and the impact on the environment as a whole". Further, the Directive states that:

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

In many countries, BAT are used to derive BAT-associated environmental performance levels (BAT-AEPLs). These encompass BAT-associated emission levels (BAT-AELs) as well as other environmental performance levels. BAT-AELs are – according to the European Union's Industrial Emissions Directive (IED) – "the range of emission levels obtained under normal operating conditions using a best available technique or a combination of best available techniques […] expressed as an average over a given period of time, under specified reference conditions" (EU, 2010[4]). That is, the BAT-AELs are

technologically driven; i.e. they reflect the environmental performance levels that can be achieved by implementing BAT or a combination of BAT, rather than being based on e.g. national emission targets and/or on the whole operating range of current performance of all installations.

Other BAT-associated environmental performance levels (i.e. other than the emission levels) can be related to consumption of material, water or energy, the generation of waste, abatement efficiency on pollutants and duration of visible emissions (EU, 2012[5]). As such, BAT-AEPLs are not limited to preventing or reducing emissions of pollutants, but can reflect sustainable chemistry, manufacturing efficiency, and other aspects of sustainable manufacturing practices.

Several jurisdictions present BAT and BAT-AE(P)Ls in BAT reference documents (BREFs), along with other relevant information. The EU defines a BREF as a document, resulting from an appropriate exchange of information amongst stakeholders, drawn up for defined activities and describing, in particular, applied techniques, present emissions and consumption levels, techniques considered for the determination of best available techniques as well as BAT Conclusions and any emerging techniques (EU, 2010[4]).

In many countries, such as in the EU Member States, Korea, Israel and the Russian Federation, BAT-AE(P)Ls form the basis for setting ELVs and other conditions in environmental permits for industrial installations. According to the IED, ELVs refer to the mass – expressed in terms of certain specific parameters – concentration and/or level of an emission, which may not be exceeded during one or more periods of time (EU, 2010[4]).

Some countries use the BAT concept in a slightly different manner. For example, the United States (US) set national standards and emission limits for various sources and industry sectors based on best available technology and in coordination with health-based standards, to ensure an ample margin of safety for public health and the environment. The standards are typically established for larger industries emitting pollutants of concern, and states or other local authorities incorporate these into permits and may require tighter standards depending on multiple factors.

Increasingly, BAT are also used in other policy areas, many of which contribute to progress towards the SDGs, including related to climate action, chemical safety, circular economy and global partnerships for sustainable development (Hjort et al., 2019[6])

Box 1.2 presents a few examples showing findings from case studies on how BAT-based permitting can provide benefits to human health, the environment, industry and society.

Box 1.2. Examples of benefits of BAT-based permitting

Case studies show that the implementation of BAT can ensure considerable reductions in industrial emissions, and thus important benefits to society, e.g. by avoiding human health damage costs due to prevented air pollution. For example, data from the Israeli PRTR for the period 2012-17 demonstrated a considerable decline in air emissions: between 8% and 62%, depending on the pollutant. (The estimates do not account for economic activity.) The reduction likely resulted from the introduction of BAT-based permitting over the period 2011-16 (OECD, 2019[7]). Another example is Sweden, where BAT-based permitting has been applied to large industrial installations for the last five decades. Over this period, the emissions of Volatile Organic Compounds (VOC) have fallen by 70%, particles by 90%, SO_2 by 97%, Hg by 99%, Pb by 99.9% and Cd by 98%. While other policies and measures may have contributed towards this significant progress, the BAT-based legislation appears to have been of pivotal importance. During the same period, the size of the Swedish economy has grown threefold (Almgren, 2009[8]) (Almgren, 2013[9]).

An EU study from 2018 explores three methods for assessing the costs and benefits of implementing BAT under the IED in the iron and steel sector. The study suggests, based on one of the methods, that the IED leads to anticipated reductions of 35% in NOx emissions from coke ovens, 71% from hot blast stoves, and 70% reductions in dust emissions from sinter plants, compared to the preceding IPPC Directive (Scarbrough et al., 2018[10]).

Furthermore, the member companies of a European Leather Tanning Association have – by introducing BAT – over ten years reduced their water consumption by about 20% and improved waste recovery to 62%. By introducing chemical products with low VOC content, they also ensured a 40% decrease in VOC emissions, equivalent to 10 000 tonnes a year. The resulting societal benefits amounted to EUR 38 million. Finally, thanks to the introduction of BAT for enhanced energy efficiency, the association secured annual savings of EUR 1.9 million and avoided 11 300 tonnes of CO_2 emissions per year, with an estimated EUR 500 000 per annum in societal benefits (EC, 2018[11]).

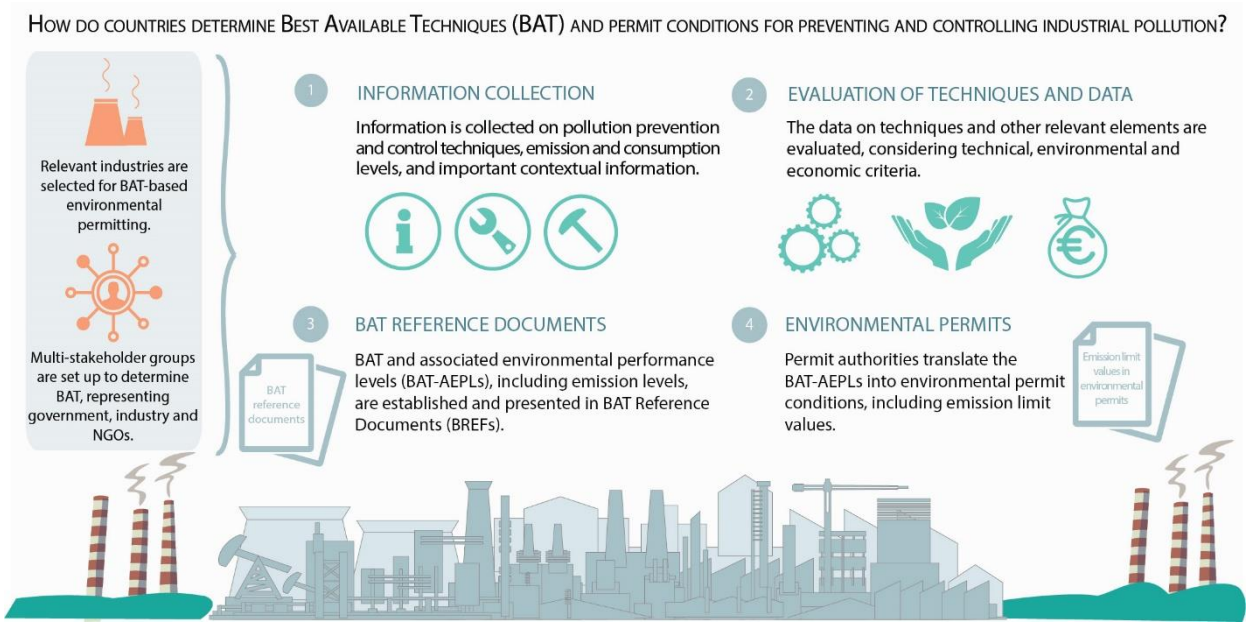
Some studies also show that the implementation of BAT can result in enhanced competitiveness for companies (Hitchens et al., 2001[12]).

Chapter 2. Guidance document on BAT

2.1. Introduction

The process of establishing BAT and BAT-associated environmental performance levels (BAT-AE[P]Ls) as well as BAT-based permit conditions, consists of several consecutive steps. A simplified illustration of these steps is provided in Figure 2.1. The steps are based on best practices from OECD member and partner countries. Each of them are presented in detail in sections 2.2-2.10, together with examples from relevant jurisdictions. Step 1 in the figure is covered by Section 2.6. Step 2 and 3 are covered by Sections 2.6-2.9. Step 4 is covered by Section 2.10.

Figure 2.1. The steps to establishing BAT, BAT-AE(P)Ls and BAT-based permit conditions



Source: OECD

2.1.1. Overview of the key steps

Recommended prerequisites for determining BAT include defining BAT in national legislation (see Section 2.2), selecting the industrial sectors and activities to which BAT-based permitting will apply (see Section 2.3), and setting up a multi-stakeholder Technical Working Group (TWG) for each sector at an early stage (see Section 2.4). One of the first tasks of a TWG is to reach consensus on the environmental scope of the BAT for the concerned industrial activity (see Section 2.5).

Assisted by a technically competent and independent body (i.e. a BAT Bureau), the TWG should identify well-performing plants, collect comprehensive data on their pollution

prevention and control techniques, emission and consumption levels, and other indicators of environmental performance, as well as important contextual information (e.g. specific background of data gathered such as monitoring specifications). The process of collecting and exchanging information in order to establish BAT is described and discussed in Section 2.6. The subsequent section, 2.7, presents the technical, environmental and economic criteria on which the determination of BAT is based. Sections 2.6 and 2.7 are complementary and should be read jointly.

Based on the selection of BAT, the TWG should derive BAT-AELs, and – where appropriate and feasible – other BAT-AEPLs related to e.g. consumption of material, water or energy, the generation of waste, abatement efficiency on pollutants and duration of visible emissions (see Section 2.8). The BAT and BAT-AE(P)Ls should be documented and described in BREFs, or the equivalent, and published once approved by relevant authorities. The BREFs should be reviewed on a regular basis to reflect technological progress (see Section 2.9). National, regional and/or local permitting authorities should use the BAT and BAT-AE(P)Ls as a basis to determine ELVs and other conditions in environmental permits for industrial installations (see Section 2.10).

2.1.2. Key recommendations for countries wishing to establish a BAT-based permitting system

- **BAT-based permitting should build on an integrated pollution prevention and control (IPPC) approach**, i.e. integrating emissions to air, water and soil, as recommended by the OECD Council Act on IPPC from 1991 (OECD, 1991[3]). This ensures that pollutant emissions and other environmental pressures are mitigated rather than shifted between different environmental media. In order for the integrated and holistic approach to be implemented in practice, it needs to be reflected in the individual BAT-AELs.
- **The BAT framework should aim to improve the environmental performance of all industrial installations**, and to introduce increasingly more stringent permit conditions, rather than simply harmonising performance levels across installations. This requires, inter alia, that BAT and BAT-AE(P)Ls be derived from information pertaining to those industrial installations with the best environmental performance, and from multiple countries.
- **BAT-associated emission and environmental performance levels should be technically driven.** That is, they should reflect the environmental performance levels that can be achieved by implementing BAT or a combination of BAT, rather than be based on e.g. politically negotiated levels.
- **The process to determine BAT and BAT-AE(P)Ls should be based on multi-stakeholder dialogue**, and build on principles of open government, including transparency and participation, as outlined in the OECD's Council Recommendation on Regulatory Policy and Governance (OECD, 2012[13]). This helps secure that all relevant interest groups are allowed to participate and get opportunities to voice their opinion. A participatory approach tends to result in better outcomes as it allows building a mutual understanding of relevant environmental challenges and of the means to address those, securing that different interests are understood and reflected in the BAT documents produced.
- **BAT and BAT-AE(P)Ls should be at least as stringent as those standards set out under relevant international conventions**, such as the Stockholm

Convention on Persistent Organic Pollutants, the Convention on Long-Range Transboundary Air Pollution and the Minamata Convention of Mercury. These conventions all provide requirements relating to BAT.

2.1.3. Further elements for consideration by countries wishing to establish a BAT-based permitting system

- **The difference between new and existing industrial installations should be taken into account.** When developing, revising or adapting BREFs, countries may want to distinguish between existing plants – which often have a fixed investment cycle and require adapted pathways reflective of the retrofit aspect – and new plants, or those that have undertaken major upgrades, which can implement modifications more easily.
- **Rather than developing their own BREFs, countries can consider adopting those of other countries or adapting them to their national circumstances**. Producing BREFs can be a very time-consuming and resource-intensive process – ranging from one extremely labour-intensive year in the Russian Federation, to three years in Korea, up to five years in the European Union and sometimes ten years or more in the People's Republic of China (hereafter: China) (see Box 2.4). Therefore, countries wishing to adopt BAT-based permitting do not necessarily have to develop their own BREFs; they could choose to use the BREFs of another jurisdiction as is (for example, Israel uses the EU's BREFs and BAT Conclusions), or to adapt a set of existing BREFs to their national circumstances (for example, in several cases, the Russian Federation used the EU BREFs as a starting point when developing their own). Countries wishing to pursue a BAT-based approach should reflect on the most appropriate approach in their circumstances, and use this guidance document accordingly by referring to those elements that are applicable to their situation. All countries are advised to follow the steps regarding the selection of sectors for application of BAT-based permitting and for determining BAT-based permit conditions. Furthermore, it is recommended to set up of a multi-stakeholder Technical Working Group that can support the possible adaptation of BREFs, and/or the overall implementation of a BAT-based permitting system.
- **The pros and cons of taking a value chain approach should be considered.**[1] BAT are usually established at the level of each industrial sector or activity, with little consideration given to the interactions with the value chain. Thus, BAT are often identified without systematically considering the up- or downstream interactions between sectors, nor the environmental impact of an industrial activity on other parts of the value chain or on the value chain as a whole. That is, each industrial activity is dealt with separately, and only limited consideration is given to the interactions with other industries and actors in the value chain. As a consequence, BREFs may prescribe BAT-AE(P)Ls that optimise environmental performance in one industrial process while at the same time could have negative environmental implications on, influence the costs of, or the need for new techniques in, other parts of the value chain (VITO, 2015[14]). Thus, researchers have called for the necessity to ensure that BAT form a driver, rather than a barrier, to greening of global value chains and sustainable supply chain management (Huybrechts et al., 2018[15]). Introducing a more thorough examination of value chain aspects by Technical Working Groups could be one way of addressing this issue. However, this requires addressing the trade-offs between considering a vast

number of environmental aspects in a BREF, and settling on an adequate amount of time and resources, and level of difficulty, needed to address them. Whether life cycle or value chain aspects are important depends on how significant they are in relation to the other environmental aspects that need to be covered. Furthermore, if a value chain approach is introduced, governments must ensure that the BAT in BREFs remain applicable at the level of each industrial installation.

2.2. Defining BAT

The definition of BAT, along with the approach to identifying BAT-AELs, determines the overall environmental stringency of a BAT-based permitting system. Therefore, each jurisdiction should define BAT in their environmental legislation, drawing on existing language and best practices from OECD member countries (see, for example, the EU's definition of BAT in Box 1.1). The specific regulations and circumstances of each country should be taken into account when defining BAT and thus the operational framework for determining BAT. The legislation in which the BAT system is embedded should convey an ambition to strengthen the environmental performance of *all* industrial installations with increasingly more stringent ELVs, and not simply to harmonise levels of environmental performance across installations.

2.3. Selecting sectors for application of BAT-based permitting

Before BAT can be established, it is necessary to select the industrial sectors and activities to which BAT-based permitting shall apply. Having a defined list of sectors and activities for regulation can make for a more targeted and cost-effective approach to emissions reduction, as it allows focusing on those emission sources that account for the largest share of external damage costs. The selection of sectors and activities should be published in an easily available document and be legally binding. The list of sectors and activities should be reviewed periodically.

A table of sectors and activities covered by selected jurisdictions is presented in 0, and can serve as guidance for other countries. Box 2.1 presents examples of how the European Union, Flanders (Belgium), Korea, the United States and the Russian Federation determine the sectors and activities to which BAT-based permitting shall be applied.

In the process to select sectors, the following indicators should be considered:

- **Observed pollution load and/or consumption quantities of each sector, and their impact on the environment as a whole.** PRTRs or other emissions monitoring databases are essential sources of the most recent information on the emissions and environmental performance of various sectors. In the absence of such databases, pollution and consumption figures need to be based on calculations of assumed performance or on sectors that have been targeted in other countries.
- **The feasibility of implementing new techniques or practices** to reduce emissions and/or to improve resource efficiency within a given manufacturing process.
- **Production capacity**, given that this is reflective of an industry's environmental impact and potential for improvement.
- **Scale, i.e. age and size** of the industry. This may have an impact on national priorities and BAT determination.

- **Existing national or regional priority lists of chemicals and pollutants of concern and associated requirements defined by international conventions,** notably those relating to the Stockholm Convention on Persistent Organic Pollutants, the Convention on Long-Range Transboundary Air Pollution and the Minamata Convention of Mercury. This will help assess which sectors emit those pollutants.
- **Relevant upstream and downstream activities** whose environmental performance would be affected by the principal activity. These upstream and downstream activities should be considered by the TWGs when establishing BAT and BAT-AE(P)Ls. This could facilitate a comprehensive BAT assessment and prevent the transfer of environmental impacts across the different parts of a value chain.

Depending on the approach taken to determine the sectors for BAT-based permitting, this selection process could be considered in parallel with the process to define the environmental scope of the BREF for each sector (see section 2.5).

Box 2.1. Examples of procedures for selection of industrial sectors for application of BAT

a European Union

Annex I of the Industrial Emissions Directive (IED) (EU, 2010[4]) lists the industrial activities to which BAT-based integrated environmental permitting applies. The Annex also provides threshold values, generally referring to production capacities or outputs, above which BAT-based integrated permitting is applicable. The activities and thresholds are dictated by a mix of regulatory legacy, technical analyses and political negotiations. According to Annex I of the IED, more than 50 000 of the largest (agro-) industrial installations across the EU must comply with the BAT-AELs defined in the EU BAT Conclusions (see Box 2.5) developed under the IED. As of December 2019, the EU has issued 31 BREFs and 14 BAT Conclusions. When establishing BAT and BAT-AE(P)Ls for the sectors in Annex I, 'Directly Associated Activities' are also considered.

Annex I of the IED reflects the industrial activities historically deemed to be the most polluting in the EU, some of which could be now obsolete, such as the production of asbestos or asbestos-based products. The industrial activities in the Annex is reviewed periodically, e.g. the 2019 IED evaluation which is part of the Better Regulation agenda.

The BAT concept is also applied to certain industrial activities that fall outside the scope of the IED, such as through the Extractive Waste Directive, the Medium Combustion Plant Directive, the Eco-management and Audit Scheme Regulation (applying to eleven industrial activities), and a stand-alone BREF on the hydrocarbons sector.

b Flanders, Belgium

The selection of industrial sectors for the BAT studies of Flanders is determined by a steering committee of representatives from the Flemish authorities, responsible for environmental and economic affairs. The committee considers the following criteria:

- the size of the average enterprise (preference is often given to sectors with many small and medium-sized enterprises, as sectors with larger enterprises usually already are covered by the EU BREFs);

- the technical and economic difficulties experienced to prevent or to reduce pollution; and
- the urgency of the need for new permit regulations (Dijkmans, 2000[16]).

According to Flemish legislation, Flemish BAT studies[2] can be produced by the Flemish BAT Centre, as a supplement to the EU BREFs, in the following cases:

- if, after a thorough assessment, this is deemed to be necessary for the specific Flemish situation, (i) on account of a Flemish policy priority, (ii) due to exceedances of one or more EU environmental quality standards in Flanders, or (iii) because a sector requests new or updated Flemish sectoral environmental conditions (not stated at the EU level);
- if the establishment(s) classified as causing a nuisance have been identified as the main cause (if not, BAT must first be applied to the more important sources) (Flemish Government, 1995[17]).

Annex I of the Flemish environmental legislation related to companies with permit requirements (VLAREM II[3]) provides a list of the establishments and activities whose operation involves serious risks or nuisance to humans and the environment, and thus have to implement BAT. Flemish BAT studies are developed for all the activities listed in Annex I of VLAREM II, and sometimes also for additional activities that are not yet listed, if they involve serious risks or nuisance to humans and the environment.

c Korea

BAT are established for 19 industrial sectors, as listed in Article 2 of the Act on the Integrated Control of Pollutant-Discharging Facilities (KLRI, 2015[18]). These sectors have been overseen by the Integrated Permit System Division of the Ministry of Environment since 2017. According to Article 2 and Annex I of the Act, approximately 1 300 installations across the 19 sectors will have to obtain integrated permits; these fall into the two first of five defined categories concerning the impact of their emissions on air and water quality.

d United States

US environmental legislation determines sources or sectors to which standards apply based on the media-specific programme; there is no fixed list of sectors across programmes. Each programme selects sectors or activities based on data about the targeted pollutant sources. The selected sectors are reviewed and updated regularly. For example, the Clean Water Act references a list of 129 ‘toxic pollutants’, which EPA used to develop a ‘priority chemicals’ list to facilitate testing and regulation, including determination of sectors for regulation under the Effluent Guidelines (US EPA, n.d.[19]). A biennial review process is used to identify sectors for which new effluent guidelines should be written, taking into account amount and toxicity of pollutants, as well as changes to control or prevention technology (US EPA, n.d.[20]).

The EPA specifies 71 sector-specific and two cross-cutting New Source Performance Standards for air emissions (US EPA, n.d.[21]), 140 sector-specific and one cross-cutting National Emission Standards for Hazardous Air Pollutants (US EPA, n.d.[22]) and 59 sector-specific water effluent guidelines (US EPA, n.d.[23]), in addition to a cross-sectoral waste treatment standard (US Government, 1996[24]). These regulations result in 175 000

US facilities with air permits, 270 000 regulated under the water programme, and 42 000 facilities covered under the hazardous waste regulations (US EPA, n.d.[25]).

e Russian Federation

Industrial installations are categorised into four categories, according to the Decree on Setting Criteria to Categories I, II, III and IV of Installations Causing Negative Environmental Impacts (Government of the Russian Federation, 2015[26]). As of August 2019, over 7 300 installations have been placed in Category I due to their *significant* level of environmental adverse impact, and must thus comply with relevant BAT-AEPLs outlined in the Russian Federation's 39 vertical (i.e. sector-specific) BREFs.

The list of industrial activities covered by the Russian BREFs is similar to that of Annex I in the IED, but reflects the specificities of the Russian economy and covers a few additional activities, such as oil and gas exploration, coal and ore mining, etc. (OECD, 2018[27]).

f China

The selection of sectors for which China develops their Guidelines of Available Technologies for Pollution Prevention and Control (GATPPCs) is embedded in two documents: the Classified Management Catalogue of Stationary Source Pollution Permits (Ministry of Ecology and Environment, 2017[28]) and the Administrative Measures for the Revision of National Environmental Protection Standards (Ministry of Ecology and Environment, 2017[29]). The Classified Management Catalogue is currently divided into 33 industries and 80 sub-sectors. For those with multiple sub-sectors, separate guidelines can be prepared for each of the sub-sectors. The Administrative Measures stipulate that all environmental protection standards should be prepared in accordance with the environmental protection standard revision plan and the associated conditions.

2.4. Setting up a multi-stakeholder Technical Working Group (TWG)

2.4.1. The benefits of a participatory approach

BAT offers a means to regulation of industrial emissions based on a participatory approach that goes beyond the traditional paradigm of *proposed regulation – public comment period – final regulation*. It is recommended to involve a wide range of stakeholders in the process to determine BAT and BAT-AE(P)Ls, and to ensure the balanced representation of different interest groups. This requires securing that all relevant stakeholders get the opportunity to participate and voice their opinion, and that they have the ability and resources to contribute with technical information and engage in discussions about detailed technical aspects of the industry. This enables stakeholders to share information and build a mutual understanding of relevant environmental challenges and of the means to address those. A participatory approach tends to result in better outcomes as it ensures that different interests are understood (e.g. citizens' environmental concerns) and reflected in the BREF produced. Stakeholder engagement is also likely to increase the acceptability of permit conditions across actors involved, including industrial operators.

2.4.2. Underlying principles for setting up a TWG

In determining BAT and BAT-AE(P)Ls, governments should abide by the second principle of the OECD's Council Recommendation on Regulatory Policy and Governance (OECD, 2012[13]). That is, they should adhere to principles of open government, including transparency and participation, in order to ensure that the BAT and BAT-AE(P)Ls serve the public interest and are informed by the legitimate needs of those interested in and affected by them. This involves actively engaging all relevant stakeholders during the process to develop BAT documents such as BREFs and BAT Conclusions, and providing meaningful and effective opportunities, including online, for the public to contribute to the process of preparing draft proposals as well as to maximise the quality of the supporting analysis. Governments should ensure that the BAT documents are comprehensible and clear and that parties can easily understand their opportunities and responsibilities.

In order to abide by these principles, governments should set up sector-specific, multi-stakeholder TWGs for the determination of BAT and BAT-AE(P)Ls. The work of the TWGs should be assisted by a technically competent and independent body, e.g. a BAT Bureau. The TWGs as well as the overseeing body should be run in accordance with the seventh principle of the OECD's Council Recommendation on Regulatory Policy and Governance (OECD, 2012[13]). That is, their role and functions should be based on a consistent policy, in order to provide greater confidence that they make decisions on an objective, impartial and consistent basis, without conflict of interest, bias or improper influence.

2.4.3. Composition and nomination of TWG members

The TWGs should include experts representing ministries (pertaining to human health, environment, industrial and/or economic affairs), industry associations (including technique providers and users), environmental NGOs and the scientific community. The members of TWGs should be selected primarily based on their technical, environmental, economic or regulatory expertise (especially in permitting or inspecting industrial installations) as well as on their ability to bring the BREF end-user perspective and balanced viewpoints into the information exchange procedure. Furthermore, it is important that the TWG members have adequate expertise on data quality and techniques for the relevant industrial sector. There should be a sufficient number of relevant participants in each TWG to ensure the adequate representations of different interest groups.

Box 2.2 presents examples of the composition and nomination of TWG members in the European Union, Flanders (Belgium), Korea, United States, the Russian Federation and China.

Box 2.2. The composition and nomination of TWG members

a European Union

Each TWG consists of technical experts representing the European Commission, the EU Member States, industries concerned and non-governmental organisations promoting environmental protection. In addition to these stakeholders, equipment suppliers that can provide valuable technical and economic data and information for the drawing up and reviewing of BREFs can be invited to actively participate in the exchange of information either directly as TWG members, or indirectly as experts providing information to the European IPPC Bureau (EIPPCB) or to other TWG members. TWG members are

nominated primarily based on their technical, environmental, economic or regulatory expertise (especially in permitting or inspecting industrial installations) as well as on their ability to bring the BREF end-user perspective into the information exchange process. In order to enhance the efficiency of participation of the industrial sectors concerned in TWGs, their nomination may be coordinated by European industrial associations. The TWGs can consist of more than 250 members (Roudier, 2019[30]).

The EU Implementing Decision (EU, 2012[5]), known as the EU BREF Guidance Document (EU, 2012[5]), provides guidance on the process of setting up TWGs.

b Flanders, Belgium

For the elaboration of each BAT sector study, an advisory committee – similar to a TWG in the EU – is set up. The government representatives on the advisory committee are appointed on the basis of a request from the steering committee or from the heads of the administrations and para-regional institutions represented in the steering committee. VITO's BAT Knowledge Centre, which is in charge of developing the BAT studies, also asks relevant business federations and/or companies to send a delegation for the advisory committee. Representatives from other associations and experts can also be invited. The BAT Knowledge Centres carefully considers the comments of this advisory committee. The government representatives on the advisory committee ensure, among other things, that the BAT reports take into account existing regulations and administrative practices. However, the final responsibility for the content of the BAT reports remains with VITO's BAT Knowledge Centre.

c Korea

The Korean TWGs consist of 20-30 members, including representatives of industrial associations, installation operators, process experts and academics. The representatives are nominated by the Minister of Environment, before the Minister of Commerce, Industry and Energy reviews the nominations. The latter Minister usually follows the Minister of Environment's decision. NGOs are not involved in the TWGs, however, they are entitled to participate in the Central Environmental Policy Committee, which reviews and makes the final decision on BREFs (OECD, 2018[27]).

d United States

In the United States, peer review and input on the scientific basis of regulations falls to the Science Advisory Board (SAB), which organises panels to act as TWGs either through standing committees within the board, or on an ad hoc basis. The SAB selects regulations for review based on their complexity, taking into account economic effects, the science underpinning the regulation, and the scope of the environmental issue it seeks to address (US EPA, 2014[31]). Nominations for panel members are solicited from SAB members, consultants, and the public (US EPA, 2019[32]). SAB staff then select panel members who will advise the agency on the regulatory matter at hand. Participants may come from academia, other state and federal agencies, consultant firms, NGOs, and industry. Members of SAB panels are screened for conflicts of interest to ensure that they offer impartial advice (US EPA Science Advisory Board, 2002[33]).

e Russian Federation

Each of the Russian TWGs consists of members representing, inter alia, federal and regional authorities concerned, industries and industrial associations, universities, research

bodies, engineering and consulting companies, and NGOs. Any party can nominate a representative to the TWGs by submitting an application for participation to the Ministry of Industry and Trade, which eventually approves the list of members of each TWG by special order. Generally, a call for applications for TWG membership attract nominations by 20-40 organisations, and the TWGs usually consist of 30-40 members, but in some cases the number of members can reach 100-200. The list of members for each TWG is available on the website of the BAT Bureau[4]. It is rather rare that NGOs nominate representatives to the TWGs; however, they participate in the public discussion concerning draft BREFs and in awareness raising events on BAT (OECD, 2018[27]).

f China

The expert groups involved in reviewing environmental protection standards are set up by the Ministry of Ecology and Environment and consist of at least seven experts in environmental management, industrial industry, pollution control and environmental monitoring.

2.5. Defining the environmental scope for a BAT reference document

Defining the environmental scope implies determining the pollutants and other environmental parameters for which BAT and BAT-AE(P)Ls will be identified. This entails, first of all, deciding whether BAT should be applied to emissions to air, water and/or soil, and to, waste, energy efficiency and/or greenhouse gases. The second step is to determine which pollutants or other parameters that should be covered for each of these categories. *Note:* whereas some jurisdictions define the environmental scope prior to, or in parallel with, the selection of industrial sectors for implementation of BAT (see Section 2.3), this process takes place in the opposite order in other jurisdictions, such as the EU: the sectors are first selected, and the environmental scope for each one of them is later defined by the relevant TWGs.

The environmental scope of each BREF should be determined based on a standardised methodology and a fixed set of criteria, taking into account existing lists of priority pollutants at national and regional level, as well as the pollutants of concern and associated requirements determined by international conventions. The scope should encompass all parameters with a significant impact on the environment. Furthermore, relevant system boundaries should be considered, for example by taking into account whether the principal industrial activity of concern has an impact on the environmental performance of downstream activities, in which case the BREF also should establish BAT-AE(P)Ls designed to prevent the impact downstream.

Narrowing the scope of a BREF comes with important trade-offs, in face of which each jurisdiction must choose an appropriate approach to prioritise their efforts, adapted to their circumstances and based on consensus amongst key stakeholders. While defining a more limited scope reduces the complexity and thus the time and resources needed to develop a BREF, reaching consensus across stakeholders on such a scope can be a time-consuming and challenging process, possibly delaying the first steps of the drawing up or review of a BREF. Furthermore, defining a narrow scope usually implies that data only will be collected, and that monitoring only will be required, for a limited set of parameters, which might make it difficult to identify important environmental issues that lie beyond the scope further down the line. It may also limit the impact of a BREF on the reduction of emissions. On the other hand, a narrower scope allows prioritising resources towards the most pressing

environmental concerns, enabling a more cost-effective approach to pollution prevention and control. Another challenge pertains to whether the environmental scope should be limited to a set of specific pollutants, or rather focused on which techniques that can optimise the reduction of the overall environmental impact of an industry.

Box 2.3 presents examples of how the environmental scope of BREFs is established in the EU and in the Russian Federation.

Box 2.3. Examples of how countries and regions define the environmental scope of BREFS

a European Union

The scope of the environmental issues to be addressed in the development or review of a BREF stems from the legislative framework of the IED, notably Article 13 and Annex III. Recently, the European Commission has proposed a new approach to focus the information exchange in the TWGs, with an attempt to speed up the review process and focus the resources spent. In line with this new approach, each TWG should identify the Key Environmental Issues (KEI) for the concerned industrial sector. According to the European Commission, KEI are issues for which BAT Conclusions have the highest likelihood of resulting in noteworthy additional environmental benefits (EC, 2015[34]). The criteria below were proposed for defining KEI by the European Commission in 2015, and have been used in recent BREF reviews, although they are not officially endorsed by the IED Forum.

- Define KEI at the earliest possible stage of the information exchange, using the following criteria:
  - environmental relevance of pollution caused by the activity or process, i.e. whether it may cause an environmental problem;
  - significance of activity (number of installations, geographical spread, contribution to total [industrial] emissions in the EU);
  - potential of the BREF review to identify new or additional techniques that would further significantly reduce pollution; and
  - potential of the BREF review to establish BAT-AELs that would significantly improve the level of environmental protection from current emission levels.
- In order to apply the identified criteria, information on the following elements is needed before the review takes place:
  - the emissions of the activities concerned and their broader environmental relevance;
  - the general environmental performance of the techniques applied within the sector; and
  - the recent evolution of the techniques applied in the sector and their environmental performance (EC, 2015[34]).

There is currently no consensus on the KEI-based approach amongst EU stakeholders. Some highlight the need to elaborate and agree on a standard methodology to determining KEI, as has been attempted in a study[5] by the European Union (OECD, 2019[7]). Further, environmental NGOs argue that the KEI approach arbitrarily restricts the scope of BREFs,

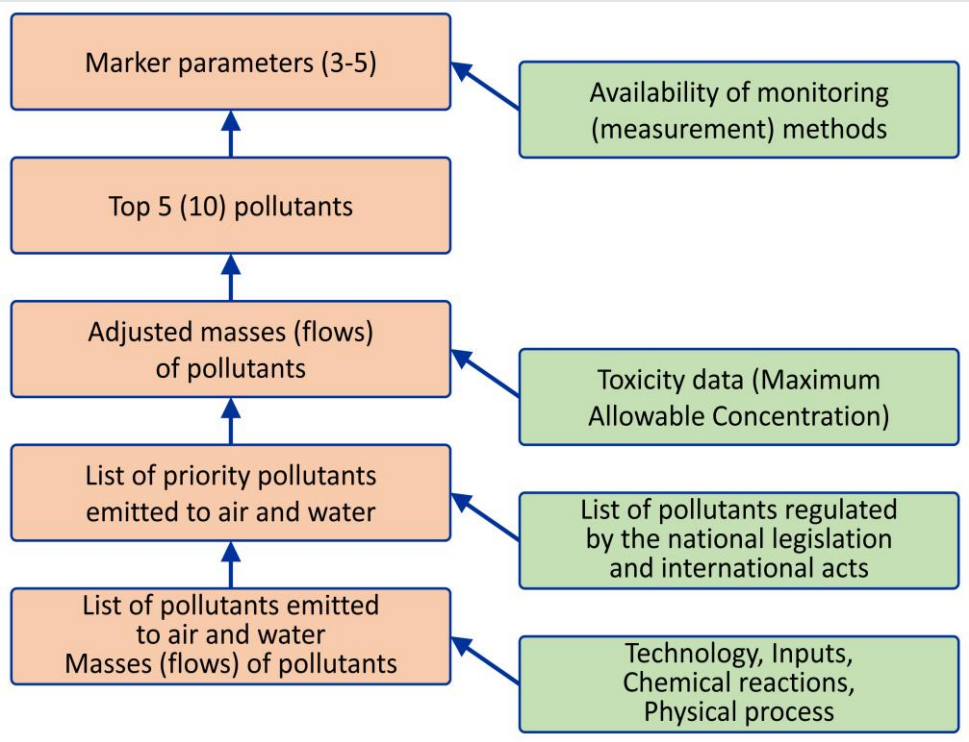
and reduces the practical impact of a BREF in terms of pollutants covered and environmental issues addressed, as well as delays the process to develop and review BREFs.

b Russian Federation

The environmental scope of the Russian BREFs is primarily determined by a set of marker substances or parameters for which BAT-AELs are established, and which industrial installations are obliged to monitor. The choice of marker parameters (by nature similar to key environmental issues) is guided by expert judgement and based on the criteria listed below. The selection procedure is illustrated by Figure 2.2.

- The significance of the parameter for the technological processes applied in the relevant industrial installations, and whether the parameter reflects the peculiarities of those processes;
- the level of emissions of the pollutant, assessed in mass flows or in 'adjusted mass' flows (considering both quantity and toxicity, according to environmental quality standards); and
- the parameters' measurability, i.e. opportunities for environmental self-monitoring in industrial installations and for providing reliable, high-quality data (Skobelev, 2018[35]).

Figure 2.2. Procedure for determining the environmental scope of Russian BREFs, i.e. the parameters for which BAT-AELs are established



Source: (Skobelev, 2018[35])

2.6. The *process* to establishing BAT: collecting and exchanging information for the determination of BAT

2.6.1. Identifying well-performing plants for data collection

In order to determine BAT and BAT-AEPLs, emission and consumption data along with the necessary contextual information should be collected from a set of real plants in operation worldwide with optimal environmental performance, i.e. considered representative for the sector at stake that, under normal operating conditions, display good environmental performance in one or more environmental aspects (e.g. low pollutant emissions, low usage or high recovery/recycling of energy/water/material), including best-performers.

It is recommended that TWG members start the process of selecting plants for the data collection as early as possible with the aim of having a draft list available in time for their first meeting. Further, it is recommended that each TWG member's organisation be invited to propose a list of well-performing plants (including best performers) for the data collection via questionnaires. Well-performing plants refer to plants that are considered to reflect good environmental performances in one or more environmental aspects, e.g. low pollutant emissions, low usage or high recovery/recycling of energy/water/material.

Criteria for selecting plants for the plant-specific data collection could include:

- environmental performance;
- the use of candidate BAT;
- production capacity – both small and large;
- age – both newer and older;
- processes – single and multi-product, continuous and batch;
- plant categories – representative of all plant categories once decided upon;
- geographical distribution – representative for all regions that have plants in a given subsector, especially when climatic conditions are relevant; and
- products/processes that might require a dedicated approach.

2.6.2. Collecting data

Once the plants for the data collection have been identified, the TWG should – assisted by a technically competent and independent body (i.e. a BAT Bureau) – collect comprehensive information on their manufacturing techniques, pollution prevention and control techniques, emission and consumption levels, other indicators of environmental performance as well as important contextual information. PRTRs and emission monitoring databases can greatly facilitate the collection of emissions data and sometimes associated information, as described in *Measuring the Effectiveness of BAT Policies* (OECD, 2019[7]).

The data should be collected, inter alia, through a survey drafted by the BAT Bureau. Recommended key elements for such surveys are included in Annex B. Provided that a broad enough range of industrial installations participate in the evidence gathering and submission, the process to determine BAT and derive associated environmental performance levels will be rooted in evidence as well as expert judgement.

In addition to collecting data at the national level, TWGs should consider data from multiple countries, including by consulting the BREFs (or the equivalent) of other jurisdictions or pertaining to international conventions, in order to allow setting BAT and BAT-AE(P)Ls that are based on international best practices and existing research, whilst

taking into account national circumstances and specificities. This helps support the harmonisation of environmental performance requirements across countries or regions, and thus BAT-based permitting can create a level playing field for industry, provided consistent application in their own and other jurisdictions. In line with Principle 12 of the OECD Council Recommendation on Regulatory Policy and Governance (OECD, 2012[13]), consideration should be given to all relevant international standards and frameworks for co-operation in the same field and, where appropriate, their likely effects on parties outside the jurisdiction.

It might be challenging to obtain disaggregated emissions data from the regulated community, e.g. due to industry operators' reluctance to sharing such information and/or intellectual property rights. This could be addressed through legal obligations or international initiatives to monitor certain pollutants, and/or by estimating emission levels through comparison with data from other countries.

Further, the gathering of information on techniques can be facilitated by adapted tools such as dynamic online environments that enable the sharing of technological advances. An example is the US' RACT/BACT/LAER Clearinghouse (US EPA, 2018[36]) (see Box 2.4). To encourage sharing of data at the international level, parties involved in determining BAT could consider promoting conditions that facilitate the exchange of relevant information in a centralised, user friendly and publicly available online portal, allowing stakeholders acting at national or regional levels to get easy access to BREFs from several jurisdictions, along with information on the benefits of costs of different BAT and on the environmental performance of installations that have installed those techniques. Such a portal would facilitate and support the information collection and exchange in each jurisdiction, including by saving TWGs a lot of time, and could enhance transparency and opportunities for benchmarking. To ease the set-up of such a portal, it could initially cover just one or a few selected sectors, and focus on a selected set of techniques. The quality of the information would have to be controlled in a suitable manner.

2.6.3. Validating and evaluating the data

The data provided during the data collection have to be validated by competent authorities. These authorities should prepare to address possible challenges related to securing the quality of collected data, especially for data concerning water and energy consumption, as these often are confidential.

The information collection and analysis should be followed by discussions in the TWG and the elaboration of drafts prepared in collaboration with the BAT Bureau. The information exchange should involve a thorough assessment of technical, environmental and economic criteria, allowing to determine BAT and BAT-AE(P)Ls (as described in Sections 2.7and 2.8). The TWG's final draft could be considered and approved by a separate decision-making body, provided the main criteria of decision making are human health and environmental protection, performance outcome oriented and based on an integrated approach.

1.2.1. Transparency and involvement of the public

The BAT Bureau should ensure the greatest possible extent of transparency of information, while protecting sensitive data such as confidential business information. The level of sensitivity might be higher related to consumption data, e.g. on energy and materials use, than in relation to emissions data. Another challenge related to consumption data can be the comparability across plants. Adequate measures should be taken to address these issues,

such as clearly defining the types of information considered confidential, the procedures used to determine whether confidential treatment should be granted, and the methods used to protect confidential information.

The information collection and exchange should be carried out according to the principles of open government, i.e. by actively engaging all relevant stakeholders, and providing meaningful and effective opportunities, including online, for the public to contribute to the process of preparing draft proposals as well as to maximise the quality of the supporting analysis (OECD, 2012[13]). Therefore, governments are encouraged to allow members of the public observe the TWG meetings, or provide input at the BREF drafting stage e.g. through BREF mirror groups. Furthermore, governments should conduct public consultations on the draft BREFs well before a decision on the issue is taken. In summary, TWGs are advised to use a multi-step model for determining BAT in order to allow for participation by a broad number of stakeholders while securing a sufficient level of expertise. Ideally, a first draft of a BREF should be developed by professionals with relevant engineering expertise, followed by review and approval by relevant stakeholders such as ministries, industries and NGO, and subsequently a public consultation period. The final BREFs should be made publicly available.

Box 2.4 presents examples of how the information exchange for, and the drafting of, BREFs are organised in the European Union, Flanders (Belgium), Korea, United States, the Russian Federation and China.

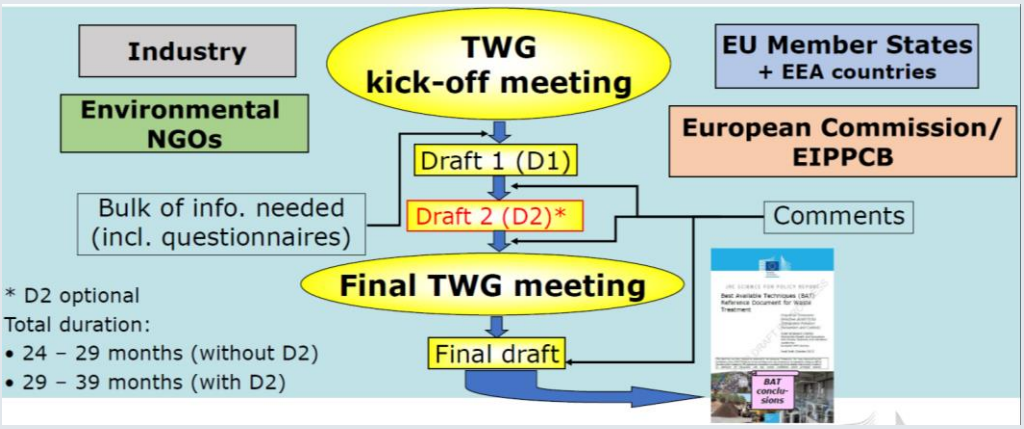
Box 2.4. Examples of procedures for information collection and exchange for the development of BREFs

a European Union

The EU BREF Guidance Document describes the process to develop BREFs, notably the steps to collect and exchange information. This process is known as the *Seville Process* (Figure 2.3). The European IPPC Bureau (EIPPCB) oversees the information exchange, and sets up or reactivates a TWG for the drawing up or review of every new BREF. When doing so, EIPPCB asks the TWG members to express their 'wishes', as an initial position based on a first proposal of the Bureau (i.e. a background paper, which is updated prior to the group's kick-off meeting), which will be used to organise and structure the discussions at the kick-off meeting. The initial positions address major issues such as the scope and structure of the BREF, the Key Environmental Issues (i.e. priority pollutants for consideration), data collection (objective of the questionnaire, parameters, units, time period, selection of plants), candidate BAT and related BAT-AELs/ BAT-AEPLs as well as emerging techniques.

Subsequently, the TWG members agree on the scope of the BREF, the Key Environmental Issues and the main principles for a questionnaire for information collection from existing installations. The EIPPCB develops and tests the questionnaire with stakeholders, before sending it to installations selected by the TWG members and approved by the relevant Member States. Depending on the sector at stake, the EIPPCB generally receives several hundreds of filled-in questionnaires. The EIPPCB processes the information received in close collaboration with the TWG, through a number of data assessment workshops, based on which it develops the first draft of the BREF. All the members of a TWG are given the opportunity to comment on the draft. The EIPPCB can receive several thousand comments concerning a single BREF (Roudier, 2019[30]).

Figure 2.3. The Seville Process



Source: (Roudier, 2019[30])

On the basis of the comments submitted by TWG members, the EIPPCB updates the draft BREF. Subsequently, the TWG meets for a final meeting, aimed at developing the BAT Conclusions (see Box 2.5) based on consensual decision-making. Members that disagree with the consensus can express a 'split-view', which can be noted in the concluding remarks in the BREF if it meets a number of conditions set out in the BREF Guidance (Evrard, 2016[37]).

Box 2.5. What are EU BAT Conclusions?

BAT Conclusions lay down the main findings of an EU BREF and includes the scope and definition of each BAT and their applicability, the BAT-AELs and BAT-AEPLs and associated monitoring requirements. They can also include information on consumption levels and, where appropriate, relevant site remediation measures (EU, 2010[4]). The BAT Conclusions constitute the references for setting permit conditions, and are published in the Official Journal of the European Union as standalone Commission Implementing Decisions and translated into all official EU languages. (OECD, 2018[27]).

The EIPPCB develops a final draft of the BREF based on the outcome of the final TWG meeting, which subsequently is reviewed by the IED's Article 13 Forum and approved by the IED's Article 75 Committee (OECD, 2018[27]). The entire process to develop a BREF can take up to five years (Roudier, 2019[30]).

The exchange of information for the drawing up or review of a BREF is facilitated by the web-based software BATIS. This is particularly useful considering that most of the work of TWG members takes place outside of the plenary meetings. In addition to EIPPCB staff, only nominated Forum and TWG members have access to BATIS (EU, 2012[5]). The official drafts of the BREFs are made available to the public on https://eippcb.jrc.ec.europa.eu/reference/.

Good examples of platforms for data sharing that facilitates BREF development in EU Member States are developed by, inter alia, Norway[6] and Italy[7].

b Flanders, Belgium

VITO's BAT Knowledge Centre develops the Flemish BAT reports according to a fixed template. The reports can be based on previously conducted studies and on information exchanged by the advisory committee (which is similar to the TWGs in other jurisdictions). Confidential information is not included in the BAT reports, but may be processed by the advisory committee.

The BAT Knowledge Centre submits at least one draft version of the BAT report (including BAT conclusions) to the advisory committee for review. The members of the committee provides comments on behalf of their organisations. To the extent possible, the BAT Knowledge Centre takes into account the comments received and, if necessary, prepares an improved draft. Once the BAT Knowledge Centre is of the opinion that the draft study is sufficiently advanced, they place the draft on the EMIS website[8] for public consultation. Ultimately, the Knowledge Centre prepares a final draft. The draft does not represent a compromise, but rather what the Centre believes to be the state of the art and the associated most appropriate recommendations.

The final draft BAT report is submitted to the members of the advisory committee. The members of the steering committee are also informed about the final version. The members of the two committees can provide comments and must submit a final assessment in line with one of the following three options: (i) I approve; (ii) I disapprove, but see no need to discuss further; and (iii) I disapprove and ask for additional consultation of the advisory committee. The third option is only provided for if a particular point of discussion was raised in the previous draft(s) without being adequately addressed at the discretion of a member of the advisory committee, or if additional information can be made available. If all members of the committees opt for Option (i) or (ii), their comments or deviating positions are included in an appendix to the BAT study, along with responses by the BAT Knowledge Centre. If one or more members choose Option (iii), the Knowledge Centre organises an additional consultation of the advisory committee, based on which the draft is adapted as appropriate, before the members of the two committees are asked to provide their reaction once again. The final BAT report is published via EMIS. An English summary of all the BAT reports are also made available via https://emis.vito.be/en/bat-studies.

c Korea

Facility-specific information for the development of BREFs is gathered through a questionnaire distributed online to all industrial operators regulated by the IPPC Act (KLRI, 2015[18]), as well as to the TWG members. The TWG members also provide and share information during their meetings and via an online platform. Each TWG has at least fifteen meetings in three years. Furthermore, up to a million data points from emission self-monitoring systems are collected from industry operators by the National Institute of Environmental Research every year, informing the evaluation of techniques. Each TWG is in charge of preparing the final decision on the evaluation of techniques for their specific sector, which subsequently is reviewed by the Central Environmental Policy Committee's sub-committee on environmental economy (OECD, 2018[27]).

d United States

In developing BAT policy, the US EPA may develop an Information Collection Request, and if approved, the request may allow EPA to administer a mandatory survey to collect information directly from facilities in the sector. Information collected could include the processes, control technologies, products and chemicals used, emissions, and locational data. The information collected that is not Confidential Business Information is publicly available on EPA's website, which allows for review and commentary from a variety of stakeholders.

EPA also consults numerous other resources for information gathering. Agency databases are a common source of information, including the Discharge Monitoring Report Database and the Toxics Release Inventory, which contain facility-level information about pollutant releases (US EPA, n.d.[38]) (US EPA, n.d.[39]). The RACT/BACT/LAER Clearinghouse contains information from air permits, including control and prevention techniques (US EPA, n.d.[40]).

To illustrate, during biennial review, EPA determines any appropriate revisions or new effluent limitation guidelines and standards (US GAO, 2012[41]). Using a two-step review process, the EPA gathers data from the Discharge Monitoring Report Database, the Toxic Release Inventory and available literature to perform screening-level reviews of waste water discharges across industries considering environmental risk, technology availability, economic achievability, and regulatory efficiency. The review allows the EPA to prioritise industries for possible revision or development of effluent limitation guidelines and standards. The EPA may choose to further review a specific industry by collecting primary data through a mandatory survey using authority derived from Clean Water Act section 308 (US EPA, 2018[42]). This information may be supplemented at various stages by consulting with industry expert and trade organisations, conducting site visits, collecting sampling data, and continuing to further review available data (US EPA Office of Water, 2016[43]). The EPA publishes a proposed plan followed by a final plan, establishing a schedule for annual review and revision, pursuant to the Clean Water Act section 304(m). The proposed plan is open for a formal comment period where stakeholders may provide input on data sources, methods, and the Agency's direction.

As an example, EPA proposed revisions in 2013 to the 1982 Effluent Guidelines for coal-fired power plants to strengthen the controls on discharges; EPA finalized the regulation in 2015 (US EPA, n.d.[44]). During review in 2005, EPA found that coal-fired power plants alone contribute 50-60 percent of all toxic pollutants discharged to surface waters by all industrial categories currently regulated in the US Furthermore, power plant discharges to surface waters were expected to increase as pollutants are increasingly captured by air pollution controls and transferred to waste water discharges. EPA completed a detailed study of the industry in 2009 identifying several waste water treatment technologies available to treat or eliminate waste water discharges from the category. The results of the study formed the basis of the proposed revisions, which were projected to reduce the amount of toxic metals, nutrients, and other pollutants that steam electric power plants are allowed to discharge by 1.4 billion pounds and reduce water withdrawal by 57 billion gallons on an annual basis. Note that EPA proposed an update to this rule in 2019 (US EPA, n.d.[45]).

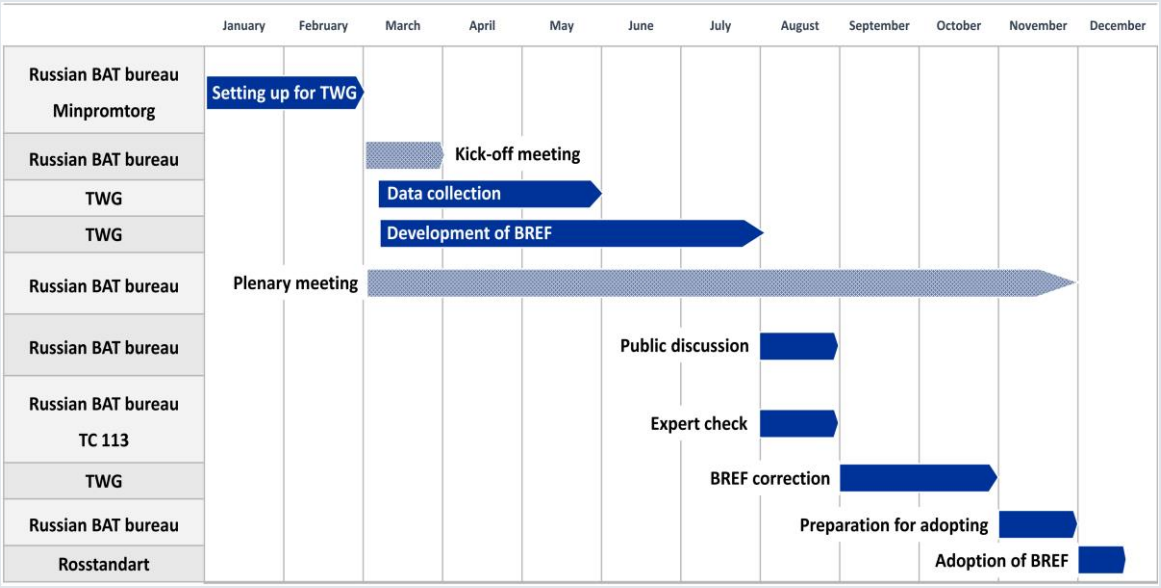
e Russian Federation

The Russian BAT Bureau is responsible for the information exchange and gathering of data needed to develop BREFs. A TWG is appointed for each industrial sector, mandated to manage the process. The Ministry of Industry and Trade fixes the date of the kick-off meeting of each TWG. Ideally, each TWG meets two to three times: (i) at the kick-off meeting; (ii) at a working meeting, which is organised once consumption and emission levels characteristics for the concerned sector have been assessed and primary and secondary environmental performance enhancement techniques have been described; and (iii) at a final meeting. The majority of the work for TWG members takes place outside of the plenary meetings (Skobelev, 2018[35]). The entire process to develop and adopt a BREF in the Russian Federation takes about a year and is illustrated by Figure 2.4.

The TWGs collect data for the drawing up of BREFs through sector-specific questionnaires to gather essential technical, environmental and economic information. The TWGs use a general questionnaire as a starting point, which they tailor to each sector. The BAT Bureau is responsible for the practical organisation and dissemination of the questionnaires (OECD, 2018[27]).

Taking into consideration the questionnaire responses received, the TWGs develop the draft BREFs chapter by chapter. Once all the members of a TWG have agreed on each chapter, the draft BREF is made available for a 30 days' public consultation. The BAT Bureau typically receives 50-60 comments on each BREF, to which the TWG provides public feedback. The TWG prepares the final draft BREF based on the comments received. In cases where it is difficult to reach consensus, the final decision on the BAT and BAT-AE(P)Ls is made by the Inter-Departmental Council on BAT. Once the final draft is ready, it is submitted to the Technical Committee 113, which runs a quality check of the document to assess its compliance with the requirements concerning the content and structure of BREFs. The BAT Bureau finalises the BREF based on the comments from the Technical Committee and submits it to the national standardisation body. The Federal Agency for Technical Regulating and Metrology ('Rosstandart') issues the official order approving the BREF. Adopted BREFs are published as official standardisation documents on the websites of the BAT Bureau and Rosstandart (Skobelev, 2018[35]).

Figure 2.4. The steps of drawing up and adopting BREFs in the Russian Federation



Source: (Skobelev, 2018[35])

f China

The process of establishing the Chinese Guidelines of Available Technologies for Pollution Prevention and Control (GATPPCs) is overseen by the Ministry of Ecology and the Environment or, in a few cases, other relevant ministries. The GATPPCs were previously determined on a case-by-case basis; however, the Ministry has recently issued a Development Guideline for GATPPCs (MEE, 2018[46]), which prescribes three steps for determination of GATPPCs (see Figure 2.5). The development of GATPPCs is usually the responsibility of a project undertaker – also referred to as a sector-specific GATPPC Development Group – such as a research institute, industry association, large enterprise or other units familiar with the technical elements of a given industry. The project undertaker is the responsible entity for project application and implementation, and shall have a research and management background as well as technical capabilities related to the project, and also be familiar with national environmental protection policies, laws, regulations and standards.

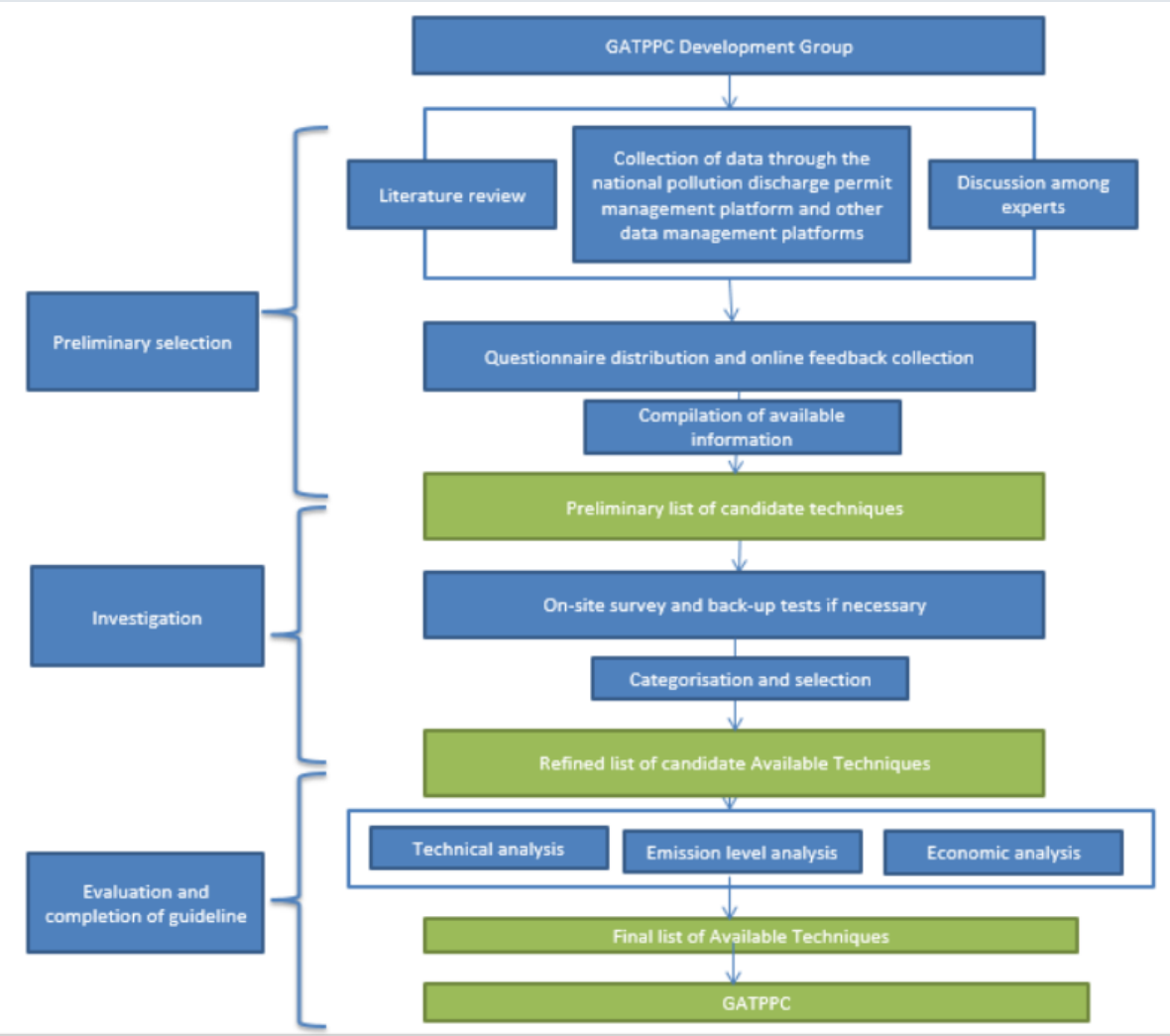
The project undertaker first conducts a preliminary data collection based on literature review, discussion amongst experts and information from national data management platforms, including a pollution discharge permit platform. Subsequently, the group distributes a questionnaire to industry operators in order to map widely used techniques. The information collected during the first phase is compiled and presented as a preliminary list of candidate techniques.

In a second phase, further investigations of the candidate techniques is carried out as necessary, based on on-site investigations and back-up tests aimed at obtaining quantitative information on the techniques. For each candidate technique, at least three cases, i.e. examples of industrial facilities that have implemented the techniques considered to have met environmental standards should be selected, based on information from pollution discharge permits, data from environmental protection monitoring of construction projects, online monitoring data, etc. Each case should be assessed based on

thorough information acquired through a comprehensive technical investigation. The second phase results in a refined list of candidate techniques.

The third phase consists of an evaluation of the candidate techniques, aimed at assessing their technical, environmental, economic and management-related aspects, taking into account qualitative factors, e.g. through peer review, and quantitative factors, preferably by using the Analytic Hierarch Process to weigh indicators. The outcome of the third phase is a final list of Available Techniques and subsequently a GATPPC (OECD, 2018[27]).

Figure 2.5. Information exchange for the development of the Chinese GATPPCs



Source: (OECD, 2018[27])

As part of the process to determine national environmental standards, the Ministry seeks the opinions of the public and relevant units (such as relevant departments of the national ministries, industry associations, enterprises and other stakeholders) as part of a consultation stage. The time for soliciting opinions is one to two months. Major standards can be consulted multiple times, and hearings or symposia can be held if necessary. If a

standard has not been released 18 months after the end of the consultation, it is necessary to re-seek comments.

An example of a good information sharing tool facilitating determination of BAT has been developed by the Chinese Institute of Public & Environmental Affairs: the "Blue Sky" map, which displays real time maps at facility level pertaining to water quality, waste water, air emissions and air quality[9]. The display of real-time emissions also includes the ELVs set in permits.

2.7. The criteria for determining BAT

2.7.1. General principles for determination of BAT

- The determination of BAT should be **based on a comprehensive information exchange process and decisions taken based on consensus** in the TWG (see Section 2.6), based upon an agreed definition of BAT. The definition of BAT combined with the approach to identifying BAT-AELs determines the overall environmental stringency of the approach.
- In order to ensure a reduction in emissions, BAT should **solely be based on those techniques used by a selected set of well-performing plants** (see Section 2.6.1), and not the whole operating range of current performance of all installations. This will allow generalising the performance of the well-performing plants and secure an improvement overall. The choice of techniques should not be limited to e.g. installations in a specific country.
- The determination of BAT should **consider all emission prevention and control techniques that are available for purchase on the global market**, and not only those that are produced or sold domestically, provided that they are not covered by a restricted patent. This allows setting BAT-AE(P)Ls that are harmonised across countries or regions and internationally competitive, and to ensure a global level playing field for industry, provided consistent application. Similarly, when considering the level of economic availability of a technique according to the economic situation of the implementing country, it is important not to compromise the global level playing field.
- BAT should not only concern the prevention and control of emissions of pollutants, but also **address the environmental impact of industrial activities more broadly**, such as through adjusted resource use, waste prevention, toxic substances substitution and improved manufacturing processes, while minimising impacts that could hamper normal operations.
- BAT should **not only encompass production and abatement technologies, but techniques more widely**; that is, both the technology used and the way in which an installation is designed, built, maintained, operated and decommissioned. This enables improved environmental management of industrial operations as a whole.
- When determining BAT, TWGs should – based on the collected information – **first and foremost identify preventive (e.g. green chemistry practices) and process-integrated measures** and – as a second best option – end-of-pipe techniques. Generally, process-integrated techniques are resource-efficient, and therefore cost efficient and often a first choice of operators. End-of-pipe techniques are usually

more expensive and generally entail cross-media effects and, unlike preventative techniques, are fundamentally limited in that they do not obviate formation of pollution.

2.7.2. Key criteria for determination of BAT

- The determination of BAT should be **based on a set of universal criteria, encompassing technical, environmental and economic aspects**. It is essential that all three aspects be considered. The following criteria, taken from Annex III in the IED, are recommended:
    - the use of low-waste technology;
    - the use of less hazardous substances;
    - the furthering of recovery and recycling of substances generated and used in the process and of waste, where appropriate;
    - comparable processes, facilities or methods of operation which have been tried with success on an industrial scale;
    - technological advances and changes in scientific knowledge and understanding;
    - the nature, effects and volume of the emissions concerned;
    - the commissioning dates for new or existing installations;
    - the length of time needed to introduce the best available technique;
    - the consumption and nature of raw materials (including water) used in the process and energy efficiency;
    - the need to prevent or reduce to a minimum the overall impact of the emissions on the environment and the risks to it;
    - the need to prevent accidents and to minimise the consequences for the environment; and
    - information published by public international organisations (EU, 2010[4]).
- In addition, **cross-media and cross-pollutant effects should be considered** when determining BAT. Furthermore, **minimum environmental quality standards**, e.g. as defined in international conventions or water quality standards that are similar across countries, should be considered when setting BAT-AELs. Countries should facilitate the exchange of information on such standards across countries.
- When evaluating candidate techniques, the TWGs should **use a standardised methodology for the assessment of economic aspects** of techniques, including affordability, e.g. through a cost-benefit analysis (CBA), or – where this is not possible – a less resource-intensive procedure. A candidate BAT can be considered economically viable if
    - it is affordable for an average well managed enterprise of the sector, i.e. it has been widely implemented in the relevant industrial sector without government subsidies or other financial support mechanisms, accounting for total financial costs and environmental benefits, and it is reasonably accessible to operators, e.g. not covered by a restrictive patent; and

- the cost/environmental benefit ratio is not unreasonable (Dijkmans, 2000[16]) (OECD, 2018[27]).

- Cost effectiveness could be assessed in one of the following ways:
  - the assessment of cost-effectiveness based on existing investments;
  - drawing up a cost-effectiveness curve for the technology and assessing where the specific application of the technology is located on the curve; and
  - the assessment of cost-effectiveness based on shadow prices.
- For CBA of techniques related to air pollutants, countries could consider adopting the OECD Recommendations on Mortality Risk Valuation in Environment, Health and Transport Policies (OECD, 2012[47]) to use the Value of Statistical Life approach, e.g. based on the methods described by US EPA (US EPA, n.d.[48]).

Box 2.6 consists of example approaches to determining BAT, with an emphasis on lists of defined criteria, in the European Union, the Russian Federation, Korea and Flanders (Belgium) as well as under the Minamata Convention and the Gothenburg Protocol.

Box 2.6. Examples of approaches to determining BAT

a European Union

In the EU, the processes to determine BAT and BAT-AE(P)Ls are interwoven, and are based on expert judgement, taking into account the information exchanged by the TWG, in particular the plant-specific information collected through questionnaires.

The TWG explores the most relevant techniques and identifies the best environmental performance levels, on the basis of available data from existing installations in the EU and worldwide. Subsequently, they investigate the conditions under which these environmental performance levels were achieved, such as costs, cross-media effects, and the main driving forces involved in the implementation of the techniques. Furthermore, they select the BAT, their associated emission levels (and other environmental performance levels) and the associated monitoring for the sector, according to the IED's definition of *Best*, *Available* and *Techniques* (see Box 1.1) and taking into account the criteria listed in Annex III of the IED (EU, 2010[4]) (as outlined above).

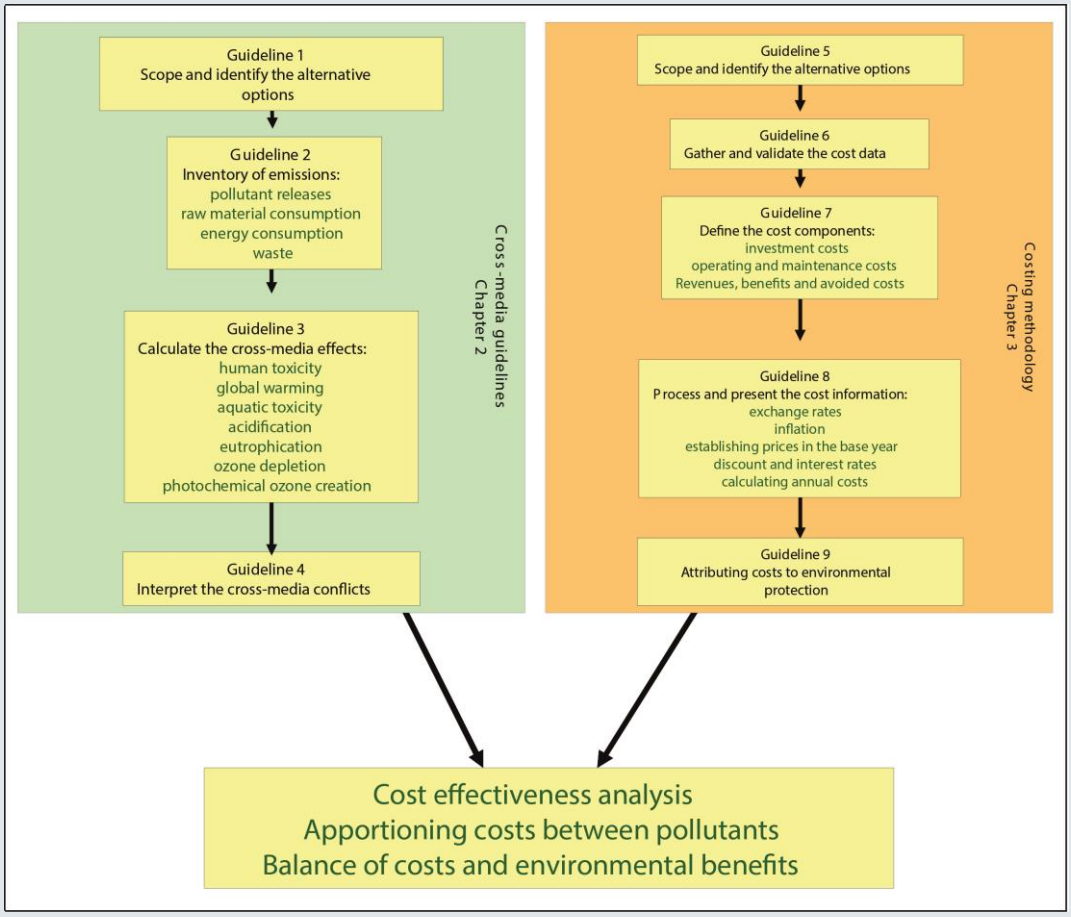
When assessing the technical aspects of candidate BAT, the TWGs take into account their safety and technological readiness level, the quality of the production process or products as well as the applicability, i.e. whether the technique is generally useable or only adapted to specific plants or subsectors. The TWGs also note whether a technique is applicable in new versus existing plants, taking into account factors involved in retrofitting (e.g. space availability) and interactions with techniques already installed for example. Other important factors are the size, capacity or load from the production lines in relation to the technique, in addition to the type of fuel or raw materials used in the production process. The TWGs

primarily seek to identify preventive and process-integrated measures and, as a second best option, end-of-pipe techniques (EU, 2012[5]). If deemed appropriate, the TWGs can choose to define a hierarchy of BAT, and to identify non-BAT.

To assess the economic viability of a technique, the TWGs consider whether the technique has been widely implemented in the relevant industrial sector, without government subsidies or other financial support mechanisms, accounting for total financial costs and environmental benefits. Candidate BAT do not have to be used or produced in an EU Member State, provided that there is available data that can be verified by the national competent authorities, but they should be reasonably accessible to operators, e.g. not covered by a restrictive patent. In the absence of data concerning costs, the TWG draw conclusions on the economic viability of techniques are based on empirical information from existing installations. Cost-effectiveness and affordability are not separate criteria for BAT selection, but are normally considered as part of the assessment of economic viability. Where available, the EU BREFs present economic data together with the descriptions of techniques, in order to give a rough indication of the magnitude of relevant costs and benefits, although the actual costs and benefits of applying a technique may depend strongly on the specific situation of the installation concerned, and thus cannot be evaluated fully in the BREFs (OECD, 2018[27]).

The assessment of environmental and economic aspects of candidate BAT is based on the TWGs' expert judgement, in combination with the methods described in the cross-sectorial Reference Document on Economics and Cross-Media Effects (EC, 2006[49]) when deemed necessary. According to the steps described in the reference document (see Figure 2.6), once the techniques have been ranked according to environmental performance, the one resulting in the lowest impact on the environment as a whole will usually be BAT, unless the technical and/or economic considerations mean that it is not available.

Figure 2.6. Method for evaluation of environmental and economic criteria in determining BAT as described in the EU's Economic and Cross-Media Reference Document



Source: (EC, 2006[49])

When assessing candidate BAT, the TWGs also seek to give priority to prevention techniques over control techniques. However, according to some stakeholders, this hierarchy is not always respected in practice.

b Korea

The TWGs evaluate the collected information and carry out a preselection of candidate BAT determination, in collaboration with the Ministry of Environment. The evaluation of shortlisted techniques involves (i) an investigation based on information provided by industry operators and experts in the TWGs; (ii) basic data analysis as well as close investigation and analysis of the emission status of pollutants relevant to each of the techniques; and (iii) a detailed analysis of monitoring data (OECD, 2018[27]). The evaluation of techniques is carried out by the TWGs, based on technical, environmental and economic aspects, as well as applicability, with a strong focus on environmental quality, i.e. the environmental impact of the various techniques in the area surrounding industrial installations. A

standardised methodology for the assessment of economic criteria is in development; currently this is done on a case-by-case basis.

c United States

The US EPA is responsible for setting minimum and standard requirements of industrial sources and categories that are regulated for example under the Clean Air Act, Clean Water Act or the Resource Conservation and Recovery Act. These national standards are legally binding and generally describe the "floor" (baseline), i.e. the minimum requirements for industry operators. The limits are usually set as a performance level based on the technology or practice (i.e. BAT) in use by the better-controlled and lower emitting sources in an industry. An air related example describing how BAT are determined in the US is provided in Box 2.7 and the regulatory process is described in Box 2.8.

d Flanders, Belgium

For the Flemish BAT studies, VITO's BAT Knowledge Centre determines BAT based on a multistep procedure (Dijkmans, 2000[16]) as described below, using a table similar to Table 2.1, so as to mark a score for each technique, pertaining to technical, environmental and economic criteria. The assessment of the criteria is considered indicative and shall be seen in the context of the overall BAT study. Furthermore, an overall positive score in the table does not necessarily imply that a given technique is applicable to every installation in the industrial sector concerned.

i. Evaluation of technical viability of candidate BAT by investigating experiences with the techniques in practical situations, e.g. by looking at whether a technique already is applied in the given sector, and under which conditions. Based on this evaluation, the techniques are deemed either technically viable (+), not technically viable (-) or only viable under certain conditions (±)."Background information for the technical evaluation is provided as footnotes to the scores or is available in the technical descriptions of the candidate BAT. The proposed scores are discussed in the advisory committee and either kept or altered. Candidate BAT that are not technically viable (score -) are considered as non-BAT.
ii. Evaluation of the environmental performance of candidate BAT, by giving an expert appreciation (+, -, 0 or ±) for each candidate BAT pertaining to the different environmental media (air water, air, soil, waste, energy, noise, etc.). The overall cross-media score of a technique is considered positive when none of the relevant media gives a negative score and at least one is positive. Candidate BAT that have a negative overall cross-media score are considered as non-BAT.
iii. Evaluation of the economic viability of candidate BAT: candidate BAT are considered economically viable if "(i) it is affordable for an average well managed enterprise of the sector; and (ii) if the cost/environmental benefit ratio is not unreasonable" (Dijkmans, 2000[16]). There are various options for assessing cost effectiveness:
    - the assessment of cost-effectiveness based on existing investments;

- drawing up a cost-effectiveness curve for the technology and assessing where the specific application of the technology is located on the curve; and
- the assessment of cost-effectiveness based on shadow prices.

Candidate BAT that are not economic viable (score -) are considered as non-BAT.

iv. Comparison with other candidate BAT.

v. Description of conditions under which the candidate technique is considered BAT, if any.

Table 2.1. Criteria for evaluation of candidate BAT in Flanders

Area	Criterion	Score
Technical viability	Proven useful in practice	+ or -
	Generally applicable in an average company without technical limitations	+ or -
	Safety: reduces risk of fire, explosions and industrial accidents	+ or 0 or -
	Impact on the quality of the end product	+ or 0 or -
	Overall technical viability	+ or 0 or -
Environmental performance	Water consumption: recycling of waste water and reduction of total water consumption	+ or 0 or +/- or -
	Waste water: input of contaminated substances into the water as a result of the operation of the establishment	+ or 0 or +/- or -
	Air: introduction of contaminated substances into the atmosphere as a result of the operation of the establishment	+ or 0 or +/- or -
	Soil: the introduction of contaminated substances into the soil and groundwater as a result of the operation of the establishment	+ or 0 or +/- or -
	Waste: the prevention and management of waste flows	+ or 0 or +/- or -
	Energy: energy savings, the use of environmentally friendly energy sources and the reuse of energy	+ or 0 or +/- or -
	Chemicals: influence on the chemicals used and the quantity	+ or 0 or +/- or -
	Effect on the value chain: influence on the before and after chain, excluding the effect on energy and water suppliers	+ or 0 or +/- or -
	Overall impact on the environment.	+ or 0 or +/- or -
Economic viability	The technique saves costs	+ or 0 or – or --
	The technique has a negligible influence on costs	+ or 0 or – or --
	The technique leads to an increase in costs; the additional costs are considered to be bearable for an average company and are in reasonable proportion to the environmental gains achieved	+ or 0 or – or --
	The technique leads to an increase in costs; the additional costs are not considered to be bearable for an average company, or are not in a reasonable proportion to the environmental gains realized.	+ or 0 or – or --
BAT	Based on the above, can the technique be considered BAT (yes, no or in certain cases)?	Yes or no or in certain cases

Source: VITO

VITO's BAT Knowledge Centre has also developed a methodology for determining BAT at the level of an industrial installation (Smets, Vanassche and Huybrechts, 2017[50]), as opposed to at the sector level. The methodology is meant to support industry operators in identifying which BAT they should implement to address a given problem in their installation, in order to reach compliance with their permit conditions.

The methodology consists of seven steps, as outlined below, which are to be completed one after the other. Depending on the complexity of the problem in

question, in addition to the information available and the degree of consensus between relevant authorities and the concerned industry operator, the seven steps can be performed in a qualitative way (i.e. based on expert judgement), or in a more detailed and quantitative manner.

i. Describe the problem.
ii. Make a list of 'candidate BAT'.
iii. Assess the technical feasibility of the candidate BAT.
iv. Assess the environmental performance of the candidate BAT. There are two possible options: a qualitative assessment or a quantitative approach. The quantitative approach can complement or replace the qualitative approach.
v. Assess the economic feasibility of the candidate BAT. There are two possible options: a qualitative assessment or a quantitative approach of the cost of the candidate BAT followed by an assessment of the profitability of the candidate BAT and the feasibility for the company, and by an assessment of the cost-efficiency of the candidate BAT and its reasonableness. The quantitative approach can complement or replace the qualitative approach.
vi. Select the BAT.
vii. Compare the selected BAT with the BAT at the sector level.

e Russian Federation

A preselection of candidate BAT takes place as part of a TWG's process to draft Chapters 2 and 3 of the BREFs, concerning applied techniques as well as consumption and emission levels. Further, the TWG evaluates the candidate BAT according to an approach described in Chapter 4 of each BREF, often based on the five criteria defined in the Government Decree on the procedure for determining technologies as BAT (Government of the Russian Federation, 2014[51]):

i. the lowest possible negative environmental impact expressed as a value per time unit or per volume of produces goods, the amount of operations carried out, the amount of services rendered or any other characteristics found in international agreements signed by the Russian Federation;
ii. the economic efficiency of its introduction and operation;
iii. the use of resource and energy saving methods;
iv. the period of time needed to introduce the technique; and
v. the successful introduction of the technique in at least two Russian installations.

The TWG can adapt these five criteria to the characteristics of the concerned industrial activity, e.g. by prioritising the environmental concerns of greatest relevance (see Box 2.3). Out of the five criteria, the techniques' ability to reduce or prevent emissions is considered the most important. The assessment of candidate BAT is based on expert judgement and conducted on a case-by-case basis. The TWGs pay particular attention to the pollutants that are considered the most significant for each sector, and nominate the best performing techniques for the reduction of given parameter in each sector. For a limited list (e.g. the top three-five techniques), the TWG conducts an in-depth technical evaluation, e.g. of how the techniques contribute to reducing the emissions of *other* pollutants as well as their cross-media effects. Techniques are removed from the list if the evaluation

demonstrates that they perform less well compared to other shortlisted techniques. All remaining techniques on the list are considered BAT; that is, they ensure the reduction or prevention of emissions of one or several key pollutants or reduce the use of resources, such as energy, raw materials or water. The BAT are presented in the BREF together with relevant information on their technical performance level and financial costs, including equipment prices where available.

There is currently no standardised methodology for the assessment of economic aspects of techniques. The Russian translation of the EU Reference Document on Economics and Cross-Media Effects (EC, 2006[49]) is sometimes used as guidance in this context (OECD, 2018[27]). For two sectors (Large Combustion Plants and Municipal Wastewater Treatment), recommendations on assessing costs of the implementation of BAT and on selecting economically feasible solutions have been developed.

f The Minamata Convention on Mercury

The BAT/BEP guidance developed under the Minamata Convention[10] does not impose any legal requirements on the Parties, these are obliged to take the guidance into account when determining BAT at the national level (UN Environment, 2016[52]). In order to determine BAT, each Party is expected to assess its national circumstances in accordance with the definition of BAT contained in the Convention's Article 2, which provides for a consideration of economic and technical elements for a given Party or a given facility within its territory (OECD, 2018[27]).

The procedure for selecting BAT at the national level under the Convention could be expected to include the following five general steps:

i. Establish information about the source, or source category, including on associated processes, input materials, feedstock or fuels, actual or expected activity levels, including throughput, in addition to, where relevant, information on the expected life of the facility and any requirements or plans for controlling other pollutants;

ii. identify all optional techniques, and combinations of techniques, for emission control of relevance for the source of concern, including the common techniques and techniques for specific source categories described in the BAT/BEP guidance;

iii. among the full range of options, identify the control techniques that are technically viable, taking into account whether the techniques are applicable to the type of facility within the sector, in addition to any physical limitations which may influence the choice of certain techniques;

iv. select which of these options that are the most effective in terms of controlling and, where feasible, reducing emissions of mercury, taking into consideration the performance levels referred in the BAT/BEP guidance, and in terms of achieving a high general level of protection of human health and the environment as a whole; an

v. determine which of these options that can be implemented under economically and technically viable conditions, taking into account associated costs and benefits and whether they are accessible to the operator of the facility as determined by the party concerned. The

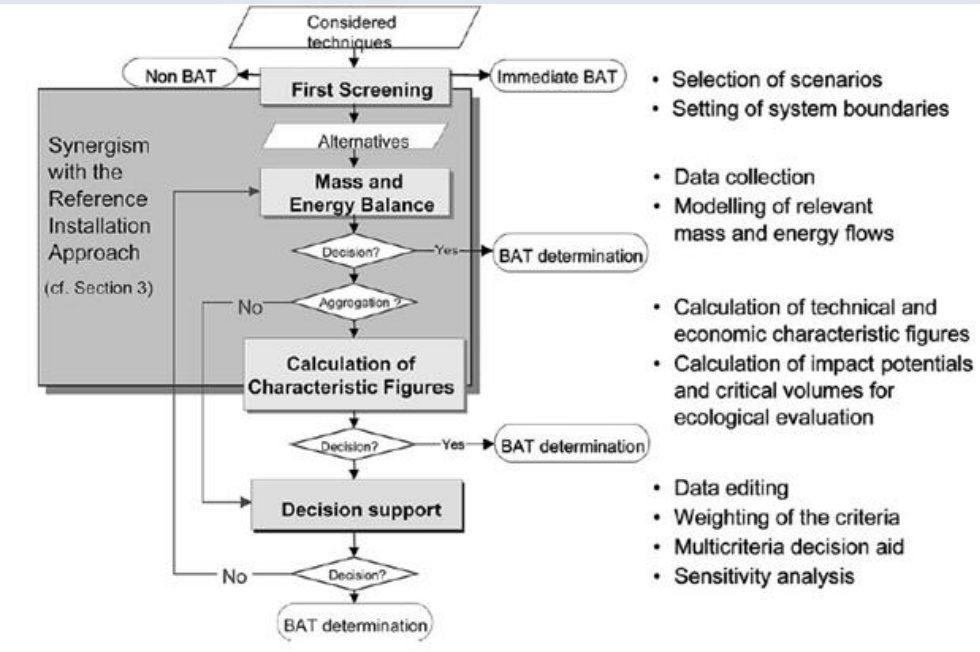
techniques selected may differ for new and existing facilities. The need for maintenance and operational control of the techniques should also be taken into account in determining BAT, in order to ensure the achieved performance over time (UN Environment, 2016, in (OECD, 2018[27]).

g Gothenburg Protocol[11]

A cross-media, quantitative approach is used as a support to identify BAT under the protocol. The approach consists of four steps (see Figure 2.7):

i. A first screening, consisting of a selection of candidate BAT based on all relevant techniques described in national BAT documents and other relevant papers;
ii. mass and energy balance, consisting of compiling all relevant input flows, emission and energy data pertaining to candidate BAT in a uniform data format;
iii. calculation of characteristic figures; and
iv. decision support (Geldermann, 2004[53]).

Figure 2.7. The proposed cross-media assessment approach for the determination of BAT under the Gothenburg Protocol



Source: (Geldermann, 2004[53])

2.8. Deriving BAT-AELs and BAT-AEPLs

2.8.1. About BAT-AE(P)Ls

A TWG has to determine emission levels (BAT-AELs) and other environmental performance levels associated with BAT (BAT-AEPLs). The group should derive both concentrations and load based BAT-AELs, in addition to other BAT-AEPLs, e.g. on water

and/or energy consumption/efficiency; this requires that sufficient and up-to-date data are made available to the TWG on all relevant parameters. It is important that the TWGs for each BREF evaluate whether BAT-AELs and/ or BAT-AEPLs are suitable and whether the data available is adequate to create such.

Units for BAT-AELs should generally be described in concentration of exhaust gas or waste water (e.g. mg/Nm^3 for emissions to air or mg/l for discharges into water) to enable quick monitoring of compliance with permit conditions. BAT-associated consumption/efficiency levels should preferably be expressed in consumption (e.g. of raw material, energy, water) per mass of product manufactured (e.g. in kg/t, MJ/t). For energy and water consumption, BAT-AEPLs may also be expressed in consumption/use per mass of raw material (e.g. MJ/t, m^3/t) (EU, 2012[5]). For pollutants with properties that can bio-accumulate and that are persistent and toxic, an absolute load-based limit could be combined with concentration-based BAT-AELs.

When setting BAT-AE(P)Ls, countries may want to distinguish between existing plants/installations – which often have a fixed investment cycle and require adapted pathways reflective of the retrofit aspect – and new plants/installations, or those that undertake major upgrades, which can implement modifications more easily. When setting BAT-AE(P)Ls for existing plants/installations, successful frontrunners could be considered as a point of reference, given that their environmental performance was achieved under normal operating conditions.

2.8.2. Recommendations for establishing BAT-AE(P)Ls

- **BAT-AE(P)Ls shall be derived from BAT**, in order to secure an adequate reduction in emissions. That is, the BAT-AE(P)Ls should be based on the environmental performance of installations that have applied BAT or a combination of BAT under normal operating conditions, i.e. levels that are associated with, and can be achieved as a result of, applying BAT. (*Note:* some jurisdictions operate in an opposite manner, i.e. by deriving BAT from target emission levels.)
- **BAT-AE(P)Ls shall be based on data from a set of *selected well-performing plants*** (see Section 2.6.1), and not the whole operating range of current performance of all installations. This helps generalising the performance of the well-performing plants and secure an improvement across the entire industry.
- **BAT-AE(P)L ranges shall be derived from a systematic and consistent approach**, based on a robust and transparent methodology. Coupled with the definition of BAT, this is what determines the overall stringency of the requirements for industry.
- **TWGs shall consider data from multiple countries when setting BAT-AE(P)Ls**, as highlighted in Section 2.6.2. The consideration of performance levels from other jurisdictions (i.e. other countries and regions) is particularly important with regards to techniques that are not yet (widely) implemented in the concerned jurisdiction, or in cases where higher performance levels have been reported in other jurisdictions. This will help ensuring that the BAT-AELs are not set based on time- and place-specific conditions, but rather on the highest possible performance related to the use of a BAT, or the combination of several BAT.

- **BAT-AE(P)Ls shall be based on evidence**, rather than being politically negotiated levels. To secure that this is done in and adequate manner, countries should consider the benefits and limitations of expert judgement versus statistical decision-making. Depending on how the approaches are applied, either can secure that BAT-AE(P)Ls are based purely on evidence on technical, environmental and economic information, and that political priorities do not interfere with environmental protection objectives. Basing BAT-AE(P)Ls on statistical decision-making may provide for a more systematic approach and be easier to interpret. However, depending on the number of installations in a given sector and their level of heterogeneity, it might be challenging to gather sufficient statistically representative data. Another challenge of using a purely statistical approach it could be to settle on an adequate technical basis for the level of ambition at which BAT-AE(P)Ls should be set, i.e. at what percentile the reported environmental performance should be capped (e.g. at the 50th, 70th or 80th percentile). Expert judgement, on the other hand, may offer a more realistic approach, which – while also being based on evidence – recognises that the reality often is far more complex than what can be reflected by a purely statistical approach, and allows considering the imperfections of the data collected (lack or imprecision of data, errors in the data reported, outliers, non-comparability of data due e.g. to differences in monitoring, etc.), the cross-media effects and costs of techniques, the trade-offs between pollutants (e.g. NO_X vs CO) or between emission reduction and energy efficiency for example, and environmental quality standards.
- **BAT-AELs should be aligned with other BAT-AEPLs**. In some jurisdictions, some BAT-AE(P)Ls have a stronger legal status than others do. This could be problematic if it obliges permitting authorities to prioritise one environmental protection priority over another. Thus, governments are advised to ensure the alignment of BAT-AELs and other BAT-AEPLs, as well as to consider making BAT-AEPLs legally binding. It is also important to ensure that AELs are not contradicting each other. Governments should also seek to ensure compatibility between BAT-AE(P)Ls and monitoring standards and reference conditions.
- **The BAT-AE(P)Ls should be coherent with the overarching objectives of the BAT-policy/regulation** as well as with any evidence-based and applicable binding rules, environmental quality standards and international conventions.
- **The wider public benefits of stricter BAT-AE(P)Ls should be considered** in the process to set BAT-AE(P)Ls, based on comprehensive system boundaries and alternative options assessment, including trans-frontier impacts.

Box 2.7 presents various approaches to establishing BAT-AE(P)Ls, from the European Union, Flanders (Belgium), Korea, the United States and the Russian Federation in Box 2.7.

Box 2.7. Examples of procedures to deriving BAT-AELs and other BAT-AEPLs

a European Union

The process to determine BAT-AELs and other BAT-AEPLs (such as e.g. consumption levels, abatement efficiency levels, etc.) is interwoven with the determination of BAT (see

Box 2.6). The EU BREF Guidance Document (EU, 2012[5]) describes the process to establishing BAT-AE(P)Ls.

BAT-AE(P)Ls under the IED are often expressed as ranges. The EIPPCB and the TWGs derive both the lower and the upper end of the range based on the assessment of the information on performance levels collected during the exchange of information. BAT-AELs under the IED have stronger legally binding effects than other BAT-AEPLs.

To define the lower end of the range, the TWG considers the performance of plant(s) achieved under normal operating conditions by the BAT obtaining the best environmental performance, under a given permit condition, as provided in the information exchange, unless this performance is excluded from the range by the TWG. (In such cases, there is usually an explanation in the BREF of why it has been rejected, considering that the plant achieving the best performance for a given environmental indicator may not be able to be the best performer for other indicators. Some EU stakeholders note that this methodology is based on observed emission levels by operating plants, and thus does not necessarily result in levels that reflect the highest achievable technical performance levels associated with a given BAT or combination of BAT running at their best technical abatement potential.

The upper end of the BAT-AEPL range is derived by considering the range of performance associated with the application of the BAT under normal operating conditions. When defining the environmental performance levels associated with BAT, the TWG may use rounded values to take into account limitations of the data collection or technical issues (e.g. use of different monitoring methods, uncertainty of measurements). The applicability restrictions or footnotes mentioned in a BAT Conclusion can explain on what basis the upper BAT-AEL range has been derived (this is often related to cost or possible space restriction concerns for the operator to implement a given technique in an existing installation).

An individual BAT conclusion with BAT-AELs will contain a numerical range of emission levels. The units, the reference conditions (e.g. flue-gas oxygen level, temperature, pressure) – if applicable – and the averaging period (e.g. hourly/daily/weekly/monthly/yearly average) must be unambiguously defined. If considered necessary, and if the data submitted allows for doing so, BAT-AELs may be expressed as short-term and long-term averages (EU, 2012[5]).

Figure 2.8 provides an example of how BAT-AELs are presented in the EU BAT Conclusions.

Figure 2.8. Example BAT-AEL in the EU BAT Conclusions

Example of an individual BAT conclusion which includes emission levels associated with BAT (BAT-AELs)

42. **In order to reduce VOC emissions from process AA, BAT is to use one or a combination of the techniques given below.**

	Technique	Description	Applicability
a	aa	[description]	new plants
b	bb		existing plants
c	cc		

The BAT-AELs for VOC are:

— For new installations: 10–20 mg C/Nm^3 as a daily average under reference conditions xx, yy, …

— For existing installations: 20–30 mg C/Nm^3 as a daily average under reference conditions xx, yy, …

Source: (EU, 2012[5])

According to stakeholders from certain EU Member States, environmental NGOs and industry associations, the EU could benefit from introducing a more standardised procedure for the derivation of the BAT-AEL range.

b Flanders, Belgium

VITO's BAT Knowledge Centre has also developed a methodology for determining emission levels associated with the best available techniques for industrial waste water (Polders et al., 2012[54]). The methodology is based on a detailed analysis of emission data for the industrial sector under consideration. This analysis consists of five steps:

i. Selection and grouping of industrial installations,

ii. Collection of emission data,

iii. Selection of parameters (pollutants),

iv. Analysis of available emission data in relation to BAT, including the exclusion of emission data (i) for which the background information shows that they are not representative of the industrial sector under consideration, (ii) from companies for which the background information shows that they do not (yet) apply the BAT for the parameter under consideration, (iii) from companies applying environmentally friendly techniques which go beyond the BAT, and (iv) that are caused by other than normal operating conditions such as start-up and shutdown operations, leaks, malfunctions, momentary stoppages and definitive cessation of operations.

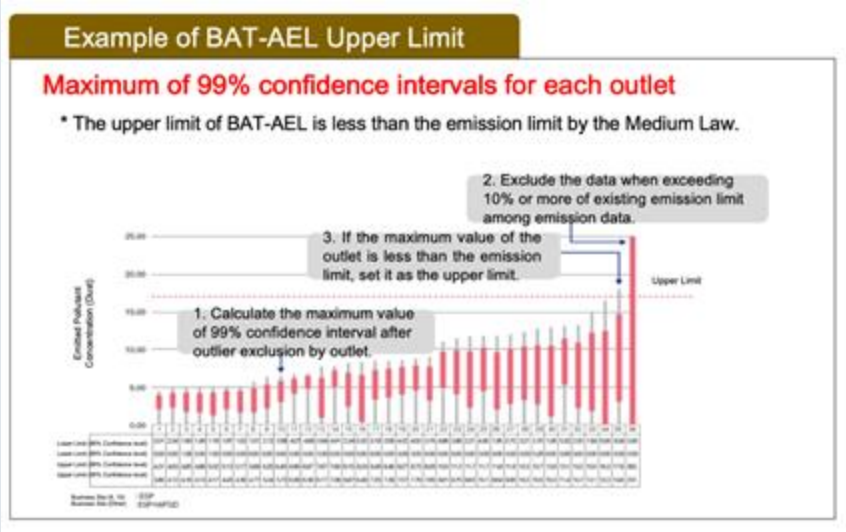
v. Determination of (differentiated) BAT-AELs.

Prerequisites for applying the methodology are that the BAT for the sector have been selected and that emission data and background information are available.

c Korea

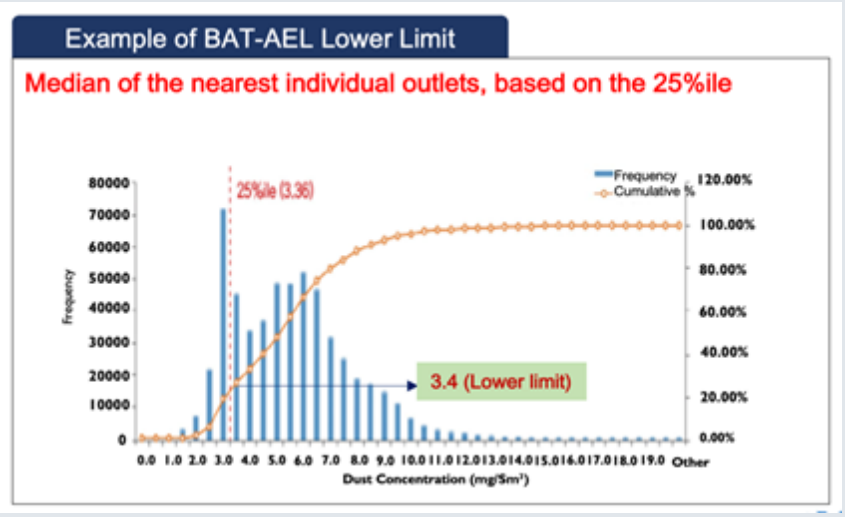
The determination of BAT-AELs in Korea takes place after the identification of BAT and consists of four steps, as listed below Figure 2.9, which illustrates the first three steps, and Figure 2.10, which shows the fourth step:

Figure 2.9. Procedure to set the upper BAT-AEL limit in Korea



Source: Korean National Institute of Environmental Research

Figure 2.10. Procedure to set the lower BAT-AEL limit in Korea



Source: Korean National Institute for Environmental Research

i. classification/grouping of BAT through analysis of emission of pollutants associated with each BAT;

ii. exclusion of non-usual outlier data by the statistical Rosner's test (based on 99% confidence level) at the normal operation state;

iii. determination of the upper limit value by calculating the maximum value at each stack or outlet, excluding the stack data if 10% or more exceed national emission limit by the medium law (i.e. Clean Air Act in Korea), and setting the maximum among stacks as the upper limit; and

iv. determination of the lower limit values by searching the 25%ile value in all emission values of stacks or outlets and finding the nearest of the median value in each stack or outlet (OECD, 2018[27]).

d United States

As an example for determination of BAT, for industrial categories in the US emitting hazardous air pollutants, as listed in the Clean Air Act, EPA follows a two-step regulatory approach (US EPA, 2002[55]). The first phase involves EPA setting technology-based standards based on MACT, which are national standards applying to specific source categories in new and existing major and area sources, as defined in the Clean Air Act (US EPA, n.d.[56]). The MACT standards represent the maximum degree of reduction in emissions taking into consideration the costs of achieving such emission reduction and any non-air health and environmental impacts and energy requirements.

The Clean Air Act defines how MACT levels of controls are to be determined. For new (and substantially reconstructed) sources, MACT standards must be at least as stringent as is achieved by the best-controlled similar source. For existing sources, MACT standards are to be at least as stringent as the average level of emission reduction already achieved by the best performing 12% of sources in the same category. This minimum control level is typically known as the MACT floor, and does not consider costs (US Government, 2013[57]).

To determine the MACT floor, EPA ranks the existing sources in each source category using emission reduction data gathered from questionnaires and other sources. If a source category has less than 30 sources, the best five performing sources are averaged to arrive at the MACT floor. These standards apply to both new and existing major and area sources, as defined in the Clean Air Act.

In the second phase, EPA is required to complete an assessment of residual health and environmental risks remaining after imposition of a MACT standard and determine whether more health protective standards are necessary. In addition, EPA is required to carry out a review periodically to account for improvements in air pollution controls and/or prevention, and to revise such standard where data so indicate (US EPA, n.d.[58]) (US EPA, n.d.[59]). Completed reviews are accessible online (US EPA, n.d.[60])

e Russian Federation

Each Russian BREF contains a thorough analysis of environmental performance levels achieved by the relevant industrial installations as well as of the techniques applied to control emissions.

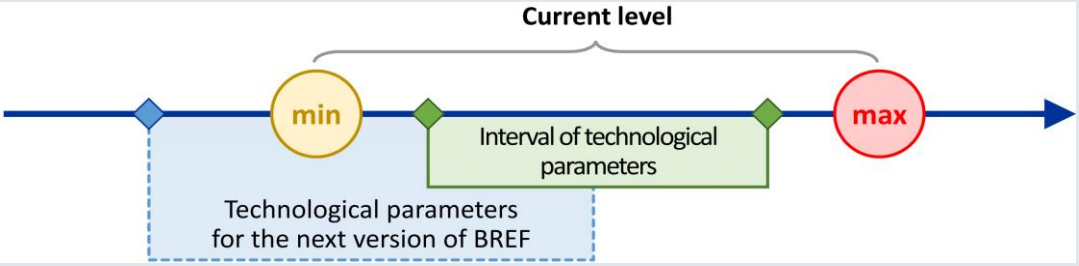
The Russian BAT-AE(P)Ls, known as technological parameters, are determined at the sector level based on expert judgement. Technological parameters equivalent to BAT-AELs for each industrial sector are approved in Orders of the Ministry for Natural

Resources and the Environment or, in special cases (for Municipal Wastewater Treatment Plants), by Government Decrees. The orders resemble the EU BAT Conclusions, albeit simplified. The next generation of Russian BREFs will contain BAT Conclusions. Nearly all such orders were published in 2018-2019. Other BAT-AEPLs than BAT-AELs are not included in the orders, but simply in the BREFs.

The technological parameters may reflect concentrations of pollutants (e.g. mg/m^3 for emissions to air or mg/l for discharges into water) or emission factors (e.g. in kg/t of product or kg/t of raw material processed). Those technological parameters that are equivalent to other BAT-AEPLs, i.e. not BAT-AELs, set values for e.g. water consumption, energy use or of products (good) manufactured, services provided etc. (e.g. MJ/t, m^3/t). These parameters are not officially approved by the Orders of the Ministry, but are just as important.

Providing an illustrative example of how BAT-AELs are set in Russia, the process followed by the TWG that developed the BREF on Refining of Natural and Associated Gas is illustrated by Figure 2.11. The group determined BAT-AELs by first presenting the range of current emission and consumption levels of gas refineries, informed by the questionnaire responses submitted to the TWG. Second, to determine the interval of BAT-AELs, the TWG considered the installations' commissioning dates, their foreseen development (including modernisation) plans, and the distribution of installations across the interval. Third, based on the levels reported in the questionnaire responses, the interval of BAT-AELs was set from 7-10% above minimum to 7-10% below maximum, to exclude outliers. If more than 70% of installations in the interval were closer to the maximum level, the range of BAT-AELs was set as $\leq max$. The BAT-AELs (technological parameters) for gas refiners are expected to be made more stringent upon revision of the BREF (Skobelev, 2018[35]).

Figure 2.11. Methodology for setting the BAT-AELs for Russian gas refineries



Source: (Skobelev, 2018[35])

2.9. Revising BAT, BAT-AELs and BAT-AEPLs

An important aspect of a BAT-based permitting is the regular review of BAT reference documents (BREFs), to ensure the dynamism of the BAT system and thus that the BAT and BAT-AE(P)Ls are updated according to the most recent technological developments and environmental performance data from reference installations, so as to reflect technological progress, and allow for permit conditions to be updated accordingly. However, how rapidly BREFs, and thus permits, are reviewed is a choice of the overall regulatory regime, and a number of trade-offs need to be considered when determining the

frequency of reviewing BREFs, such as the resources required to operate the process versus the change expected. Reviewing a BREF is a resource-incentive and time-consuming process, due to the thorough examination of available information, procedures related to determining the scope of the BREFs, as well as the participatory assessment of the technical, environmental and economic criteria of candidate BAT. Another trade-off relates to certainty for operators (e.g. in terms of payback on investment) versus improved environment performance. Furthermore, it is essential to consider expectation of how fast techniques will evolve in a given sector – if it is slow, frequent BREF reviews probably will not result in any significant changes. Therefore, it is important that countries settle on an optimal review cycle, e.g. every five-ten years. Finally, the frequency of BREF reviews is not the only consideration, added to that is the time allowed to update permits and meet the new operating conditions

Box 2.8 highlights examples of approaches to revising BREFs in the EU, Korea, the United States and the Russian Federation and Kazakhstan.

Box 2.8. Examples of approaches to revising BREFs

a European Union

According to the Industrial Emissions Directive, BREFs should be revised every eight years. The process to review a BREF is based on the same steps as those to draw up a BREF for the first time (see Box 2.4) Reviewing a BREF requires *reactivating* a TWG.

Environmental NGOs in the EU suggest that the BREF review process could be sped up by enabling a fast-track procedure for the revision of the sections on candidate BAT, in particular emerging techniques, prior to the publication of the final, revised BREF.

b Korea

The Government sets out to update the Korean BREFs every five years, following the same methodology as for the drawing up of BREFs, and based on, inter alia, an assessment of the field applicability of reference documents. The field applicability assessment reviews the number of BAT currently in use by industry compared to the number of BAT listed in a BREF, and will be conducted quantitatively and qualitatively for each industrial sector. If 90% of the BAT in a BREF have been implemented by industry, the field applicability will be deemed excellent, 80-90% applicability will be rated good, and levels below 80% will be considered normal. The qualitative assessment of BAT field applicability will consist of taking a closer look at whether facility improvements and new techniques introduced by industry operators are listed in existing BREFs or not (OECD, 2019[7]).

c United States

US BREF-type documents that stipulate emission limits or standards based on sector, process or device types may be found within US environmental regulations (see Annex A). These regulations must be reviewed on a regular cycle, typically every five to eight years. The reviews may result in updated and more stringent standards that facilities must comply with, typically within three years of rule promulgation. Implementing regulatory revisions, including adjustments to ELVs, requires information gathering, public consultation and engagement, leveraging experts, and coordinating amongst other environmental programmes and reconciliation of comments prior to final rules (US EPA, 2011[61]).

For instance, eight years after the technology-based MACT standards, from which the NESHAPS are derived and are issued for a source category, EPA is required to complete an assessment of residual health and environmental risks remaining after imposition of a MACT standard, and determine whether more health protective standards are necessary. In addition, EPA is required to carry out a review periodically to account for improvements in air pollution controls and/or prevention, and to revise such standard where data so indicate.

As another example, under EPA's water discharge regulations, EPA annually reviews and, if appropriate, revises effluent limitation guidelines and standards. The review considers environmental risk, technology availability, economic achievability, and regulatory efficiency, and allows the EPA to prioritise industries for possible revision of the guidelines and standards.

Up to date information can be accessed at EPA's webpage[12] on regulatory information by sector or by referencing the standards directly:

- Air NSPS www.epa.gov/stationary-sources-air-pollution/new-source-performance-standards
- Air NESHAP: www.epa.gov/stationary-sources-air-pollution/national-emission-standards-hazardous-air-pollutants-neshap,
- Water Effluent Guidelines: www.epa.gov/eg/industrial-effluent-guidelines, and
- Hazardous waste disposal, RCRA: www.epa.gov/hw/treatment-standards-hazardous-wastes-subject-land-disposal-restrictions#apply.

d Russian Federation

According to the Russian legislation (Russian Federation, 2019[62]), the Russian BREFs have to be revised during the period 2019-2024). The first seven BREFs were revised in 2019; work is in progress in 2020.

e Kazakhstan

The draft Kazakh Environmental Code (Government of Kazakhstan, 2019[63]) establishes an eight years' review cycle for BREFs.

f China

China has not set a clear revision interval for the GATPPCs, but since the introduction of the Development Guideline for GATPPCs (MEE, 2018[64]) in 2018, the GATPPCs for several industries have been revised, including for thermal power plants and paper production.

2.10. Determining BAT-based permit conditions

2.10.1. Key points on BAT-based permit conditions

- Environmental permits for industrial installations should take an **integrated approach** to pollution prevention and control, as stipulated by the OECD Council Act on IPPC (OECD, 1991[3]). Detailed guidance for permitting authorities is

available in the OECD's *Integrated Environmental Permitting Guidelines for EECCA Countries* (OECD, 2005[65]).

- Permits should include **emission limit values (ELVs) and other BAT-AEPL-based permit conditions as well as monitoring standards**, such as on frequency, reference conditions and reporting periods, and relevant technical requirements.
- Permit conditions should be set by **adequate environmental permitting authorities**. Such authorities should also be in charge of conducting inspections and compliance assessment.
- Local permitting authorities can be a good means to ensure that **essential local knowledge** is taken into account, so as to determine permit conditions in a robust manner and based on detailed site-by-site assessments.
- As an alternative to setting permit conditions at the local level, or in order to support a level playing field within countries where permits are issued at local level, **governments can consider setting BAT-based requirements through general binding rules** that apply at country level as a minimum standard. This approach may reduce flexibility for deviation, thereby ensuring a level playing field for industry. Furthermore, the general binding rules may be presented in a format the permitting authorities are more acquainted with, and thus facilitate the implementation of BAT-AE(P)Ls within the desired timeframe for compliance.)
- In order to avoid that permitting authorities face technical and interpretational challenges when determining ELVs, e.g. in the face of seemingly incompatible or conflicting standards, **governments should make available adequate guidance on how to interpret the BAT-AELs and other BAT-AEPLs**. Such guidance may in particular be helpful to permitting authorities that lack broad knowledge due to limited exposure to a large number of installations or if they only occasionally issuing a permit for a specific sector. Governments should aim to provide guidance on how to ensure compatibility between ELVs and those permit conditions that are based on BAT-AEPLs, in order not to compromise important circular economy objectives, such as energy and resource efficiency as well as the reuse of materials or other relevant environmental quality standards such as WHO air quality standards and good ecological and chemical status of water bodies.
- Industrial operators with an environmental permit are not obliged to apply those techniques defined as BAT, as long as they **ensure at least an equivalent level of environmental protection**. That is, although the emission levels associated with BAT have legally binding effects, industry operators and permitting authorities enjoy some flexibility at the implementation stage.
- Because of the differing circumstances and configurations of installations, there will always be some uncertainty over how equal the obligations on two installations are. To the degree that judgment is required by permitting authorities, there will be a risk that the stringency is not the same. Therefore, additional requirements such as **comparing permit conditions or other parameters may be needed as part of the overall regulatory framework**.

2.10.2. General considerations for permitting authorities

- **Predictability** is crucial in order for industry operators to plan investments, and thus permitting authorities should aim to accommodate for this by preparing

permits in a timely – albeit thorough – manner. Defining clear milestones and improvement conditions also helps operators make adequate investment decisions. Furthermore, permit conditions should be measurable and enforceable, so that accurate installation data can feed into the next review of BREFs.

- Permit authorities should **seek information on possible upcoming permit applications**, i.e. those that are expected during a certain period, e.g. through regular communication with permit holders and industry associations, and/or inspections of installations. Permitting authorities should also make sure to stay informed of changes to BREFs and/or relevant BAT legislation (IMPEL, 2018[66]).
- Permit authorities must take measures to **prevent inconsistencies** as well as be careful not to be influenced by potential pressure from industry operators when setting permit conditions, whilst maintaining dialogue with local industry.
- Permitting authorities should aim to use **digitalised procedures** for permitting, as this greatly facilitates the procedures for all involved parties. Information on permit conditions as well as annual compliance performance information should be supplied electronically and disseminated to the public.
- BAT are derived from, and thus apply to, normal operating conditions. When a disruption occurs and causes increased emissions, the operation enters a state of 'other than normal operating conditions' (OTNOC). Thus, permitting authorities **also need to regulate periods of OTNOC** (other than at start-up and shut-down), i.e. how such periods are to be registered, and how to limit the number of hours per year of operation allowed under these circumstances. IED Chapter III Article 37 provides an example of good practice: the allowed operation time under breakdown in abatement equipment is limited to 120 hours.

2.10.3. How to set ELVs or other permit conditions

ELVs should not exceed the upper value of the range of BAT-AELs defined in the applicable BREF or BAT Conclusions (i.e. ELV ≤ upper value BAT-AEL range). The upper end of the BAT-AEL range should not be considered a default option when establishing ELVs; the permitting authorities should aim to set the lowest achievable (i.e. as stringent as possible) ELVs for each installation. ELVs should be set at the upper end of the BAT-AEL range only in exceptional cases, e.g. in case of application of new technology or uncertainty related to an installation's performance. ELVs should – as a minimum – be based on current performance, and preferably be more stringent. If an installation has shown good recent performance, e.g. over the last three years, the ELV should be set lower than the top of the BAT-AEL range.

Further, when setting ELVs, permitting authorities should take into account the following aspects, whether the installation is existing, or if it new or has undergone major upgrades:

a. the **technical characteristics** of the installation;
b. **emissions monitoring data** for the installation for the preceding years, while paying attention to any measurement uncertainty[13];
c. **local conditions** and **geographical specificities** of the installation;
d. **cross-media effects**, **cross-pollutant effects** as well as the **cumulative effects of pollutants** discharged by the same facility or upstream pollution load from other sources in a systematic manner; and

e. relevant **environmental quality standards** at the local, national and regional levels.

In cases where applicable environmental quality standards or health-based standards require stricter conditions than those achievable by implementing the techniques defined as BAT, more stringent ELVs and/or additional measures shall be included in the permit, going beyond the lower end of the range of BAT-AELs, if feasible and necessary to protect ecosystems, aquatic life and human health. This contributes to the coordinated use of technology-based and health-based standards, facilitating long-term improvements in environmental quality and public health (Robinson and Pease, 1991[67]). To stimulate installations to go beyond compliance with the BAT-AELs, permitting authorities, and/or regulators, should quantify and communicate to industry operators the benefits of optimised performance.

Derogations may apply only where an assessment shows that the achievement of the BAT-AELs would lead to disproportionately higher costs compared to the environmental benefits at a specific installation, provided this is without prejudice to the achievement of relevant environmental quality standards. If an installation requests a derogation from BAT-AELs, the installation (as well as the permitting authority, should it accept the request) should be asked to provide a justification. The derogation procedure should be subject to a public consultation, ensuring that the public has the opportunity to provide effective and timely comments before a decision is made, e.g. at least two months prior to taking a decision. Installations for which derogations are granted should be required to implement BAT, and to comply with monitoring and reporting requirements. Any derogation should be limited in time, e.g. maximum five years, with defined milestones towards compliance, reflecting a clear balance between the interests of the public and the operator. Furthermore, measures should be taken to prevent derogations from creating an uneven playing field for industry or undermining BAT uptake.

Where ELVs are not adequate, alternative permit conditions can be proposed, e.g. prescription of certain technical measures. The latter category of permit conditions can for example be of value in sectors with small companies that all use similar processes (Dijkmans, 2000[16]). Furthermore, permit conditions based on BAT-AEPLs should be set for parameters such as consumption of material, water or energy, the generation of waste, abatement efficiency on pollutants and duration of visible emissions. Permitted ELVs should be set as both concentration limits and mass emission limits where applicable in order to prevent unforeseen increase in the mass of pollutant released from any given installation over time, without the regulatory authority being informed or requested to permit any such increase.

Permit conditions should be reviewed and, where necessary, revised at least in the following cases:

i. the pollution caused by the installation is of such significance that the ELVs in the existing permit need to be updated, or new values need to be included in the permit;
ii. the operational safety requires other techniques to be used;
iii. where it is necessary to comply with a new or revised environmental quality standard (EU, 2010[4]).

Box 2.9 presents examples of procedures to determine BAT-based permit conditions from the EU, the United Kingdom, the United States, Israel and the Russian Federation.

Box 2.9. Examples of procedures to determine BAT-based permit conditions

a European Union

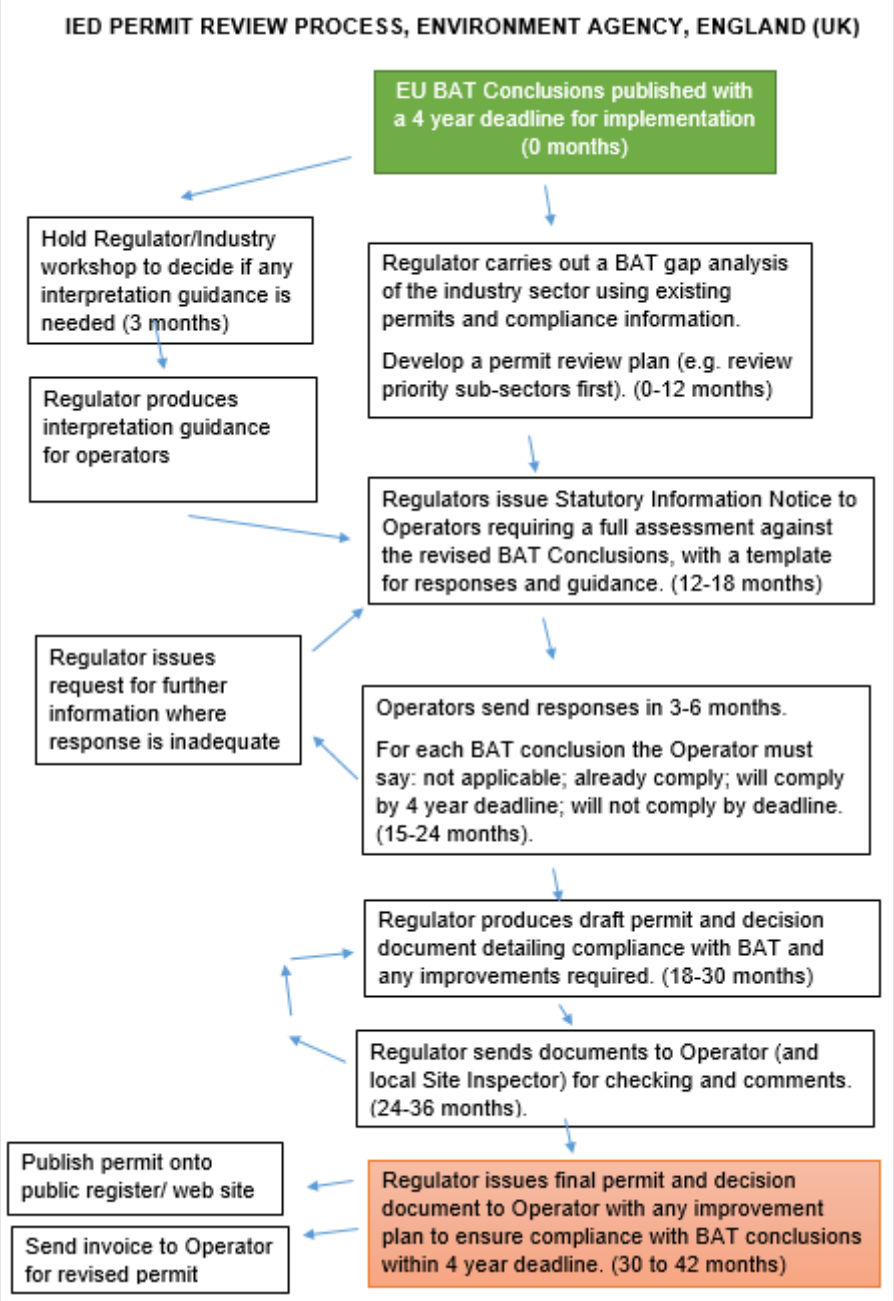
The EU BAT Conclusions may be transposed into national legislation in different ways across EU Member States, potentially with implications for which part of the BAT-AELs ranges that are set as ELVs in permits. Some Member States recommend permitting authorities to use the least stringent end of the BAT-AEL range as a default option. Furthermore, BAT-AELs and BAT-AEPLs are likely to be weighted differently by permitting authorities, considering that BAT-AELs are legally binding, while other BAT-AEPLs are not.

The European Union Network for the Implementation and Enforcement of Environmental Law (IMPEL) has issued a step by step guidance document for permitting and inspection under the IED, called "Doing the Right Things (IED): Combined Guidance" (IMPEL, 2018[66]). The guidance document describes, amongst others, the permitting procedure under the IED, involving three steps with sub-steps: application, decision-making and access to justice. The document also provides guidance on inspections, compliance assessment and enforcement.

b England and Wales

Figure 2.12 presents the key features of the IED permit review process in England.

Figure 2.12. IED permit review process in England



Source: Environment Agency, England (UK)

The UK Department for Environment, Food and Rural Affairs (DEFRA) has also issued guidance to competent authorities in charge of determining permit conditions of IED installations in England and Wales (DEFRA, 2013[68]). Selected elements from the guidance document are presented below:

- ELVs in permits must be set for polluting substances listed in Annex II of the IED and for other polluting substances likely to be emitted in significant quantities, having

regard to their nature and potential to transfer between environmental media. ELVs may be supplemented or replaced by equivalent parameters or technical measures ensuring an equivalent level of environmental protection. The ELVs, or the supplemented or replacement permit conditions, should be based on the application of BAT without prescribing the use of any technique or specific technology. However, the permit conditions can be written in such a way as to accord with the operator's choice of techniques.

- ELVs have to apply at the point where the emission leaves the installation.
- Except in the case of installations subject to the EU Emissions Trading System, for which no ELV for carbon dioxide can be set unless necessary to protect the local environment, the environmental assessment must consider direct and indirect emissions of carbon dioxide that result from the industrial activity in question. The assessment must take into account that trade-offs between carbon dioxide and other pollutant emissions will sometimes have to be made.
- When setting permit conditions based on BAT, permit authorities should give due consideration to energy efficiency, waste issues, consumption and nature of raw materials, accidents and site restoration.

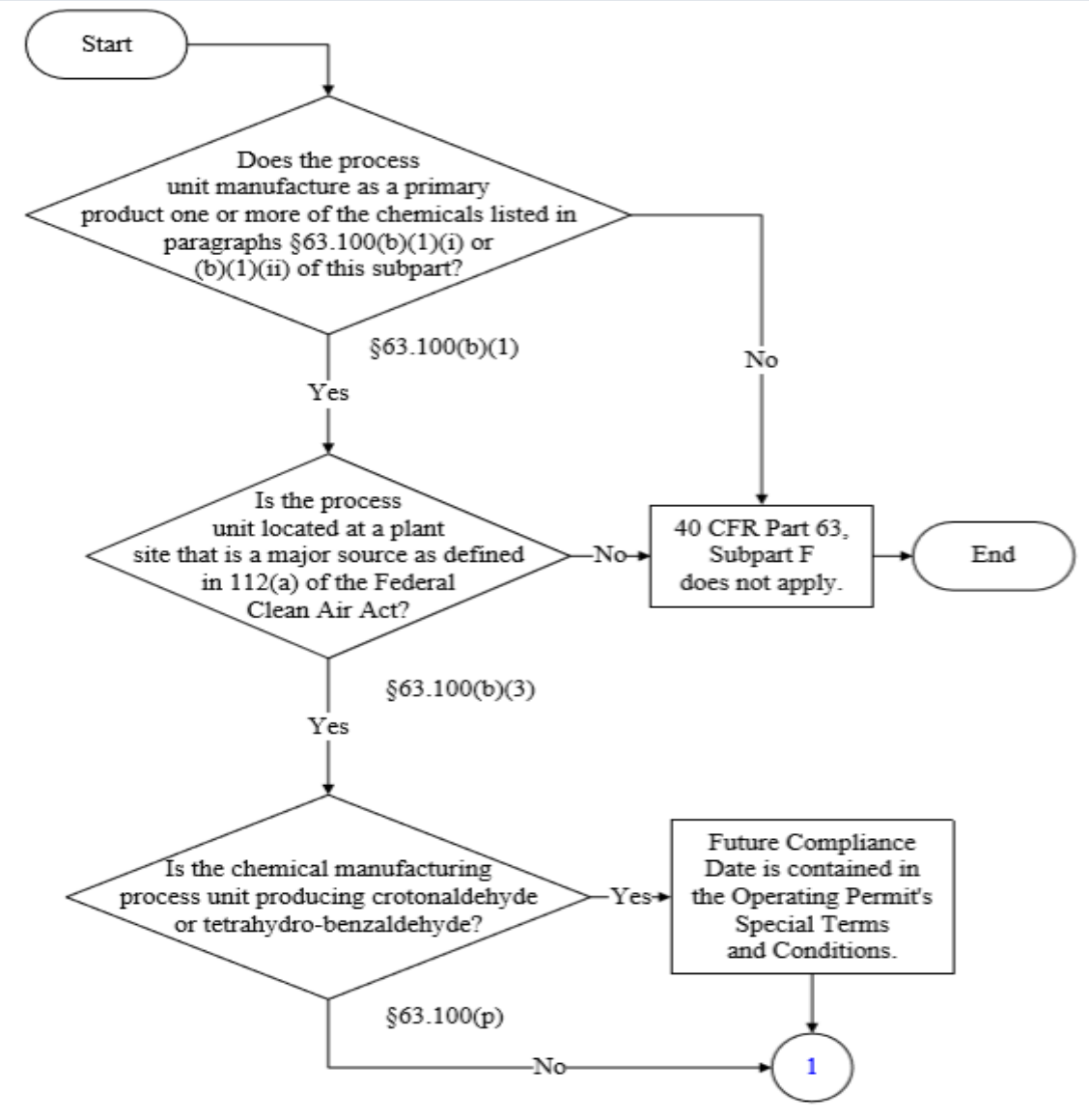
c United States

In the US, various resources are available to help permitting authorities—in the majority of cases, state and city governments—to aid in determining permit conditions. Besides guidance documents or supporting materials contained in the federal docket for national technology-based standards, the public has access to a national database, the RACT/BACT/LAER Clearinghouse[14], which stores facility, process, and pollutant data designed to help permit applicants and writers to make pollution prevention and control technology decisions for stationary air pollution sources. Data is available on over 200 different air pollutants and 1000 industrial processes. Further, states, such as New Mexico, often provide applicants with detailed information on the Web about permitting procedures, permit templates and monitoring protocols (New Mexico Environment Department, n.d.[69]) (New Mexico Environment Department, n.d.[70]). For source categories or simple industry sources, such as concrete batch plants, states often offer general permits. Examples of the conditions are viewable online (New Mexico Environment Department, n.d.[71]) (Michigan Department of Environment, Great Lakes, 2019[72]). Permit transparency helps with receipt of complete applications and in making adequate determinations of BAT-associated emission levels and permit conditions.

The EPA provides guidance to EPA Regions, States and permittees to assist in the implementation of its Clean Air Act and Clean Water Act permitting programs (US EPA, n.d.[73]). For example, EPA developed numerous Clean Air Act permitting tools and resources[15], and a permit writer's manual for its discharge permitting program called the National Pollutant Discharge Elimination System[16]. States also provide guidance to assist in the implementation of permitting programs. For example, to aid permit writers in the interpretation and application of national standards, the state of Texas has prepared flow diagrams based on the regulatory requirements specified in e.g. National Emission Standard for Hazardous Air Pollutants (NESHAP), which are based on MACT. The flowcharts also help determine the type of monitoring, testing, and emission limits that may be applicable to each installation (Texas Commission on Environmental Quality, 2011[74]). Figure 2.13

presents the first part of the flowchart pertaining to the NESHAP on synthetic organic chemical manufacturing.[17]

Figure 2.13. Part 1 of 6 of the Texas flowchart for establishing permit conditions pertaining to the NESHAP on synthetic organic chemical manufacturing



Source: (Texas Commission on Environmental Quality, 2011[74])

Further, the US EPA and its partners operate numerous compliance monitoring programmes to assure compliance with environmental laws, including to assess and document compliance with permits and regulations.

d Israel

The procedure for determining air permit conditions is prescribed in guidelines issued by the Ministry of Environment Protection, by virtue of the Clean Air Act (2008).

Along with their permit application, industrial operators are required to submit an assessment of the gaps between their current emissions and the BAT-AELs listed in the latest applicable EU BREF or BAT Conclusions. The assessment is provided in an Excel table that lists the BAT-AELs for air emissions. The operators also have to submit a plan for bridging the gaps. The assessment and the plan shall be based on the BAT that would result in maximum reduction of emissions. If the operator wishes to implement a different BAT than this one, they shall include in the application a cost-benefit analysis based on the EU Reference Document on Economics and Cross-Media Effects (EC, 2006[49]), which compares each of the techniques (from the relevant BREF) that would lead to a higher reduction than the proposed alternative. The analysis must include a detailed assessment of the economic efficiency and environmental effects of each of the techniques.

Based on the permit application, the permit issued determines individual ELVs from the range of BAT-AEL values, in addition to the gap bridging plan, including measures for reaching compliance with ELVs as well as for control of diffuse and fugitive emission sources.

For pollutants or processes not covered in the EU BREFs or BAT Conclusions, permit conditions are generally set in accordance with the ELVs in the German Technical Instruction on Air Quality Control (TA-Luft), (BMU, 2002[75]).

The air permits also include conditions concerning the handling of storage tanks, in line with the EU BREF on Emissions from Storage (EC, 2006[76]), and stack height and sampling infrastructure, in accordance with TA-Luft (BMU, 2002[75]). Furthermore, the permits cover requirements regarding the implementation of an environmental management system, sampling and continuous monitoring in accordance with national guidelines, air quality monitoring if the dispersion model raises concern of deviation from air quality standards, and conversion from liquid fuels to natural gas, as applicable.

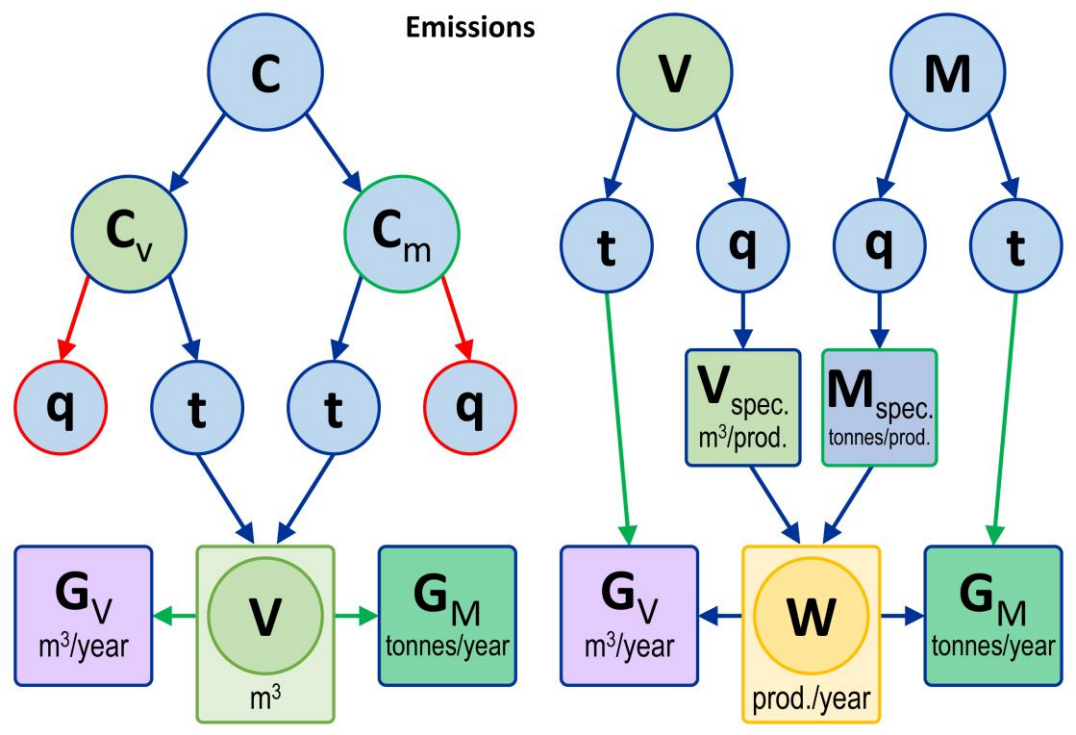
ELVs for permits for industrial waste water discharged to the sewage system are in most cases based on values set in regulations. As for permits for discharges into the sea, individual values are determined. There is no defined methodology for determining them.

e Russian Federation

Integrated environmental permits for industrial installations define maximum quantities of pollutants allowed for emission to the atmosphere and/or water as well as maximum amounts of waste. ELVs in the permits are expressed in tonnes per year and mg/sec (air) or kg/hour (waste water).

A special order (Russian Ministry of Natural Resources and Environment, 2019[77]) sets the rules for how the BAT-based ELVs should be determined. The principles of converting sector-based BAT-AELs into individual, installation-based ELVs is illustrated by Figure 2.14.

Figure 2.14. Interrelatedness of sector-oriented BAT-AELs and ELVs for individual industrial installations



Source: (Skobelev, 2018[35])

Note:
C: concentration (Cv: volume concentration; or Cm: mass concentration);
V: volume;
M: mass;
t: time;
q: units, in which production capacity is measured (tonnes, GJ, m^3 of waste water treated, etc.);
G: annual volume or mass of emission (reported);
Vspec and Mspec: emission factors (emission factors, specific volume or mass of emission, per unit of product); and
W: production capacity (tonnes, GJ, m^3 of waste water treated, etc.) (Skobelev, 2018[35])

In the Russian Federation, existing installations that cannot meet BAT-AELs are required to develop and implement a seven-year Environmental Performance Enhancement Programme (EPEP). The installations have to submit their draft EPEP to the Ministry for Industry and Trade, for assessment by BAT experts and approval by an Inter-Departmental Commission. The installations are to include their approved EPEP in their permit application. Permits are issued by the regional units of the Federal Supervisory Natural Resources Management Service and follow up on the implementation of the EPEPs, to ensure that the installations improve their environmental performance over seven years and thus reach compliance with relevant BAT-AELs (OECD, 2019[7]).

In 2019, first 16 installations were granted IEPs in Russia. These installations represent hydrocarbon exploration, coal, iron and copper ore mining, aluminium, cement, lime, and pulp and paper production sectors. Seven of sixteen installations had to develop EPEPs and will be gradually meeting BAT-AEL requirements in 2020-2026.

Notes

[1] The OECD will conduct further research on value chain approaches to determining BAT in 2020-21, as part of Activity 5 of the BAT project.

[2] See https://emis.vito.be/en/BAT/publications/studies.

[3] See https://navigator.emis.vito.be/mijn-navigator?woId=69985.

[4] See www.burondt.ru/informacziya/texnicheskie-rabochie-gruppyi/.

[5] See https://circabc.europa.eu/ui/group/06f33a94-9829-4eee-b187-21bb783a0fbf/library/5a427270-f380-47ca-96be-4804da6f1bff/details.

[6] See https://tema.miljodirektoratet.no/en/Useful-Sites1/The-Norwegian-PRTR/.

[7] See https://va.minambiente.it/en-GB/Ricerca/AIA.

[8] See https://emis.vito.be/nl/bbt-studies.

[9] See http://wwwen.ipe.org.cn/.

[10] A guidance document on BAT and best environmental practices (BEP) for the implementation of the Minamata Convention on Mercury was adopted by the Conference of the Parties in 2017, as called for in the Convention's Article 8. The guidance document provides BAT and BEP for industrial sectors and activities potentially emitting mercury (that is, coal-fired power plants and industrial boilers, smelting and roasting processes used in the production of non-ferrous metals, waste incineration and cement clinker production) as well as for monitoring of mercury emissions (OECD, 2018[27]).

[11] The Gothenburg Protocol refers to the 2012 amendments to the Protocol to Abate Acidification, Eutrophication and Ground-level Ozone to the Convention on Long-range Transboundary Air Pollution. The protocol requires the implementation of BAT in order to satisfy the obligations concerning the emissions of nitrogen oxides and Volatile Organic Components.

[12] See www.epa.gov/regulatory-information-sector.

[13] Measurement uncertainty related to air emissions monitoring is discussed in a report by INERIS: https://www.cewep.eu/ineris-report-on-monitoring-of-air-emissions/.

[14] See https://www.epa.gov/catc/ractbactlaer-clearinghouse-rblc-basic-information.

[15] See https://www.epa.gov/caa-permitting/caa-permitting-tools-related-resources.

[16] See https://www.epa.gov/npdes/npdes-permit-writers-manual.

[17] The rest of the flowchart is available at https://www.tceq.texas.gov/assets/public/permitting/air/Rules/Federal/63/f/f63f.pdf.

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Annex A. List of BREFs by sectors and activities covered by each jurisdiction

The table below outlines available BAT guidance material from different jurisdictions according to industrial sectors. Readers should keep in mind that sectors can be categorised and defined slightly differently across countries.

Table A.1. List of BREFs by sectors and activities

Sector	European Union: BREFs and BAT Conclusions	Russian Federation: BREFs	Korea: BREFs	US: NESHAP, NSPS, and Industrial Effluent Guidelines	People's Republic of China: Guidelines on Available Technologies for Pollution Prevention and Control (GATPPCs)	India: Comprehensive Industry Documents (COINDs)	International Finance Corporation's (IFC) EHS Guidelines[1]
Agriculture	• Intensive Rearing of Poultry or Pigs	• Intensive rearing of pigs • Intensive rearing of poultry		• Aquaculture (Water)	• Livestock and Poultry Farms	• Cotton Gin Industry	• Poultry Production • Annual Crop Production • Perennial Crop Production • Aquaculture • Mammalian Livestock Production
Forestry	• Wood-based Panels Production			• Timber products processing (Water) • Wood preserving (NESHAP) • Wood building products surface coating (NESHAP) • Plywood and composite wood products (NESHAP) • Wood furniture manufacturing (NESHAP)	• Wood-based Panel Industry		• Board and Particle-based Products • Sawmilling and Wood-based Products • Forest Harvesting Operations
Food	• Food, Drink and Milk Industries • Slaughterhouses and Animals By-products Industries	• Manufacture of food products • Manufacture of beverages, milk and dairy products • Slaughterhouses (meet-processing plants and combined slaughterhouses, refrigeration, and storing of meat plants) and animals by-products	• Food, Drink and Milk Industry • Slaughterhouses and Animal By-products Industry	• Dairy processing (Water) • Meat and poultry products (Water) • Canned fruits and vegetables (Water) • Canned seafood (Water) • Grain mills (Water) • Sugar processing (Water) • Nutritional yeast (NESHAP) • Solvent	• Meat Industry • Sugar Industries • Starch Industry	• Dairy Industry • Slaughter House, Meat and Sea Food Processing • Rice Mills • Tea Processing Industry • Sugar Industry • Khandsari (type of sugar) Industry • Edible Oil & Vanaspati Industry • Starch and Glucose Industry • Soft Drink	• Food and • Dairy Processing • Poultry Processing • Beverage Processing Breweries • Meat Processing • Fish Processing • Sugar Manufacturing • Vegetable Oil Production and Processing

Sector	European Union: BREFs and BAT Conclusions	Russian Federation: BREFs	Korea: BREFs	US: NESHAP, NSPS, and Industrial Effluent Guidelines	People's Republic of China: Guidelines on Available Technologies for Pollution Prevention and Control (GATPPCs)	India: Comprehensive Industry Documents (COINDs)	International Finance Corporation's (IFC) EHS Guidelines[1]
		industries		extraction for vegetable oil production (NESHAP)		Manufacturing Unit, Bakeries and Confectioneries • Fruit and Vegetable Processing Industry • Coffee Processing Industry	
Gas & Oil	• Refining of Mineral Oil and Gas	• Extraction (production) of natural gas • Extraction of (mineral) oil • Refining of (mineral) oil • Refining of natural and associated gas	• Refining of Mineral Oil and Gas	• Extraction of natural gas & oil (NESHAP) • Extraction of natural gas & oil (NSPS) • Extraction of natural gas & oil (Water) • Refinery (NESHAP) • Refinery (NSPS) • Refinery (Water) • Reforming, cracking, and sulfur recovery (NESHAP) • Refinery-equipment leaks (NSPS) • Onshore natural gas production (NSPS) • Onshore natural gas production-equipment leaks (NSPS)	• Petroleum Refining Industry	• Oil Refineries	• Natural Gas Processing • Liquefied Natural Gas Facilities • Offshore Oil and Gas Development • Onshore Oil and Gas Development • Petroleum Refining
Mining	• Management of Waste from Extractive Industries	• Mining industry, general processes and methods • Coal mining and processing • Mining and processing of ferrous metals ores • Mining and processing of nonferrous metals ores • Precious metals mining		• Mineral mining and processing (Water) • Ore mining and dressing (Water) • Mining and processing coal (NSPS) • Mining and processing coal (Water) • Taconite processing (NESHAP) • Gold ore processing and production (NESHAP)	• Mining and Mineral Processing of the Iron and Steel Industry	• Iron Ore Mining	• Mining
Non-ferrous metals	• Non-ferrous Metals Industries	• Aluminium production • Copper	• Non-Ferrous Metals Industry	• Primary Aluminum	• Copper Smelting Industry • Nickel Smelting	• Integrated Aluminium Industry	• Base Metal Smelting and Refining

Sector	European Union: BREFs and BAT Conclusions	Russian Federation: BREFs	Korea: BREFs	US: NESHAP, NSPS, and Industrial Effluent Guidelines	People's Republic of China: Guidelines on Available Technologies for Pollution Prevention and Control (GATPPCs)	India: Comprehensive Industry Documents (COINDs)	International Finance Corporation's (IFC) EHS Guidelines[1]
		production • Production of lead, zinc and cadmium • Production of nickel and cobalt • Precious metals production • Production of rare and rare earth metals		Production (NESHAP) • Primary Aluminum Production (NSPS) • Secondary Aluminum Production (NESHAP) • Primary Copper Production (NESHAP) • Primary Copper Production (Area sources) (NESHAP) • Primary Copper Production (Arsenic) (NESHAP) • Primary Copper production (NSPS) • Secondary Copper production (NESHAP) • Primary lead smelting (NESHAP) • Primary lead smelting (NSPS) • Secondary lead smelting (NESHAP) • Secondary lead smelting (NSPS) • Primary zinc production (NSPS)	Industry • Cobalt Smelting Industry • Lead Smelting • Secondary Lead Smelting • Rare Earth Metallurgical Industry	• Spent Pot Lining Waste from Aluminium Industry	
Iron & Steel	• Iron and Steel Production • Ferrous Metals Processing Industry	• Production of iron, steel and ferro-alloys • Manufacture of ferrous metals processing products	• Iron and Steel Production	• Iron & Steel (Water) • Integrated iron & steel (NESHAP) • Electric Arc (NESHAP) • Electric arc (NSPS) • BOPF steel (NSPS)	• Coking Process of the Iron and Steel Industry • Steel-making Process of the Iron and Steel Industry • Rolling Process of the Iron and Steel Industry • Sintering and Pelletizing Process of the Iron and Steel Industry	• Integrated Iron & Steel Plants • Sponge Iron Industry	• Integrated Steel Mills

Sector	European Union: BREFs and BAT Conclusions	Russian Federation: BREFs	Korea: BREFs	US: NESHAP, NSPS, and Industrial Effluent Guidelines	People's Republic of China: Guidelines on Available Technologies for Pollution Prevention and Control (GATPPCs)	India: Comprehensive Industry Documents (COINDs)	International Finance Corporation's (IFC) EHS Guidelines[1]
Chemicals	• Large Volume Organic Chemical Industry • Production of Polymers • Large Volume Inorganic Chemicals – Ammonia, Acids and Fertilisers • Large Volume Inorganic Chemicals – Solids and Others Industry • Production of Chlor-alkali • Manufacture of Organic Fine Chemicals • Production of Speciality Inorganic Chemicals	• Production of main (large volume) organic chemical substances • Production of polymers, including biodegradable ones • Production of ammonia, fertilisers and inorganic acids • Manufacture of fine chemical synthesis products • Production of other main (large volume) inorganic chemicals • Production of solids and other inorganic chemical substances • Production of speciality inorganic chemicals	• Large Volume Organic Chemical Industry • Large Volume Inorganic Chemicals • Organic Fine Chemicals and Speciality Inorganic Chemicals • Plastic Industry • Fertilizer Industry	• SOCMI[2] (NESHAP) • SOCMI air oxidation processes (NSPS) • SOCMI distillation (NSPS) • SOCMI reactor processes (NSPS) • SOCMI equipment leaks (NSPS) • Misc. Organic Chemical Manufacturing (NESHAP) • Polyether polyols (NESHAP) • Vinyl chloride (NESHAP) • Organic chemicals, plastics, and synthetic fibers (Water) • Gum and wood chemicals (Water) • Acrylic and Modacrylic Fibers (Area sources) (NESHAP) • Acrylic and Modacrylic Fibers (NESHAP) • Cellulosics (NESHAP) • Group I Polymers and Resins (NESHAP) • Epoxy Resins Production and Non-Nylon Polyamides (NESHAP) • Amino/Phenolic Resins (NESHAP) • Group IV Polymers and Resins (NESHAP) • PVC and Copolymers (NESHAP) • Reinforced plastic	• PVC Industry • Pesticide Industry	• Chlor-Alkali Industry • Fertilizer Industry	• Large Volume Petroleum-based Organic Chemicals Manufacturing • Petroleum-based Polymers Manufacturing • Large Volume Inorganic Compounds Manufacturing and Coal Tar Distillation • Nitrogenous Fertilizer Manufacturing • Phosphate Fertilizer Manufacturing • Pesticides Formulation, Manufacturing and Packaging • Oleochemicals Manufacturing • Coal Processing

Sector	European Union: BREFs and BAT Conclusions	Russian Federation: BREFs	Korea: BREFs	US: NESHAP, NSPS, and Industrial Effluent Guidelines	People's Republic of China: Guidelines on Available Technologies for Pollution Prevention and Control (GATPPCs)	India: Comprehensive Industry Documents (COINDs)	International Finance Corporation's (IFC) EHS Guidelines[1]
				composites (NESHAP) • Polymers manufacturing industry (NSPS) • Synthetic fiber manufacturing (NSPS) • Generic MACT I (Acetal resins, polycarb resins) (NESHAP) • Generic MACT II (Ethylene processes) (NESHAP) • Generic MACT II (Spandex) (NESHAP) • Hydrochloric acid (NESHAP) • Phosphate fertilizers (NESHAP) • Phosphoric acid (NESHAP) • Hydrofluoric acid (NESHAP) • Triple superphosphate plants (NSPS) • Triple superphosphate storage (NSPS) • Diammonium phosphate plants (NSPS) • Wet process phosphoric acid plants (NSPS) • Superphosphoric acid plants (NSPS) • Fertilizer production (Water) • Ammonium sulfate (NSPS) • Sulfuric acid plants (NSPS) • Nitric acid plants (NSPS) • Phosphate manufacturing (Water) • Inorganic chemicals (Water) • Carbon black (NESHAP)			

Sector	European Union: BREFs and BAT Conclusions	Russian Federation: BREFs	Korea: BREFs	US: NESHAP, NSPS, and Industrial Effluent Guidelines	People's Republic of China: Guidelines on Available Technologies for Pollution Prevention and Control (GATPPCs)	India: Comprehensive Industry Documents (COINDs)	International Finance Corporation's (IFC) EHS Guidelines[1]
				• Carbon black (Water) • Mercury cell (NESHAP) • Explosives manufacturing (Water)			
Cement	• Production of Cement, Lime and Magnesium Oxide	• Production of cement • Production of lime • Production of magnesium oxide, magnesium hydroxide, magnesium chloride		• Cement production (NESHAP) • Cement production (NSPS) • Cement production (Water) • Lime Production (NESHAP) • Lime Production (NSPS)	• Cement Industry	• Cement Industry	• Cement and Lime Manufacturing
Paper & Pulp	• Production of Pulp, Paper and Board	• Production of cellulose, pulp, paper and board	• Production of Pulp, Paper and Board	• Combustion (NESHAP) • Non-combustion (NESHAP) • Kraft pulp mills (NSPS) • Paper & pulp (Water)	• Wood Pulping Process • Non-Wood Pulping Process • Recycled Fiber Pulping and Papermaking Process	• Large Pulp and Paper Industry • Small Pulp and Paper Industry	• Pulp and Paper Mills
Power Plants	•			• Transmission and distribution (NESHAP) • Transmission and distribution (boilers) (NSPS) • Transmission and distribution (GHG) (NSPS)	• Thermal Power Plant • Coal-fired Power Plant	• Gas-based Thermal Power Plant	• Thermal Power • Geothermal Power Generation • Wind Energy • Electric Power Transmission and Distribution
Manufacturing	• Textiles Industry • Ceramic Manufacturing Industry • Manufacture of Glass • Smitheries and Foundries Industry	• Textiles industry (washing, bleaching, mercerizing, Dying of textile fibres; bleaching, dying of textile products) • Ceramic goods manufacturing • Manufacture of glass	• Textiles Industry • Production of Electronic Parts • Semiconductor Industry • Auto Parts and Equipment Manufacturing Industry	• Textiles (NESHAP) • Textiles (Water) • Clay Ceramics Manufacturing (NESHAP) • Clay Ceramics Manufacturing (Area Sources) (NESHAP) • Porcelain enameling (Water) • Arsenic Emissions from Glass Manufacturing (NESHAP) • Glass Manufacturing Area Sources (NESHAP)	• Dyeing and Finishing of Textile Industry • Ceramic Industry • Glass Industry • Motor Vehicle Industry	• Textile Industries • Ceramic Industry • Glass Industry • Rubber Products Manufacturing Industry • Man-Made Fibre Industry • Asbestos Products Manufacturing Industry	• Textiles Manufacturing • Ceramic Tile and Sanitary Ware Manufacturing • Glass Manufacturing • Foundries • Semiconductors and Electronics Manufacturing • Metal, Plastic, Rubber Products Manufacturing

Sector	European Union: BREFs and BAT Conclusions	Russian Federation: BREFs	Korea: BREFs	US: NESHAP, NSPS, and Industrial Effluent Guidelines	People's Republic of China: Guidelines on Available Technologies for Pollution Prevention and Control (GATPPCs)	India: Comprehensive Industry Documents (COINDs)	International Finance Corporation's (IFC) EHS Guidelines[1]
				• Glass (NSPS) • Glass (Water) • Auto surface coating (NESHAP) • Auto surface coating (NSPS) • Bricks (NESHAP) • Electronic parts (Water) • Semiconductor (NESHAP) • Pesticides (NESHAP) • Pesticides (Water) • Polyurethane foam (Area sources) (NESHAP) • Polyurethane foam (NESHAP) • Rubber tire manufacturing (NESHAP) • Rubber tire manufacturing (NSPS) • Rubber (Water) • Chromium electroplating (NESHAP) • Plating and polishing (NESHAP) • Electroplating (Water) • Smitheries and foundries (Aluminum) (Water) • Smitheries and foundries (Copper) (Water) • Metal molding and casting (Water) • Nonferrous metal forming and metal powders (Water) • Iron and Steel Foundries (NESHAP) • Nonferrous foundries (aluminum, copper, and other) (NESHAP) • Manufacturing of			

Sector	European Union: BREFs and BAT Conclusions	Russian Federation: BREFs	Korea: BREFs	US: NESHAP, NSPS, and Industrial Effluent Guidelines	People's Republic of China: Guidelines on Available Technologies for Pollution Prevention and Control (GATPPCs)	India: Comprehensive Industry Documents (COINDs)	International Finance Corporation's (IFC) EHS Guidelines[1]
				asbestos (Water)			
Construction Materials				• Mineral wool (NESHAP) • Asphalt processing and roofing manufacture (NESHAP) • Asphalt processing and roofing manufacture (Area sources) (NESHAP) • Asphalt processing and roofing manufacture (NSPS) • Hot mix asphalt (NSPS) • Wet formed fiberglass production (NESHAP) • Wool Fiberglass (NESHAP) • Wool Fiberglass (Area sources) (NESHAP) • Wool fiberglass insulation (NSPS) • Paving and roofing materials (Water)			• Construction Materials Extraction
Others in industry	• Large Combustion Plants • Energy Efficiency • Emissions from Storage • Industrial Cooling Systems • Surface Treatment Of Metals and Plastics • Surface Treatment Using Organic Solvents (including Wood and Wood Products Preservation with Chemicals) • Tanning of Hides and Skins	• Burning fuel at large combustion plants for energy generation purposes • Enhancing energy efficiency of economic and/or other activities • Industrial cooling systems • Reducing emissions (waste gas) and effluents (waste water) of pollutants resulting from storage of goods • Surface treatment of goods and products using organic solvents	• Large Combustion Plants	• VOC chemical storage (NSPS) • Industrial cooling systems (NESHAP) • Steel pickling (NESHAP) • Large appliance surface coating (NESHAP) • Large appliance surface coating (NSPS) • Metal coil surface coating (NESHAP) • Metal coil surface coating (NSPS) • Metal coil surface coating (Water) • Metal can coating (NESHAP) • Metal can coating (NSPS)	• Tanning of Hides and Fur Industry • Pharmaceutical Industry • Monosodium Glutamate Industry • Coal to Methanol Industry • Electroplating Industry • Industrial Boilers • Printing Industry • Paint and Ink Industries • Furniture Industry	• Electric Arc and Induction Furnaces • Lime Kilns • Brick Kilns • Siting of rice mills, storage of rice husk and handling of ash generated in rice husk boilers • Stone Crushers • Fermentation Industries	• Pharmaceuticals and Biotechnology Manufacturing • Printing • Tanning and Leather Finishing

Sector	European Union: BREFs and BAT Conclusions	Russian Federation: BREFs	Korea: BREFs	US: NESHAP, NSPS, and Industrial Effluent Guidelines	People's Republic of China: Guidelines on Available Technologies for Pollution Prevention and Control (GATPPCs)	India: Comprehensive Industry Documents (COINDs)	International Finance Corporation's (IFC) EHS Guidelines[1]
		• Surface treatment of metals and plastics using electrolytic or chemical processes • Tanning, dyeing and currying of hides and skins		• Metal furniture coating (NESHAP) • Metal furniture coating (NSPS) • Misc. metal part and products coating (NESHAP) • Plastic parts surface coating (NESHAP) • Plastic parts surface coating (NSPS) • Metal finishing (Water) • Halogenated solvent cleaning (NESHAP) • Paint stripping and misc. surface coating (NESHAP) • Pharmaceuticals (NESHAP) • Pharmaceuticals (Water) • Paper and other web coating (NESHAP) • Printing and publishing surface coating (NESHAP) • Printing and publishing surface coating (NSPS) • Photographic (Water) • Tanning of skins and hides (NESHAP) • Tanning of skins and hides (Water)			

Sector	European Union: BREFs and BAT Conclusions	Russian Federation: BREFs	Korea: BREFs	US: NESHAP, NSPS, and Industrial Effluent Guidelines	People's Republic of China: Guidelines on Available Technologies for Pollution Prevention and Control (GATPPCs)	India: Comprehensive Industry Documents (COINDs)	International Finance Corporation's (IFC) EHS Guidelines[1]
Infrastructure	•			• Airport deicing (Water) • Gasoline distribution bulk terminals, plants, and pipeline facilities (NESHAP) • Bulk gasoline terminals (NSPS) • Gasoline dispensing facilities (NESHAP) • Gasoline distribution (NESHAP) • Natural gas transmission and storage (NESHAP) • Ethylene oxide from sterilizers (NESHAP) • Ethylene oxide from hospitals (NESHAP) • Dental offices (Water) • Hospitals (Water) • Benzene transfer operations (NESHAP) • Marine vessel loading (NESHAP) • Publicly-owned water treatment works (NESHAP)			• Airlines • Airports • Crude Oil and Petroleum Product Terminals • Gas Distribution Systems • Health Care Facilities • Ports, Harbors and Terminals • Railways • Retail Petroleum Networks • Shipping • Telecommunications • Toll Roads • Tourism and Hospitality Development
Waste	• Waste Incineration • Waste Treatment • Common Waste Water and Waste Gas Treatment in Chemical industry	• Waste Incineration • Disposal of municipal waste • Recycling and detoxification of waste • Waste water treatment at larger industries[3] • Waste gas treatment (larger industries) • Waste water and waste gas treatment in chemical industry • Waste water treatment at centralised systems	• Waste Incineration	• Hazardous waste combustion (NESHAP) • Sewage treatment plant incineration (NSPS) • Waste combustors (Water) • Landfills (NESHAP) • Landfills (NSPS) • Landfills (Water) • Off-site recovery (NESHAP) • Oil-water and organic-water separators (NESHAP)	• Disposal of Sludge from Municipal Waste water Treatment Plant • Mercury-containing Waste Disposal • Medical Waste Treatment and Disposal		• Waste Management Facilities • Water and Sanitation

Sector	European Union: BREFs and BAT Conclusions	Russian Federation: BREFs	Korea: BREFs	US: NESHAP, NSPS, and Industrial Effluent Guidelines	People's Republic of China: Guidelines on Available Technologies for Pollution Prevention and Control (GATPPCs)	India: Comprehensive Industry Documents (COINDs)	International Finance Corporation's (IFC) EHS Guidelines[1]
				• Petroleum refinery wastewater systems (NSPS) • Centralized treatment (Water)			
Others	• Economics and Cross-media Effects • Monitoring of emissions	• General principles of industrial production, environmental control (monitoring) and its metrological assurance (support)			• Enterprise Mobility Management • Township-villages		

Source: (OECD, 2018[27])

Notes

[1] The World Bank Group (WBG)'s International Finance Corporation (IFC) has published a set of General Environment, Health and Safety (EHS) Guidelines for Industry. The WBG EHS Guidelines are developed by the IFC, in consultation with the World Bank and the Multilateral Investment Guarantee Agency, and are used by WBG's clients. The guidelines address environmental matters and other issues that potentially apply to all industrial sectors, including community and occupational health and safety, construction and decommissioning. For each guideline, see https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/sustainability-at-ifc/policies-standards/ehs-guidelines.

[2] SOCMI: Synthetic Organic Chemical Manufacturing Industry.

[3] Larger industries: manufacturing products, implementing works and rendering services.

Annex B. Recommended elements for industry surveys aimed at collecting information for the development of BAT Reference Documents

The elements below are largely based on the EU BREF Guidance Document (EU, 2012[5]).

1. General information on consumption, including data on the use of raw and auxiliary materials/feedstocks, water and energy in the relevant processes.

   a. Consumption of raw and auxiliary materials/feedstocks, including, to the extent that it is relevant for the activities concerned:

      i. the quantity of raw and auxiliary materials/feedstocks used (including secondary/recycled material) and composition and whether materials/feedstocks are renewable, and

      ii. an indication of the techniques used (including both the technology used and the way in which the installations are designed, built, maintained, operated and decommissioned) to maximise the efficient use of resources.

   b. Water use, distinguishing between cooling water and process water, and indicate whether water is reused and if so how much. Data/information should include, if relevant for the activities concerned, the items specified below:

      i. Information about the origin of the water used and about the receiving water (e.g. name, type – rainwater, surface water, i.e. lake, river, stream, sea, or ground water; when relevant also temperature, flow, quality).

      ii. Whether treatment of supply waters is carried out on site and an indication of the type of treatment performed (e.g. desalination, filtration).

      iii. An indication of the techniques used (including both the technology used and the way in which the installations are designed, built, maintained, operated and decommissioned) to reduce the consumption of water. If efforts made to reduce water consumption lead to more concentrated effluents, this will be indicated as well as measures taken to minimise the environmental impact of more concentrated effluents.

   c. Energy use, including – if relevant – on:

a. Inputs:

   - The type and quantity of fuel/energy used (e.g. fuel oil, liquefied petroleum gas, natural gas, steam, electricity, waste, biogas, biofuel or biomass used as

fuel), including cooling and technical gases (e.g. N_2, O_2). If steam is used, the temperature and pressure of the steam will be indicated.

- Fuel/energy consumption (per type), making a distinction between thermal and electrical energy.

b. Outputs:

a. Whether energy is produced (e.g. electricity production) and how much. If steam is produced, the temperature and pressure of the steam will be indicated.

b. Whether energy is sold or heat energy is used on or off site (e.g. district heating).

c. Other:

- Whether there is recovered energy and in what part of the installation, under which form and how much.
- Whether there are exothermic reactions and in what part of the installation and how much.
- Heat losses in what part of the installation and how much.
- Whether energy benchmarking is used.

NB: System boundaries (included parts of a plant) and reference conditions should be provided when presenting energy consumption/efficiency values. Energy data should be expressed in a standardised unit of measure, for example kWh or MJ per mass of product (or per mass of raw materials), indicating whether net or gross calorific values were used to determine this.

2. Emissions to water, distinguishing between cooling water and process water, and indicating whether water is reused and, if so, how much. Data/information should include the items listed below, if relevant for the activities concerned.

a. The amount and flow rate of discharged process waste waters as well as an indication of whether exceptional discharges are included.

b. An indication of the sources (e.g. unit processes) of discharged process water.

c. The amount, flow rate and temperature of discharged cooling water.

d. Whether rainwater is collected and treated in the installation and how much.

e. Whether waste waters coming from other plants (including municipal waste waters) are treated in the installation and how much

f. The emission levels (as concentrations and/or (specific) loads if considered relevant of discharged pollutants for each waste water stream considered and whether the waste water is discharged directly or indirectly to the receiving water. The information will also specify whether or not other than normal operating conditions (such as start-up and shutdown operations, leaks, malfunctions, momentary stoppages and the definitive cessation of operations) are included.

g. An indication of whether the water effluents are treated in a waste water treatment plant (WWTP) located on site or off site (e.g. municipal or central for a whole industrial site) of the installation.

h. An indication of the techniques used (including both the technology used and the way in which the installations are designed, built, maintained, operated and decommissioned) to prevent, and where this is not practicable, to reduce emissions to water.

i. The quantity of pollutant(s) before and after the (abatement) technique(s) in order to determine abatement efficiency(ies).

j. Information on conditions/circumstances hampering the use of the (abatement) technique at full capacity and/or necessitating full or partial bypassing of the (abatement) technique and measures taken to restore full (abatement) capacity.

3. Air emissions, including the items listed below, if relevant for the sector concerned:

a. The emission levels (as concentrations and/or (specific) loads if available; of pollutants emitted, making a distinction between channelled (e.g. stack) emissions and non-channelled (e.g. diffuse/fugitive) emissions as well as an indication of whether emissions under other than normal operating conditions (such as start-up and shutdown operations, leaks, malfunctions, momentary stoppages and the definitive cessation of operations) are included. For specific load data, the product referred to should be clearly defined.

b. An indication of whether the gas effluents are treated in a central waste gas treatment plant located on site or off site.

c. An indication of the sources (e.g. unit processes) of both diffuse/fugitive and stack emissions.

d. Flue-gas flow rate.

e. Reference conditions (e.g. concentration data will refer to dry waste gases - if not, this will be indicated - and the reference oxygen content will be mentioned, if applicable).

f. An indication of the techniques used (including both the technology used and the way in which the installations are designed, built, maintained, operated and decommissioned) to prevent, and where this is not practicable, to reduce emissions to air.

g. The quantity of pollutant(s) before and after the (abatement) technique(s) in order to determine abatement efficiency(ies).

h. Information on conditions/circumstances hampering the use of the (abatement) technique at full capacity and/or necessitating full or partial bypassing of the (abatement) technique and measures taken to restore full (abatement) capacity.

4. Residues/waste information submitted should include, if relevant for the sector concerned, the items listed below.

a. General information on the overall efficiency (i.e. the atom economy) of the relevant manufacturing process

b. The type(s) and quantities of residues/waste (e.g. sludge) generated/created by the activity / from the input.

c. The (physical/chemical) characteristics of the residues/waste generated/created by the activity (e.g. metals content, average dry solid content).

d. The specific weight of organic and inorganic residues/waste disposed of and the specific weight which is recycled/ reused internally or externally.

e. An indication of the techniques used (including both the technology used and the way in which the installations are designed, built, maintained, operated and decommissioned) to prevent the generation of residues/waste or, when this is not practicable, to reduce the generation of residues/waste.

5. Other information: The environmental performance and operational data provided should be accompanied by all the relevant general information such as, where applicable:

a. The year the installation was built and commissioned, and an indication of the nature and dates of major retrofits;

b. the type of production processes, catalysts, process equipment (e.g. mill, heat exchanger and furnace) used;

c. the main operating conditions of the process (e.g. continuous or batch process, recurring events such as furnace decoking, catalyst regeneration, production load, process temperature);

d. the different types of products manufactured and how their quality/composition may affect the consumptions/ emissions;

e. measures taken to prevent or, where this is not practicable, to reduce pollution during other than normal operating conditions (such as start-up and shutdown operations, leaks, malfunctions, momentary stoppages and the definitive cessation of operations);

f. measures taken to reduce the likelihood (frequency) and/or environmental effects of incidents/accidents.

6. Reference information that must accompany emission data:

a. For emission data, in addition to the value and unit for the parameter monitored, the information submitted should include, where applicable:

i. the emission source (e.g. reactor, furnace); and

ii. an indication of the type of emission pattern (e.g. minimum/maximum values, percentiles or a graphic presentation).

b. For emission monitoring data, the information submitted should include, where applicable, the items listed below.

i. The frequency of the measurement/sampling/monitoring.

ii. The averaging period used to report the data (see detailed information below).

iii. The type of monitoring method used (e.g. direct measurement, indirect measurement, mass/heat balances, emission factors) and an indication of the EN/ISO (or other) monitoring standard(s) used including the sampling method and sample pre-treatment. If available, the limit of detection (LOD) and the limit of

quantification (LOQ) should be given for the parameter monitored. In cases where the monitoring standard used is not an EN/ISO standard, a description of the standard should be provided.

c. An indication of the measurement/sampling/monitoring uncertainties.

d. Details of the data source, e.g. who collected, analysed and submitted the data.

e. Whether the data was taken during normal operation or under other than normal operating conditions (e.g. start- ups/shutdowns, regular maintenance, exceptional conditions).

7. Averages, ranges and distributions of emission values: When providing emission monitoring information, the period over which the values have been collected and averaged should be unambiguously indicated. Information collected during other than normal operating conditions should be reported separately.

1. The exchange of information should address the performance of plants/installations and techniques in terms of emissions, expressed both as short- and long-term averages, where appropriate. The availability of both types of information, the relevance as well as the feasibility of their collection and subsequent analysis should be discussed at the first meeting of the TWG (the “kick-off meeting”).

2. A set of data containing short-term averages (e.g. half-hourly, hourly, daily averages) covering a longer time span (e.g. one or several years) allows for subsequent calculations of short- and long-term averages and percentiles. Particularly the variation range and distribution functions (e.g. maximum, mean, standard deviation from the spot measurements) of daily or hourly averages collected over a long period of time (e.g. one year or more) is necessary to identify the emission pattern and possible peak emissions that may occur.

3. Yearly averages generally give a good image of the environmental performance related to a process/technique, independently of local disturbances or short-term variations as they include emissions at installation levels from all sources and conditions throughout the year, i.e. in a relative steady-state situation. Yearly averages are also of interest in the context of benchmarking candidate techniques. For yearly averages, it is important to indicate how they were derived or calculated (e.g. from continuous or spot measurements and, if the latter, how many) and if emissions during other than normal operating conditions are included.

A growing number of governments seek to adopt an approach based on Best Available Techniques (BAT) as part of the regulatory framework to prevent and control industrial emissions. Providing guidance on BAT-based permitting is, in the short term, a means to strengthen policy in individual countries. In the long term, it might facilitate greater international harmonisation of procedures to establish BAT and BAT-AE(P)Ls. This would assist efforts to protect human health and the environment across countries, and expand the level playing field for industry.

This document presents a high-level overview of each step of the process to determine BAT, BAT-AE(P)Ls and permit conditions, including information on the principles and factors that should be considered in this process, based on best practices from OECD member and partner countries. It provides references to more detailed information from countries where such approaches are employed, and includes a range of elaborate examples from national and supra-national jurisdictions as well as international conventions. The document promotes an integrated approach to BAT-based environmental permitting.

This is the fourth in a series of documents developed as part of the OECD's BAT project.

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