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

Activity 3:
Measuring the Effectiveness of BAT Policies

OECD
BETTER POLICIES FOR BETTER LIVES

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

Activity 3: Measuring the Effectiveness of BAT Policies

This document was approved by the Expert Group on Best Available Techniques in May 2019, and is published under the responsibility of the Joint Meeting of the Chemicals Committee and the Working Party on Chemicals, Pesticides and Biotechnology.

Please cite this publication as:
OECD (2019), Best Available Techniques (BAT) for Preventing and Controlling Industrial Pollution, Activity 3: Measuring the Effectiveness of BAT Policies, Environment, Health and Safety, Environment Directorate, OECD.

Photo credits: Cover © LALS STOCK/Shutterstock.com

About the OECD

The Organisation for Economic Co-operation and Development (OECD) is an intergovernmental organisation in which representatives of 36 industrialised countries in North and South America, Europe and the Asia and Pacific region, as well as the European Commission, meet to co-ordinate and harmonise policies, discuss issues of mutual concern, and work together to respond to international problems. Most of the OECD's work is carried out by more than 200 specialised committees and working groups composed of member country delegates. Observers from several countries with special status at the OECD, and from interested international organisations, attend many of the OECD's workshops and other meetings. Committees and working groups are served by the OECD Secretariat, located in Paris, France, which is organised into directorates and divisions. The Environment, Health and Safety Division publishes free-of-charge documents in twelve different series: Testing and Assessment; Good Laboratory Practice and Compliance Monitoring; Pesticides; Biocides; Risk Management; Harmonisation of Regulatory Oversight in Biotechnology; Safety of Novel Foods and Feeds; Chemical Accidents; Pollutant Release and Transfer Registers; Emission Scenario Documents; Safety of Manufactured Nanomaterials; and Adverse Outcome Pathways. More information about the Environment, Health and Safety Programme and EHS publications is available on the OECD's World Wide Web site (www.oecd.org/chemicalsafety/)

This publication was developed in the IOMC context. The contents do not necessarily reflect the views or stated policies of individual IOMC Participating Organizations. The Inter-Organisation Programme for the Sound Management of Chemicals (IOMC) was established in 1995 following recommendations made by the 1992 UN Conference on Environment and Development to strengthen co-operation and increase international co-ordination in the field of chemical safety. The Participating Organisations are FAO, ILO, UNDP, UNEP, UNIDO, UNITAR, WHO, World Bank and OECD. The purpose of the IOMC is to promote coordination of the policies and activities pursued by the Participating Organisations, jointly or separately, to achieve the sound management of chemicals in relation to human health and the environment.

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

The Best Available Techniques (BAT) concept is an evidence-based, multi-stakeholder tool that supports the establishment of legally binding emission limit values in environmental permits, to effectively prevent and control industrial emissions to air, water and soil. The European Union's Industrial Emissions Directive defines 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".

By implementing BAT-based policies, governments and industry enable a high level of environmental and human health protection and contribute to achieving progress towards Sustainable Development Goals, notably Target 12.4 on the environmentally sound management of chemicals and waste. Further, the enforcement of BAT-based emission standards ensures a level playing field for industry and fosters more efficient operations.

The implementation of BAT or similar concepts generally requires a high level of resources. There is thus benefit in sharing experience and knowledge amongst OECD member and partner countries on this issue. The OECD Joint Meeting of the Chemicals Committee and the Working Party on Chemicals, Pesticides and Biotechnology, at its 54th meeting in February 2016, approved a new project on BAT for preventing and controlling industrial chemical pollution. The project has been conducted with the financial assistance of the European Union.

The OECD's BAT project sets out to strengthen the performance of BAT policies and practices around the world by exchanging best practices amongst countries that already have a BAT-based policy in place, and by providing guidance to governments considering adopting a BAT-based approach.

The project consists of three activities: (i) compile information on policies and practices embodying BAT; (ii) exchange experiences on how to gather information on techniques and establish BAT; and (iii) assess methodologies for evaluation of the effectiveness of policies and practices embodying BAT or similar concepts by using Pollutant Release and Transfer Register (PRTR) information or emissions monitoring data. The first two activities resulted in the following reports:

i. Activity 1: Policies on BAT or Similar Concepts Across the World.

ii. Activity 2: Approaches to Establishing BAT Around the World

This report is the final output of the third activity and presents the first comprehensive, cross-country analysis of data and methodologies for evaluating the effectiveness of policies that aim to prevent and control industrial emissions using BAT or similar concepts. With ten chapters addressing specific countries or regions, the report examines opportunities for, and barriers to, BAT policy impact assessment in Chile, the European Union (EU) (including specific references to Germany, Sweden and the United Kingdom), India, Israel, Kazakhstan, Korea, New Zealand, the People's Republic of China (hereafter China), the Russian Federation and the United States (US). In doing so, the report provides important guidance to countries seeking to evaluate their policies' effectiveness or wishing to design data systems that can facilitate such evaluations. Where necessary, the report also complements the Activity 2 report with new information on the countries' BAT policies. The key findings from the ten country and region chapters are presented in Table 13.1.

Information analysed in this report was collected through: (i) extensive contact with national experts, notably the members of OECD's designated Expert Group on BAT, through a survey and subsequent information exchange; and (ii) desk research, based on the consultation of online websites, publications and other resources. The draft report was reviewed at the Third Meeting of the Expert Group on BAT in October 2018.

The report presents existing methodologies and projects for evaluation of the impact of industrial emissions policies using BAT or similar concepts, and demonstrates governments' diverse approaches to such evaluations. It provides examples of assessment studies carried out at the local, national and supranational level. Further, the report provides an overview of available quantitative data, such as emissions and activity data, in all the countries and regions covered. The first chapter of the report outlines considerations and data needed for analysing the impact of a BAT policy. For those countries that have adequate data readily available, i.e. Chile, the EU and the US, the report conducts an analysis of SO_2 and PM emission trends in the primary copper and aluminium production sectors (Chapter 2.). Due to limited information on the characteristics and emission limit values applying to each of the facilities investigated, as well as the recent or ongoing implementation of new BAT-related requirements, the analysis does not draw definite conclusions regarding the impact of the industrial emissions policies of each of the three jurisdictions.

In the absence of countrywide, facility or installation level emissions monitoring data, case studies can provide revealing insights into the effects of a policy at the local level. The report includes case studies from several different industrial sectors, including lead smelting, leather tanning, aluminium production, pharmaceutical manufacturing, copper smelting, large combustion plants, oil refinery, waste incineration, the chlor-alkali industry, common effluent treatment plants, zinc smelting, and the pulp and paper industry.

Besides quantitative data sources, the report draws on qualitative information, i.e. stakeholder opinions, on the effectiveness of BAT-based policies. The stakeholders consulted for the development of this report include representatives of government, environmental NGOs, industry and academia.

Acknowledgements

This report is an output of the OECD Environment Directorate. It was prepared under the supervision of the OECD's designated Expert Group on BAT and is published under the responsibility of the Joint Meeting of the Chemicals Committee and the Working Party on Chemicals, Pesticides and Biotechnology of the OECD. The report was prepared by Marit Hjort and Takaaki Ito (OECD Secretariat), and benefitted from consultancy work by An Derden, Caroline Polders and Jan Duerinck (VITO). Review and comments from Krzysztof Michalak, Jean-François Lengellé, Guy Halpern, Bob Diderich and Eeva Leinala along with the editing contribution of Hannah Thabet (OECD Secretariat) are gratefully acknowledged. The authors of this report also drew on work conducted by, and input of expertise from staff of, the OECD Environment Directorate.

Experts consulted for the development of this report include Annalisa Bortoluzzi and Stefan Drees (Business at OECD, BIAC), Sergio Barrientos (ASIQUIM), Christian Brito (the Chilean Ministry of Environment), Ian Hodgson and Alex Radway (Directorate-General for Environment, the European Commission), Gianluca Cusano and Serge Roudier (Joint Research Centre, the European Commission), Klaus Ebert and Katja Kraus (the German Federal Environment Agency), Manoranjan Hota and Jatinder S. Kamyotra (independent environmental experts, India), Deepshikha Sharma (Innovation Centre, Embassy of Denmark, New Delhi), Ayelet Ben Ami and Lihie Iuclea (the Israeli Ministry of Environmental Protection), Aliya Shalabekova (the Kazakh Ministry of Energy), Alia Baimaganova, Abylaikhan Dauletalin and Saltanat Rakhimbekova (the Kazakh International Green Investments and Technologies Center), Philgoo Kang, Cheulhong Kim and Jaewoong Lee (the Korean National Institute of Environmental Research), Peter Dawson (the New Zealand Environmental Protection Authority), Liu Liyuan and Chen Yang (the Beijing Advanced Science and Innovation Centre, Chinese Academy of Science), Tatiana Guseva, Dmitry Skobelev, Alexander Sanzharovskiy and Kirill Schelchkov (the Russian BAT Bureau, Environmental Industrial Policy Centre), Svetlana Sheynfield (UNIDO Center for International Industrial, Cooperation in the Russian Federation), Jamie McGeachy (the Scottish Environment Protection Agency), Spence Seaman (the English Environment Agency), Husamuddin Ahmadzai (the Swedish Environmental Protection Agency), Stephen DeVito (the United States Environmental Protection Agency, Office of Chemical Safety and Pollution Prevention), Cheryl Keenan and Brian Palmer (Eastern Research Group) and Gail Lacy (the United States Environmental Protection Agency, Office of Air and Radiation).

The OECD BAT project has been produced with the financial assistance of the European Union. The views expressed herein can in no way be taken to reflect the official opinion of the European Union.

Table of contents

Tables

Figures

Boxes

Abbreviations and acronyms

AMPD: Air Markets Program Data
APL: Acuerdo de Produccion Limpia (Clean Production Agreement)
BACT: Best Available Control Technology
BAT: Best Available Techniques
BAT-AEL: emission levels associated with the best available techniques
BATIS: Best Available Techniques Information System
BAU: Business as usual
BEP: Best Environmental Practice
BIAC: Business at OECD
BMU: The German Federal Minister for the Environment, Nature Conservation, and Nuclear Safety
BOD: biochemical oxygen demand
BPO: Best Practical Options
BREF: BAT reference document
CEMS: Continuous Emission Monitoring System
CEPI: Comprehensive Environmental Pollution Index
CETP: common effluent treatment plants
COD: chemical oxygen demand
COINDS: Comprehensive Industry Documents Series
CPCB: Central Pollution Control Board
CREP: Charter on Corporate Responsibility for Environmental Protection
DG ENV: Directorate-General for the Environment (of the European Commission)
EC: European Commission
EDS: Environmental Defence Society
EEA: European Environment Agency
EEB: European Environmental Bureau
EF: emission factor
ELV: Emission Limit Value
ENVIS: Environmental Information System
EPA: Environmental Protection Agency
EPIP: Environmental Performance Improvement Programme
ESP: electrostatic precipitator
EU: European Union
GAINS: Greenhouse gas - Air pollution Interactions and Synergies
GATPPC: Guidelines on Available Technologies of Pollution Prevention and Control
HAP: Hazardous Air Pollutant
HELCOM: Baltic Marine Environment Protection Commission
ICSG: International Copper Study Group
IED: Industrial Emissions Directive (2010/75/EU)
IIASA: International Institute for Applied Systems Analysis
IPPC: Integrated Pollution Prevention and Control
LAER: Lowest Achievable Emission Rates

LNG: Liquefied Natural Gas
LVIC-AAF: large volume inorganic chemicals - ammonia, acids and fertilisers
MAC: Maximum Allowable Concentrations
MACT: Maximum Achievable Control Technology
MEE: Ministry of Ecology and Environment (China)
MfE: Ministry for the Environment (New Zealand)
MINAS: Minimum National Standards
MMA: Ministerio del Medio Ambiente
MoEP: Ministry of Environmental Protection (Israel)
MoJ: Ministry of Justice (Russian Federation)
MoNRE: Ministry of Natural Resources and Environment (Russian Federation)
NAAQS: National Ambient Air Quality Standards
NCh: Norma Chilena
NEI: National Emissions Inventory
NES: National Environmental Standards
NESHAP: National Emission Standard for Hazardous Air Pollutants
NGO: Non-Governmental Organisation
NIS: New Israeli Sheqel
NMVOC: Non-methane volatile organic compounds
OCEMS: Online continuous emissions monitoring system
OECD: Organisation for Economic Co-operation and Development
NSPS: New Source Performance Standard
PCDD: polychlorinated dibenzo-*p*-dioxins
PCDF: polychlorinated dibenzofurans
PM: Particulate matter
$PM_{2.5}$: Particulate matter - fraction of particles having an aerodynamic diameter of less than 2,5 µm
PM_{10}: Particulate matter - fraction of particles having an aerodynamic diameter of less than 10 µm
PRTR: Pollutant Release and Transfer Register
RACT: Reasonably Achievable Control Technology
REFIT: Regulatory Fitness and Performance
RMA: Resource Management Act
Snifa: Sistema Nacional de Información de Fiscalización Ambiental
SO_2: Sulphur dioxide
SO_x: Sulphur oxides
SPCB: State Pollution Control Board
TEDA: Tianjin’s Economic and Technology Development Area
THC: total hydrocarbons
TRI: Toxics Release Inventory
TSS: Total suspended solids
UBA: Umweltbundesamt (Germany)
UNECE: United Nations Economic Commission for Europe
UNEP: United Nations Environmental Programme
UNIDO: United Nations Industrial Development Office
US: United States
VOC: Volatile organic compound

Definitions

Term	Definition
Tonne	Metric ton, i.e. 1 000 kg
Ton	United States ton, i.e. 907 kg
Facility	Industrial facility; can consist of several installations
Installation	One of several parts of an industrial facility; can consist of several plants

Executive summary

Industrial pollution prevention and control policies can achieve significant environmental, financial and human health gains. A growing number of countries use Best Available Techniques (BAT) to set industrial emission levels that are rooted in evidence and based on multi-stakeholder dialogue. BAT policies are a trusted means to preventing or reducing emissions from the world's most polluting industries. They are also a tool to 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.

Evaluating the effectiveness of BAT-based policies is essential to enhance their impact and strengthen future policy design. Failing to evaluate the effectiveness of environmental policies can result in governments wasting time and resources on the implementation of inappropriate or inadequate measures. By seeking to understand and assess the impact of a BAT policy, governments can inform and develop tailored and more effective emission limit values in the permits of industrial installations. An evaluation exercise can also facilitate enhanced communication with key stakeholders and the public about the objective, operation and impact of the BAT policy.

The evaluation of a BAT-based policy can aim to assess its effects on industrial emissions, analyse the policy's costs and benefits, or provide useful information to review BAT reference documents. An assessment of how a BAT policy affects emission and consumption trends relies on high-quality monitoring and activity data. A cost-benefit analysis would, in addition, consider the gains accruing to society as a result of the emissions reduction ensured by the policy, such as improvements to human health, the environment and economic indicators, as well as the costs to industry operators of implementing new techniques. Reviews of existing BAT reference documents (BREFs) aim to assess whether the techniques identified as BAT and the associated emission levels (BAT-AELs) reflect the most adequate means to reaching defined emissions reduction targets.

Many countries do not have the most appropriate datasets for an adequate analysis of the effectiveness of BAT-based policies. Governments can facilitate the effectiveness evaluation of BAT-based policies by collecting and publishing data on industrial emissions, production and consumption volumes, environmental permit conditions and techniques installed by individual facilities, whilst taking into account possible confidentially issues. An optimal evaluation of the impact of a BAT policy on emission trends requires readily available emissions monitoring data disaggregated at the level of each installation of an industrial facility, and corresponding activity data. Data from Pollutant Release and Transfer Registers, i.e. publicly available facility level data, can also be an option for the assessment of the BAT policy's impact on industrial emissions. However, even where detailed activity and emissions monitoring data exist, it can be hard to determine whether observed emission trends can be attributed merely to the BAT policy. One way to draw a conclusion in this regard is to assess which other external factors could also affect emission trends, such as other policies or changes to economic activity.

The majority of countries evaluate the effectiveness of their industrial emissions policies, but the methodologies vary greatly. For example, the European Union (EU) has an objective to review its BREFs every eight years in addition to frequently conducting assessment studies of the impact of its Industrial Emissions Directive (IED) at the supra-national and national levels. Korea sets out to update its BREFs every five years based on regular assessments of their field applicability. Israel has published a report estimating the expected impact of BAT on emissions, and the US EPA recently issued a report assessing the effect of federal and state regulations on emissions of pollutants to air. Chile and the People's Republic of China have official methodologies developed by the governments to guide the evaluation of environmental programmes and regulations, but no evaluation of industrial emission policies has yet been completed using these methodologies.

There are several advantages of existing BAT-based policies, with positive implications for the environment as well as industry. European industry representatives highlight that the IED creates a level playing field for industry, aligning environmental performance requirements for industrial installations. The Russian BAT Bureau stresses that their BAT policy will likely foster enhanced resource efficiency and an upgrade of industry. Case studies show that the implementation of BAT can ensure considerable savings to society, due to improved air quality, but also to industry, as a result of more efficient operations. Representatives of the European Commission further note that the integrated approach to pollution prevention and control is an important advantage of the EU's BAT policy. Other stakeholders highlight that the participatory approach is gaining traction as a result of BAT-based projects, as illustrated by initiatives in countries with emerging economies such as India and Pakistan.

Measures could be taken to leverage the untapped potential of BAT policies. For example, although beyond the current European legal definition of BAT, the European Commission notes that there might be value in looking at a wider life cycle approach to BAT determination. Whilst already a highly cooperative process, representatives from European industry associations and environmental NGOs advocate increasing the transparency of the procedures for the determination of BAT and BAT-AELs. Korean and Russian government representatives observe the shortage of capacity of competent authorities, and the Israeli government stresses that strengthened inspection routines are needed. The European Environmental Bureau recommends that more adequate emissions monitoring systems and user-friendly databases be established, enabling easy and timely gathering of performance data for compliance assessment, policy development and public awareness raising. Recent OECD research (OECD, n.d.[1]) concludes that, for some countries, having wider inclusivity in the selection of industry experts involved in the determination of BAT would be of value, to ensure that techniques identified as BAT are the *best available* techniques worldwide, developed at a scale that enables implementation in the relevant sector under economically and technically viable conditions.

Further research is needed to strengthen existing and future BAT-based policies. To that end, the OECD will continue its ongoing BAT project by developing guidelines on how to determine BAT, derive BAT-AELs and translate BAT-AELs into emission limit values in permits. Further, the OECD will be conducting a study on value chain approaches to determining BAT for industrial installations, and cross-country comparisons of BAT and BAT-AELs for selected industrial sectors, in order to foster enhanced knowledge sharing

Part I. Key elements of effectiveness evaluations of BAT policies

Chapter 1. Evaluating the effectiveness of BAT policies

This chapter examines the value and objectives of performance evaluation of governmental policies and programmes, and provides an overview of the types of data and methodologies that can be used to evaluate the effectiveness of BAT policies. This includes methodologies for detailed process-level cost-benefit analyses as well as for high-level emission and consumption trends analyses. Due to limited publicly available data on the elements required for a cost-benefit analysis, the chapter primarily considers options for analysis of emission trends. Amongst others, the chapter describes approaches to such analysis under different data availability scenarios.

1.1. The value of evaluation

Evaluation of governmental programmes and policies is an essential tool to understanding and assessing their effectiveness (Newcomer, Hatry and Wholey, 2015[2]; EC, 2013[3]). Feedback and evaluation allow the effects of past actions to be measured, including both process and substantive programme outcomes, as well as to strengthen future decisions, and thus benefit governments and the public alike by helping develop faster and better solutions (Madden, 2016[4]; Coglianese, 2012[5]). The performance evaluation of a policy instrument can enable strengthened administration of current policy, and feed into a process of policy reappraisal and enhancement based on empirical evidence. Notably, evaluations can help improve the choice of future policy instruments by demonstrating and analysing the functioning of a certain instrument in a specific context, often facilitating policy makers' learning from approaches adopted in other countries (OECD, 2005[6])

Evaluation can also facilitate enhanced communication with relevant stakeholders and the public about the objective, operation and impact of a policy, programme or specific instrument (OECD, 2005[6]). According to the World Bank, with policy makers and civil society demanding accountability from public programmes, impact evaluations can provide robust and credible evidence on performance as well as on whether a particular programme has achieved its desired outcomes (Gertler et al., 2011[7]). The European Commission observes that "[e]valuation is a key Smart Regulation tool, helping the Commission to assess whether EU actions are actually delivering the expected results and ultimately improving conditions for European citizens and businesses and contributing to the EU's global role" (EC, 2013[3]).

Evaluation of BAT policies are an invaluable tool to policy makers and industry operators, as it informs and facilitates the development of more effective and tailored BAT and emission limit values in permits. Moreover, BAT policy impact assessments can be beneficial in order to demonstrate that environmental policies deliver adequate results in an effective manner, so as to convince the public and politicians about their importance.

An adequate BAT policy impact assessment aims to analyse the causal relationship, and show any gap, between the policy's objectives or desired outcomes and the trajectory of the results derived from the evaluated instrument – i.e. BAT – or the lack thereof. The objective of a BAT policy is generally to reduce the environmental impacts of industrial operations in a cost-effective manner without hampering other aspects of the operations (as opposed to reducing the environmental impact by closing industrial facilities), contributing to a high level of environmental protection. This objective is often accompanied by specific, quantified targets with a clearly defined timeline for attainment.

Evaluations are more likely to result in meaningful evidence about the performance of a policy instrument if they are well informed, objective and based on good research practice (OECD, 2005[6]). While quantitative data provide for the most robust assessment of the effect of BAT policies, qualitative data may complement the analysis and provide useful insights into different stakeholders' perception of the policy. Qualitative data can, however, be subject to bias.

1.2. Approaches to effectiveness evaluation of BAT policies

1.2.1. Options for evaluation

Evaluating the effectiveness of a BAT policy can involve assessing the policy's impact on emission trends, i.e. on the concentration, mass or percentage of industrial emissions, assessed against the policy's defined objectives and a *business as usual* scenario. The assessment may also consider the impact of declining emission trends on the negative externalities associated with industrial pollution, by measuring improvements in human health, the environmental and economic indicators. This could include assessing changes in concentrations or relative proportions of key indicator pollutants in environmental media, and the amount of hazardous substances generated in production processes, as well as the resulting changes in, inter alia, environmental impacts, resource use, mortality and morbidity rates attributed to environmental quality.

The effects of industrial air emissions on human health and the economy have been projected by the OECD (2016[8]) by assessing the market costs of outdoor air pollution, i.e. on productivity, health care expenditures and changes in crop yields, and the non-market health impacts of pollution, including on individual willingness-to-pay for reducing health risks, using the OECD's ENV-Linkages model. ENV-Linkages is a multi-sectoral, multi-regional model that links economic activities to energy and environmental issues. Industrial emissions constitute one of the key sources of air pollution, together with fossil-fuel based power generation, transport and burning of traditional biomass in the residential sector (OECD, 2016[8]). For example, in OECD countries, emissions from power stations, industrial combustion, and industrial processes and product use, accounted for approximately 90% of SOx emissions, 40% of NOx emissions and 20% of PM10 emissions over the period 2014-16. (Fugitive emissions from production processes come in addition to this) (OECD, n.d.[9]). Therefore, this kind of model could feed into an analysis of the impact of air pollution caused by industrial emissions on human health and the economy, and thus be part of a BAT policy effectiveness assessment.

A comprehensive and detailed process-level cost-benefit analysis of a BAT policy could involve comparing the likely benefits of the policy, i.e. reduced industrial emissions, gains in productivity, and health and environmental costs (i.e. damage costs) avoided, to the cost to industry operators of implementing improved techniques in order to comply with permit conditions. For a cost-benefit analysis, emission reductions should be estimated for a period equivalent to the lifetime of the emissions reduction techniques and/or the envisaged operating time of the operator, and taking into account the conditions of use of the techniques. A cost-benefit analysis would allow quantifying whether the emission reductions and other benefits achieved through the policy outweigh the costs of its implementation, and thus help assess the policy's value to society.

Fully understanding and obtaining supporting data on industry operators' costs to BAT implementation can be difficult, notably if industry operators cannot provide such data, e.g. due to legal requirements or confidentiality issues. Even where such data are available, the proportion of the cost due to BAT-related requirements relative to other factors can be uncertain. Further, it may not be obvious how these costs compare to industry operators' costs under a business as usual scenario. Estimating the damage costs avoided can also be challenging, both in terms of data access and methodology. For example, available methodologies and data for monetising the complete health and environmental benefits of the avoided emission of certain pollutants, accounting for short-term or long-term effects and local situations, create uncertainties in the estimates. (EC, 2018[10]).

An alternative to a process-level cost-benefit analysis of a BAT policy is a high-level assessment of its impact on emissions trends. In many cases, this can be based on publicly available data. The object of such an analysis is to investigate the emission reductions that can be achieved by reaching compliance with BAT-associated emission levels. While a high-level emissions assessment cannot estimate the cost-benefit of a BAT policy, it can determine the practical effects of the measures deployed.

1.2.2. Reviews of BAT reference documents

In addition to evaluating the impact of BAT policies overall, it is essential to assess the effectiveness of the BAT themselves, as part of regular reviews of BAT reference documents (BREFs). Such evaluations consist of assessing whether the techniques defined as BAT are indeed still the *best available* techniques, reflective of the most recent technological developments of the concerned industrial sector, or whether there would be more optimal ways of reaching the defined objectives. The frequency with which BREFs are reviewed varies across countries. The EU Industrial Emissions Directive sets the objective to review each BREF every eight years in order to reflect technical progress. Korea sets out to update BREFs every five years, based on information resulting from various evaluation exercises, such as of the applicability of existing BREFs. The Russian Federation has not yet agreed on a BREF review cycle, but the Russian BAT Bureau acknowledges the importance of establishing an environmentally sound and economically feasible rationale for the revision of the country's first set of BREFs. The United States' Clean Air Act (US EPA, n.d.[11]) requires that a risk and technology review be conducted eight years after setting technology-based standards for hazardous air pollutants.

1.2.3. Ex post versus ex ante evaluations

The effectiveness of a BAT policy can be assessed ex post or ex ante. Ex post analysis is based on historical observations and seeks to quantify the impact of a BAT policy *after* its implementation, while ex ante analysis aims to predict the quantified impact of a policy *prior to* its implementation. There is a long tradition for ex ante regulatory impact assessment in many OECD countries, with established analytical steps (OECD, 2008[12]) and opportunities for public engagement to hold governments accountable for conducting analysis before regulations or policies are issued (Dudley, Wegrich and Wegrich, 2015[13]). Ex ante assessments aim to determine whether something that has not yet been done should be done, e.g. whether public money should be spent on the introduction of a certain policy (OECD, 2018[14]). Ex ante analyses relies on hypotheses, i.e. unverifiable assumptions and models, of what the world would look like without a given governmental policy, and how responses to, and effects of, the policy will alter those conditions. With strong ex post policy evaluations conducted after the introduction of a policy, stakeholders could test the hypotheses from the ex ante evaluation against actual outcomes. This would not only inform decisions related to the effectiveness of existing policy, but would provide feedback that would improve future ex ante analyses and future policies (Dudley, 2017[15]).

Ex post evaluations take a retrospective approach, seeking to verify whether a policy that has been implemented should have been implemented, i.e. assess the actual outcomes of a policy after its implementation (Dudley, 2017[15]) (OECD, 2018[14]). While it is impossible to reverse actions already taken, an ex post assessment can help cast light on the accuracy of the conclusion of an ex ante evaluation, the policy modifications that are needed to deliver the original aims or on the decision that originally was used to justify the introduction of the policy or programme. In both cases, the outcome of the ex post assessment is designed to contribute to learning about what does and what does not contribute to achieving progress towards defined objectives and thus improve future policies (OECD, 2018[14]). By verifying hypotheses and assumptions regarding causation and outcomes, an ex post evaluation also helps inform future ex ante evaluations (Dudley, 2017[15]). It can, however, be difficult to conduct an ex post evaluation, as it is not always obvious what the world would have looked like without the policy that is being evaluated (the so-called ‘counter-factual’); measuring benefits and opportunity costs can be hard. Further, once a policy or regulation is in place, regulators or policy makers do not necessarily have strong incentives for examining its effect (Dudley, 2017[15]).

Many countries have BAT policies that have not yet taken full effect, making it preferable to opt for an ex ante assessment of their possible effectiveness, be it at a national, sectoral or operator level. Prior to taking measures to prevent and control industrial emissions in order to ensure compliance with BAT-based emission standards, an industry operator may want to conduct an ex ante evaluation of these measures as well as a baseline assessment of current emissions. Such assessments can serve as a basis for future ex post assessment, for example at the operator’s level. If no baseline is established or the necessary data are not gathered through the implementation period, conducting an ex post evaluation will not be possible. The data that will have to be collected, from the baseline and forward, in order to inform an ex post evaluation of the effectiveness of a BAT policy include emissions monitoring data at facility level or, ideally, at installation level, activity data at a corresponding level, and BAT-associated emission levels and/or the emission limit values of individual facilities. The effectiveness evaluation is further facilitated if information on the emission reduction techniques installed by facilities is also collected. The data sources that enable ex post evaluations of the impact of BAT policies on emission trends are further outlined in Section 1.3 below.

1.3. Useful data sources for analyses of the impact of BAT policies on emission trends

Carrying out a high-level, quantitative analysis of the effects of a BAT policy on emission trends requires access to readily available sources of accurate data, comparable across years and for an adequate period of time. Emissions trend assessments can be conducted for a period equivalent to the lifetime of the emissions reduction techniques, or alternatively – and often more easily done – for a few years or one specific year, as this also provides useful information on the effectiveness of a BAT policy. The most important data sources for analysis of the effect of BAT policies on emission trends are presented below.

1.3.1. Emissions monitoring data

Emissions monitoring data are, obviously, an essential source of information for the assessment of a BAT-based policy’s impact on emission trends. An industrial facility has several emission points at which monitoring can be carried out. Each emission point is connected to one or more installations. The assessment of the impact of a BAT policy on emission trends should ideally be based on emissions monitoring data collected at installation level, as BAT-associated emission levels (BAT-AELs) are usually defined at installation level, and as this allows emissions to be linked to specific processes and related BAT-AELs. Monitoring data from the emission points are usually expressed in mass per volume, resulting from a calculation based on concentration and total flow. When using such data to assess the impact of a BAT policy, it is essential to have information on which installations are connected to each of the emission points.

Monitoring at emission points can be done either by Continuous Emissions Monitoring Systems (CEMS) or by analysing samples taken with a certain frequency. In both cases, the concentration of pollutants in flue gas or wastewater streams is measured. Emission loads are calculated as the product of the flue gas or wastewater flow, the concentration and the operating time. Emissions monitoring data include average concentrations, flue gas or water flows, operating time and total emission loads disaggregated at the level of each industrial installation. Such data are the most suited for analysing the effectiveness of BAT policies.

The availability of emissions monitoring data collected at installation level varies largely across countries, depending on requirements for data reporting and disclosure, the level of detail of data reported to competent authorities and the transparency of the plant operators. Many countries do not publish installation level emissions monitoring data, but rather data that are aggregated at the level of each facility (i.e. covering several installations). Facility level data are often published in a Pollutant Release and Transfer Register (PRTR). More information on PRTRs is available in Box 1.1.

Box 1.1. Pollutant Release and Transfer Registers

A Pollutant Release and Transfer Register (PRTR) is an environmental inventory of chemical substances and/or pollutants that are harmful or potentially pose risks to human health and/or the environment, released by industrial facilities to air, water and soil or transferred off-site for treatment and disposal. Two of the key elements of a PRTR are that data are publicly available and that reporting is periodic. PRTR data represent the total annual emission releases during normal operations and accidents at facility level. Emissions reported to PRTRs are usually expressed in mass/year, i.e. loads, at facility level.

The Revised OECD Core Set of Environmental Indicators (OECD, 2013[16]) points to PRTR data as a possible indicator for measuring toxic contamination, which is one of the key items on the OECD's list of major environmental issues.

Numerous countries have developed PRTRs. Following the adoption by the OECD Council of a Recommendation on Implementing PRTRs (OECD, 1996[17]), 35 Adherents to the Recommendation have set up an operational PRTR, and 40 non-Adherents have developed, or are currently developing, a PRTR. Based on the accumulated experience and knowledge resulting from the widespread implementation of PRTRs, the OECD Council adopted an updated version of the Recommendation in 2018 (OECD, 2018[18]) which covers not only the establishment of PRTRs, but also their operation.

The UNECE Kyiv Protocol (UNECE, 2003[19]) imposes binding PRTR requirements on signatories. Its impact is significant, since it is the only legally binding international instrument on PRTRs.

The EU PRTR - known as E-PRTR - contains data for 91 substances. The US PRTR – the Toxic Release Inventory – covers 692 substances, the Korean PRTR includes data on 415 substances, whilst Chile's and Israel's PRTRs cover 130 and 114 substances, respectively. In most PRTR systems, releases and transfers must be reported only if the emissions of a facility are above the activity and/or pollutant thresholds. This is not, however, the case in Norway, where all data on all releases are made public. Spain also requires reporting of all releases; however, only data above the thresholds are made public.

The OECD's Working Group on PRTRs (WG-PRTRs) has proposed a harmonised list of 126 substances (OECD, 2014[20]) that should be part of all PRTRs in order to increase the comparability of data derived from various PRTR systems. In addition, the WG-PRTRs has proposed a harmonised list of reporting sectors (OECD, 2013[21]) for enhancing the comparability of PRTRs.

1.3.2. Environmental permits

Environmental permits are particularly useful for analysing the emission trends of specific industrial facilities, as they contain valuable reference information, such as emission limit values (ELVs), to which emissions monitoring data can be compared in order to measure compliance with the ELVs. ELVs can be defined for each individual process, or installation, in a facility. In specific cases, e.g. in some EU countries, the ELVs could be more stringent than the lower limit of the BAT-AELs range, as a means to reach local environmental quality standards. In some countries, where there are no BAT-AELs determined at the national level, access to information on ELVs in individual permits is crucial for policy impact assessments, as they allow measuring reported emissions against defined targets.

Permit-related information, such as on the drivers for setting a certain ELV, can also help analyse emission trends. In addition to ELVs, permits may contain data on production capacities, description of installations, etc. Further, permit information is notably useful to conduct a sampling or analysis of a selected share of industrial facilities, e.g. the biggest polluters.

While this is not the case everywhere, some countries make permit information publicly available online, such as Ireland and the UK. This largely facilitates effectiveness evaluation of BAT policies.

1.3.3. Activity and capacity data at installation level

Industrial emissions are the result of economic activities, i.e. the production of certain quantities of goods in industrial facilities. Therefore, comparable annual activity data - at an aggregation level corresponding to that of the available emissions monitoring data (ideally disaggregated at the level of each installation) - are necessary for an adequate assessment of the impact of BAT policies on emission trends. Activity data express quantities of production in, inter alia, monetary units, as an index relative to a base year, or in physical units such as weight, area or volume.

It is often hard to access activity data (i.e. production or consumption data) that are disaggregated at the level of each industrial installation and thus can be used for an adequate quantitative analysis of the effectiveness of a BAT policy. If activity data are not available, capacity data can be a useful indicator of production at the level of individual installations. Certain countries, such as Norway[1], make activity data publicly available through their PRTR, including annual flow rates to water and air per facility. This way the effective environmental performance, i.e. inputs and outputs, can be assessed.

For some industries, activity data are published by international sector associations, such as the International Copper Study Group and the International Manganese Institute. Activity data are also contained in Greenhouse gas - Air pollution Interactions and Synergies model (the GAINS model) of the International Institute of Applied Systems Analysis (IIASA), which were used by Ricardo Energy & Environment (EC, 2018[10]) to estimate emissions reductions in the EU iron and steel sector. GAINS defines activity data as “data on anthropogenic activities that are used by the GAINS for calculating emissions” (IIASA, 2009[22]). The GAINS model uses activity data for past and future years, on energy use, industrial processes, agriculture and transport. In addition, the GAINS database holds data that supplement the activity projections (IIASA, 2009[22]).

1.3.4. Emission levels associated with BAT

In addition to ELVs for individual facilities, BAT-associated emission levels (BAT-AELs) are crucial for the assessment of the impact of a BAT policy, as they form defined objectives against which emissions monitoring data can be measured, in order to assess whether these objectives have been attained. The EU Industrial Emissions Directive (IED) (EU, 2010[23]) defines BAT-AELs as the range of emission levels obtained under normal operating conditions using a BAT or a combination of several BAT, expressed as average concentrations at installation level over a given period, under specified reference conditions. This range forms the basis of emission limit values in permits. EU BAT-AELs are stated in the BAT reference documents (BREFs) and in the BAT Conclusions (the key part of a BREF). Under the IED, there are also other BAT Associated Environmental Performance Levels, which are relevant for the assessment of resource and energy consumption or waste generation. In the Russian Federation, the BAT-AELs are published in BREFs and in Orders of the Ministry for Natural Resources and Environment. In Korea the BAT-AELs are also stated in the BREFs.

1.3.5. Information on techniques

Knowledge of the applied production process enables enhanced understanding and interpretation of emissions data. Relevant descriptions of techniques and processes may be available through various sources, for example in the EU's BAT reference documents (BREFs). Access to information on the exact prevention and control technique applied by a given facility – currently and/or in the past – is crucial for the analysis of the emission trends resulting from a BAT policy, notably in cases where several technique options exist. The US Environmental Protection Agency facilitates access to such information, through its Air Markets Program Data (AMPD) website[2]. The website allows real time query searches to obtain detailed information on various BAT used in a given sector. For example, the website contains information on specific attributes for large combustion plants, such as types of boilers, categories and subcategories of techniques. For mercury abatement, information on the chemical additives can easily be consulted. Further, AMPD demonstrates that with adequate IT technology, it is feasible to publish continuous emissions monitoring data online within one month.

In Israel, information on which techniques will be applied by each industry operator in order to achieve compliance with ELVs is usually included in their individual environmental permit and/or permit application, and is publicly available online.[3] The techniques that will be used for each installation are determined in dialogue between the industry operator and the permitting authority, and must be based on a cost-benefit analysis, as well as on considerations of emission characteristics, prevention of malfunctions and reduction of the overall effects of emissions to the environment (see Section 6.1.2).

In cases where information on techniques adopted is not available, assumptions on technology uptake can be used to estimate emission reductions, in combination with activity data (EC, 2018[10])

1.4. Methodology for analysis of emission trends at installation level

1.4.1. Methodology

Depending on the level and quality of data available, different approaches can be taken to assess a BAT policy's impact on emission trends at installation level.

Using activity data, an *emission factor* (i.e. a representative value that attempts to relate the quantity of a pollutant released to an activity associated with the release of that pollutant (US EPA, n.d.[24])) can be calculated by dividing the emissions by the yearly activity level. A common approach to estimating emissions reductions is to develop one emissions scenario based on the assumption that the BAT policy has not been implemented (business as usual, or BAU), and one policy scenario in which the BAT policy has been implemented (POL), for a given period of time (e.g. 5/10-15 years). The emissions reduction is calculated as the difference between the BAU and POL scenarios over the period of time considered. For any emissions scenario for a typical installation, this can be expressed as shown below, with *EF* referring to emission factor.

$$Emissions\ (tonne, kg, \dots) = \ Activity * \ EF$$

Using index *i* for the different installations in one industrial facility and *j* for the different facilities of one sector in a particular region, the formula expressing the sector-specific emissions in this region is as follows:

$$Total\ Emissions\ in\ a\ sector\ (tonne, kg, \dots) = \sum_j \sum_i \ (Activity_{i,j} * \ EF_{i,j}\ )$$

In this case the units for the activity and the emission factor (EF) should be consistent. As shown by Table 1.1, several options can be considered.

Table 1.1. Options for expressing units for *activity* and *emission factor* in a quantitative analysis

Unit of measure	Activity	Emission Factor (EF)	Domain
Emissions in tonnes	Tonnes of yearly production	Tonnes emitted/tonnes produced	Air/water
Emissions in kg	Yearly flue gas volume (1 000 000 m³)	Yearly average concentration (mg /Nm³)	Air
Emissions in kg	Yearly wastewater stream (1 000 m³)	Yearly average concentration (g/m³)	Water
Emissions in tonnes	Index (base year = 1)	Tonnes emitted in base year	Air/water

Source: Developed by the authors

The activity is usually based on assumptions regarding how demand is likely to evolve, often referring to external sources like economic growth projections or based on expert judgement. It is generally assumed that a BAT policy has no impact on the activity's production output, whereas it does have an impact on the emission factor. A critical element is thus the determination of the emission factors $EF_{BAU,i}$ and $EF_{POL,i}$, and how these relate to the BAT policy. In many cases the BAT are linked to BAT-AELs, expressed as concentrations. When BAT has no impact on the activity's production output, the reduction of emissions at the facility level is given by:

$$Emission\ reduction = \sum_i \ (Activity_i * \times (EF_{bau,i} - EF_{pol,i})$$

1.4.2. Data availability scenarios

The extent to which the above methodology can be used to assess the emissions trends resulting from a BAT policy depends on the level of the data available. The section below describes different approaches to evaluating the effectiveness of a BAT policy, relating to five data availability scenarios.

i. Emissions monitoring data and activity data at installation level are available for a period of time covering years *before and after* the implementation of the BAT policy: This allows emissions to be compared before and after the implementation of the policy, accounting for changes in economic activity. $EF_{BAU,i}$ is based on the historical data before the implementation of BAT (e.g. an average of data of some years before the BAT policy was implemented). $EF_{POL,i}$ is based on data after the implementation of the BAT policy.

ii. Emissions monitoring data and activity data at installation level are only available for a period *after* the implementation of the BAT policy: An estimation can sometimes be made for $EF_{BAU,i}$, based on activity data and adequate knowledge of the concerned production process and related emissions.

iii. Emissions monitoring data and activity data at installation level are only available for a period *before* the implementation of the BAT policy: This might be the case if the BAT policy has been implemented recently, and is not yet fully operational. In this case one may make an estimation for $EF_{POL,i}$ based on the following principles:

iv. $EF_{BAU,i}$ x $Activity_{BAU,i}$ < BAT-AEL => $EF_{POL,i}$ = $EF_{BAU,i}$: installation already complies with BAT-AELs

v. $EF_{BAU,i}$ x $Activity_{BAU,i}$ > BAT-AEL: installation does not comply– action required to comply with BAT-AELs

vi. Emissions monitoring data are only available at facility level (PRTR data): In this case, conducting an adequate analysis of emission trends is more difficult because the BAT-AELs often are expressed as concentrations at installation level, whereas PRTR data are expressed as loads at facility level. PRTR data can be compared to BAT-AELs in cases where the BAT-AELs are expressed as a load of pollutant per production volume (provided that activity data are available). The approach will have to be determined on a case-by-case basis, and will differ depending on whether PRTR data are available for the periods before and after the implementation of the BAT policy. One option, explored in a report for the European Commission by Ricardo Energy & Environment (EC, 2018[10]), could be to compare past and current BAT-AELs to derive emission reduction factors, which in turn can be compared to PRTR emissions data in order to produce emission reduction estimates.

vii. No emissions monitoring data are available: Estimations can sometimes be made for both $EF_{BAU,i}$ and $EF_{POL,i}$ based on activity data, adequate knowledge of the production process as well as historical emissions information. A critical factor is the relationship between BAT-AELs expressed as concentrations and emissions reported as loads. If activity data are available in physical units (tonne and/or cubic metres) and the processes are well documented in the BREF, it is often possible to make the necessary linkages between BAT-AELs and historical emissions information to estimate recent emissions

Notes

[1] See https://www.norskeutslipp.no/en/Frontpage/.

[2] See https://ampd.epa.gov/ampd/.

[3] See http://www.sviva.gov.il/subjectsEnv/SvivaAir/LicensesAndPermits/PermitEmission/Pages/default.aspx.

Chapter 2. **Trends in emissions from copper and aluminium production**

This chapter is based on data from sources presented in Chapters 3-5 and attempts to evaluate the effects of BAT-based (or similar) policies on emissions of SO_2 and PM_{10} from primary copper and aluminium production in Chile, the EU and the US, using publicly available emissions monitoring data. The analysis presents relevant data sources, and compares emission and production trends across countries. Further, the chapter investigates selected regulations and BAT-associated emission levels that are relevant to primary copper and aluminium production. In so doing, the chapter provides important insights into pollution trends in the three economies. However, the analysis does not attempt to draw definite conclusions regarding the impact of the industrial emissions policies of each of the three jurisdictions, due to the following limitations: (i) the lack of data from the period before adoption of current industrial emission policies; (ii) the absence of readily available installation level data for the EU and Chile; (iii) limited information on the characteristics and emission limit values of each of the facilities investigated; (iv) the partially restricted comparability of data across countries; and (v) the ongoing implementation of new BAT conclusions in the EU, which impact cannot be assessed until after the compliance deadline in 2020.

2.1. Introduction and key findings

This chapter draws on the data sources presented in Chapters 3-5 to reveal trends in SO_2 emissions from primary copper production in Chile, the EU and the US, and SO_2 and PM_{10} emissions from primary aluminium production in the EU and the US. Amongst the countries and regions considered in 0 of this report, these three are the only ones for which sufficient emissions data for these sectors and pollutants are readily available. This chapter consists of two sections, which provide an overview of available emissions and activity data sources pertaining to each of the two industrial sectors, before presenting emission and production trends in the light of relevant emissions reduction policies. Annexes 2.A and 2.B describe the processes for primary copper and aluminium production as well as outlines the most relevant BAT that apply to these processes in the EU.

For the EU Member States, emissions data are available in the E-PRTR[1] – if greater than reporting thresholds – for the period 2007-2016; however the analysis in this chapter cover the years 2009-2015.[2] The US Environmental Protection Agency's National Emissions Inventory (NEI)[3] compiles data every three years, with data currently being available for 2008, 2011 and 2014; processing of the data for 2017 is ongoing. NEI provides data in tons (i.e. units of 907 kg), but for the analysis in this chapter, the figures have been converted into metric tonnes. As regards Chile, SO_2 emissions data for primary copper smelters are available in the Sistema Nacional de Información de Fiscalización Ambiental (Snifa)[4] for the period 2014-2016.

While the US' NEI holds publicly available emissions data at *installation* level, the EU's E-PRTR and Chile's Snifa only contain *facility* level data. Therefore, the analysis in this chapter relies on facility level data. This limits, however, the value of the analysis, as it makes it difficult to connect emissions data to the installations from which they originate, as well as restricts the comparability of the emissions data measured at facility level and the BAT-associated emission levels (BAT-AELs), which – at least in the EU – are established at installation level.

The analysis looks at reported emissions data for Europe in the light of selected BAT-associated emission levels established in the EU BAT Conclusions for the non-ferrous metals industries (EU, 2016[25]) and the EU BAT reference document (BREF) on large volume inorganic chemicals - ammonia, acids and fertilisers (LVIC-AAF) (EIPPCB, 2007[26]). Considering the four years compliance deadline for BAT Conclusions foreseen by the Industrial Emissions Directive (IED) (EU, 2010[23]), it would be premature to draw conclusions on the emissions impact of the BAT Conclusions for the non-ferrous metals industries before 2020. For LVIC-AAF, no BAT Conclusions have yet been developed under the Industrial Emissions Directive, and thus, no EU-wide legally binding emission levels currently apply. Further, as E-PRTR data only have been collected as of 2007, while the first BREF for the non-ferrous metals sector was adopted in 2001 and the LVIC-AAF BREF in 2007, the emission trends observed after the introduction of the BAT-based approach (i.e. in a *policy scenario*) cannot be compared to a *business as usual scenario*. Yet, considering that the BREFs define an upper level of (usually) emission concentrations, it is likely that they had an effect on emissions, notably for the worst performing facilities. Furthermore, considering that the IED allows for competent authorities to set emission limit values (ELVs) at the lower end of the BAT-AEL ranges or even below, taking into account local conditions, the Directive has likely had an effect on the emissions from the better performing facilities as well.

For the US, operating permits for each facility would have to be examined in order to find information about emission limit values and thus to conduct a comparison of emissions before and after implementation of the most recent permit conditions (a *business as usual* versus a *policy* scenario). For new and modified facilities, emission limit values for criteria air pollutants, such as SO_2 and PM_{10}, are determined under the New Source Permitting programme, in compliance with the National Ambient Air Quality Standards (NAAQS) (US EPA, n.d.[27]), and based on Best Available Control Technologies (BACT) or Lowest Achievable Emissions Rates (LAER), depending on whether the facility is located in an area that does – or does not – attain the NAAQS. The emission limit values of each facility can be consulted in the US EPA's RACT/BACT/LAER Clearinghouse[5], which is a searchable database by pollutant or sector that contains case-specific information on the emissions limitations that have been required to reduce the emission of air pollutants from stationary sources, based on information provided by State and local permitting agencies. The database has not been consulted for this analysis.

For Chile, reported emissions data are seen in the light of the national Emission Standard for Copper Smelters and Arsenic Emission Sources (MMA, 2013[28]). However, as this regulation was adopted in 2013 and relevant emissions data in the Snifa database only are available for the period 2014-16, it is not possible to compare data for a *business as usual* scenario and a *policy* scenario.

The data limitations to which the analysis in this chapter is subject underlines the necessity of publicly available emissions data, at installation level, along with activity data and permit information – for a period before *and* after the adoption of new emission levels – in order for a proper effectiveness analysis of BAT-based policies to be conducted. Furthermore, the chapter shows that further research would be needed in order to investigate and ensure the comparability of data across countries.

2.2. Primary copper production

2.2.1. Result of the data collection

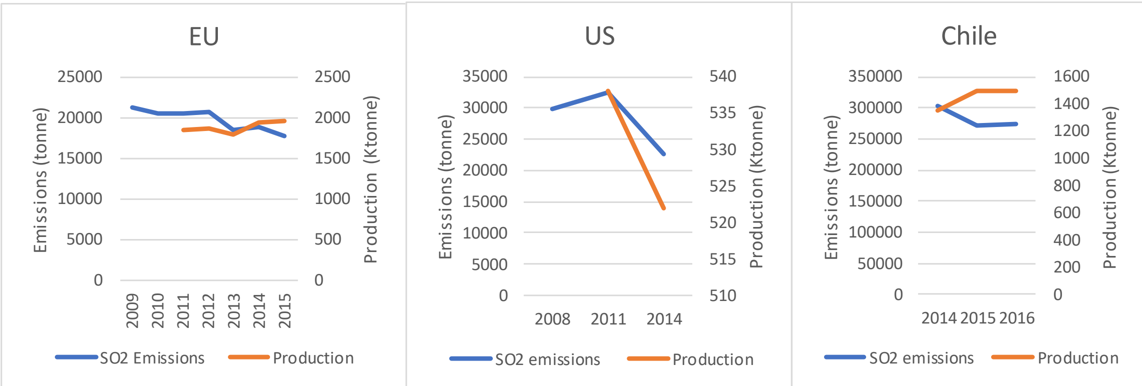
The available databases (E-PRTR, NEI and Snifa) contain SO_2 emissions data for seven primary copper producing facilities in the EU (two of them located in Poland and the others in Bulgaria, Germany, Spain, Finland and Sweden, respectively), three in the US and seven in Chile.

The US Geological Survey has made activity data (production volumes) available for both the EU and the US, as part of their production statistics for primary and secondary production at country level (US Geological Survey, 2018[29]). Production capacities at the facility level have been projected by the Directory of Copper Mines and Plants from the International Copper Study Group (ICSG) from 2012 to 2017 for all three countries/regions (ICSG, 2013[30]). Activity data at the facility level have been estimated from these production capacities (in the case of Chile) as well as national production statistics (for the EU and the US, from the US Geological Survey's database) assuming similar operating hours in all the facilities in one country. This is an estimation, but nevertheless relevant for illustrating variation between facilities.

2.2.2. SO_2 emissions from primary copper production in Chile, the EU and the US

Trends of SO_2 emissions from primary copper production can be calculated by simply aggregating the emissions of the identified plants. Figure 2.1 shows a continuous downward trend in SO_2 emissions for copper plants in the EU over the period 2009-2015: emissions decreased by 16% in spite of production increase of 5% over the same period. In the US, an increase of SO_2 emissions was observed between 2008 and 2011. However, due to lack of production data for this period, it cannot be verified whether this is related to a production increase or a decline in environmental performance. Between 2011 and 2014, copper production decreased by 14%, while there was a sharp average decrease in emissions (24%) over the same period, primarily due to the strengthened environmental performance of one of the three plants, which is located in Miami. In Chile, emissions decreased by 10% from 2014 to 2016, while production decreased by 5% only.

Figure 2.1. Historical trends in SO_2 emissions in primary copper production



Source: Developed by the authors.

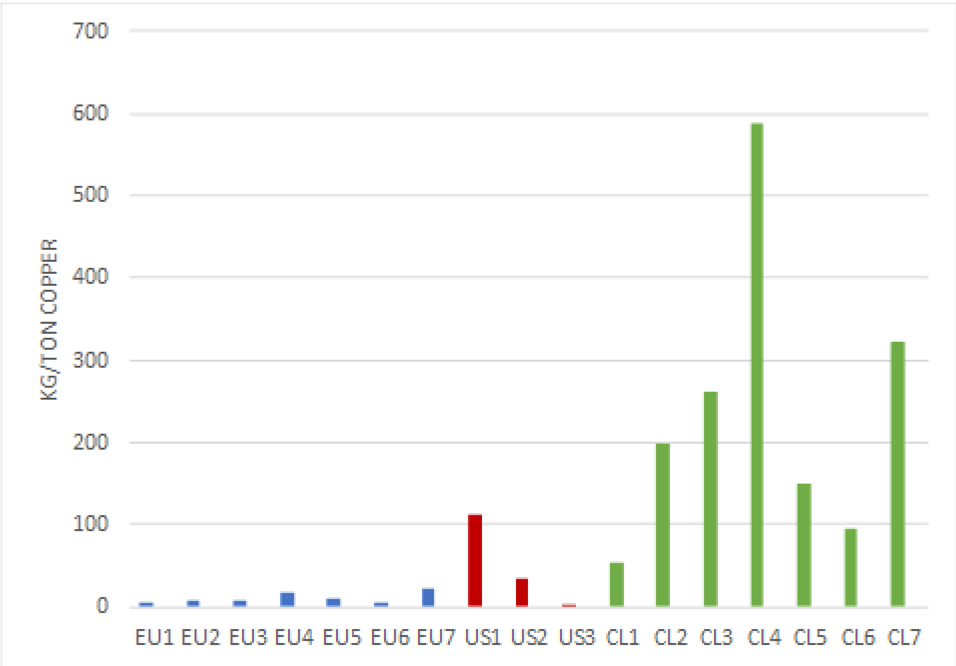
No plant closures have been observed in any of the three economies during the reporting periods. Consequently, besides production volumes, the downward trend in emissions is likely related to the implementation of improved technologies, possibly due to the introduction of increasingly stringent emission limit values in permits. In the EU, permit conditions were established under the IPPC Directive (EU, 1996[31]) (adopted in 1996) and later the IED (EU, 2010[23]) (adopted in 2010); however, no legally binding BAT Conclusions were introduced for the non-ferrous metals industries or for LVIC-AAF during the period for which E-PRTR data are presented in Figure 2.1. Yet, the BAT-AELs established in the BREFs for these sectors have informed the emission limit values defined in the permits of the EU copper plants and are thus likely to have had an impact on their environmental performance.

In the US, technology-based performance standards established at national, state or local level play into the setting of permit conditions. Other information, such as the US EPA's RACT/BACT/LAER Clearinghouse would have to be consulted in order to obtain information on the emission limit values of each of the facilities and thus to draw a conclusion concerning the impact of these values on the decline in reported emissions. In 2010, the US primary NAAQS for SO_2 emissions was revised and strengthened (US EPA, n.d.[27]). EPA designates whether a geographic area is meeting (attainment) or not meeting (non-attainment) the NAAQS, after which states are required to develop plans for implementing the NAAQS and submit them to EPA for approval. Given the timeline of the NAAQS implementation process, the revised NAAQS could result in new requirements and control measures beyond the time period of 2014, i.e. this did not affect the emission trends presented in Figure 2.1.

In the case of Chile, where SO_2 emissions dropped significantly between 2014 and 2015 (before stabilising), it is likely that this was the result of the national Emission Standard for Copper Smelters and Arsenic Emission Sources (MMA, 2013[28]), which was implemented in 2013. However, emissions data in Snifa are only available for the period 2014-16, and cannot be used to determine how the new national standard impacted emission trends.

Figure 2.1 further shows that in 2014, Chile produced almost three times as much copper as the US, with about 12 times more emissions. The EU produced about four times the amount of the US, but with lower emissions. The specific SO_2 emissions in 2014 – expressed in kg/tonne copper production – for 17 primary copper production facilities in Chile, the EU and the US are displayed by Figure 2.2. The figures were calculated from estimated production figures, which for the EU and the US are based on national production statistics from the US Geological Survey (US Geological Survey, 2018[29]), and for Chile on production capacity statistics from the International Copper Study Group (ICSG, 2013[32]).

Figure 2.2. Specific SO_2 emissions from primary copper production facilities expressed as kg per tonne of production in the EU, Chile and the US (2014)



Source: Developed by the authors

According to Figure 2.2, the best performing plant, of those examined, is located in Utah in the US. SO_2 emissions from this plant are as low as three kg per tonne copper. This is partly due to this facility carrying out recycling of copper scrap, a process which is less SO_2-intensive than production from concentrates. It is also the result of the Utah State Department for Environmental Quality having imposed particularly stringent ELVs for SO_2 emissions (State of Utah, 2014[33]). The two other US plants have SO_2 emissions of 31 and 102 kg/tonne copper. The EU copper plants have emissions in the range 4-16 kg per tonne copper. These figures cannot be compared to the pertaining BAT-AEL from the LVIC-AAF BREF (EIPPCB, 2007[26]) (30-770 mg/Nm^3), due the difference in unit of measure.

The plants in Chile demonstrate the highest SO_2 emissions per production unit, in the range 55-390 kg/tonne copper. A possible explanation for this is the Chilean Emission Standard for Copper Smelters and Arsenic Emission Sources (MMA, 2013[28]), which states that at least 95% of SO_2 emissions should be recovered as sulphuric acid, whereas in the EU the required recovery rates are much stricter: 99.70-99.92% (EIPPCB, 2007[26]).

The low level of specific emissions from one of the US plants and from most of the EU plants may suggest that emissions could be further reduced from the other plants, notably those in Chile and the remaining plants in the US (US1, US2) and in the EU (EU4, EU7). However, each plant is different and the possibility to further reduce emissions needs to be evaluated case by case. Moreover, further analysis of the comparability of the data presented in Figure 2.1 and Figure 2.1 would be needed in order to draw strong conclusions on this basis. For example, such analysis would have to take into account that comparing emissions from various copper plants has certain limitations related to the heterogeneity and variability in the scale of operations, product portfolios (e.g. production of other metals at the same site) and the process configuration of copper smelters.

2.3. Primary aluminium production

2.3.1. Result of the data collection

Emissions data for aluminium production are available for plants in two of the economies examined, i.e. the EU and the US. Emissions have been reported to E-PRTR for 22 European primary aluminium producing plants for the period 2007-2016. Norway is the biggest aluminium producer in Europe with six facilities. The other plants are located in Germany (DE) (4), Spain (ES) (2), France (FR) (2), Iceland (IS) (3), the Netherlands (NL) (1), Sweden (SE) (1), Slovakia (SK) (1) and Romania (RO) (1). There were previously also three plants in the UK, but these have been closed down. For the plant in Romania, emissions have only been reported for 2008.

For the analysis in this chapter, production capacities for the 22 European plants were compiled from information on the companies' websites. Consistency checks with production figures were carried out to link production capacities and reported emissions. Aggregated primary production statistics for the EU and the US were provided by the US Geological Survey (US Geological Survey, 2018[29]), for up to 2012 for the US and 2015 for Europe. Production figures were split for countries with more than one production facility, based on production capacities. Apart from the closing of three plants in the UK, European aluminium production appears to have been constant from 2012 to 2015. Therefore, in the framework of this analysis it is assumed that production at the facility level remained constant after 2012.

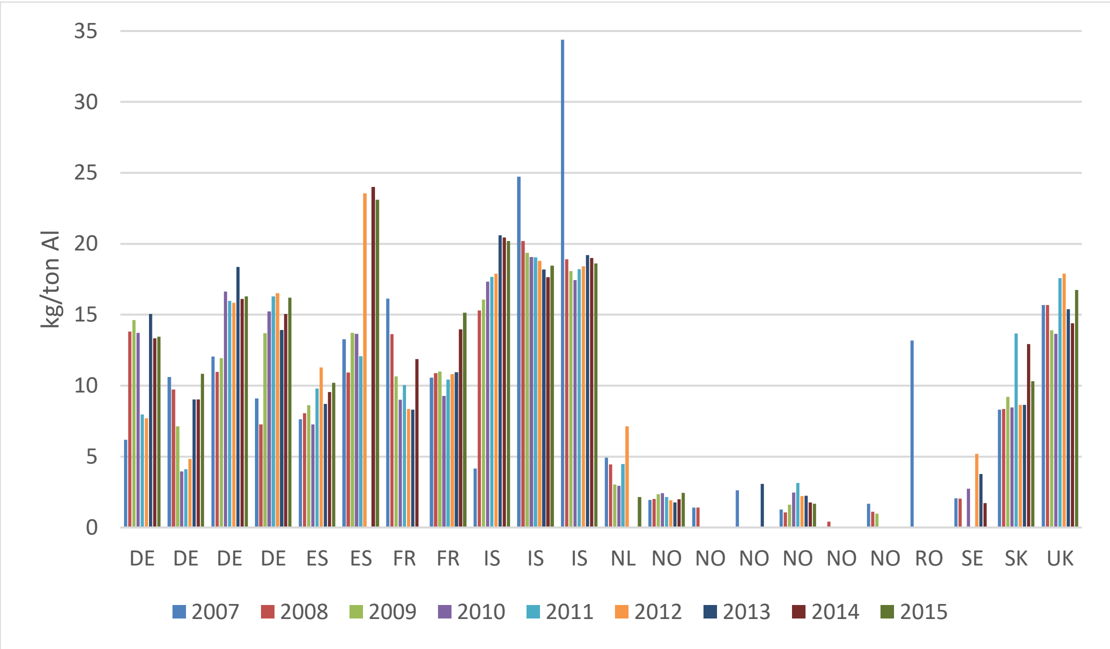
Data on emissions from primary aluminium producers in the US can be extracted from the NEI. The data are readily available for 2008, 2011 and 2014, and include information on 13 plants. Yet, for 2014, data are only available for eight of these plants. The five plants for which no 2014 data are available are identified as closed, based on information collected from the websites of the individual companies. Production capacities for operating plants were collected from the websites of the operators. However, collecting production capacities for closed plants is difficult. Not taking into account these capacities when allocating national production statistics to individual producers would be inaccurate. Therefore, for the sake of this analysis, the capacities of closed plants were estimated based on the total collected capacity and the ratio of reported SO_2 and PM_{10} emissions for open and closed plants[6].

2.3.2. SO_2 emissions from aluminium production in the EU and the US

SO_2 emissions per unit of production

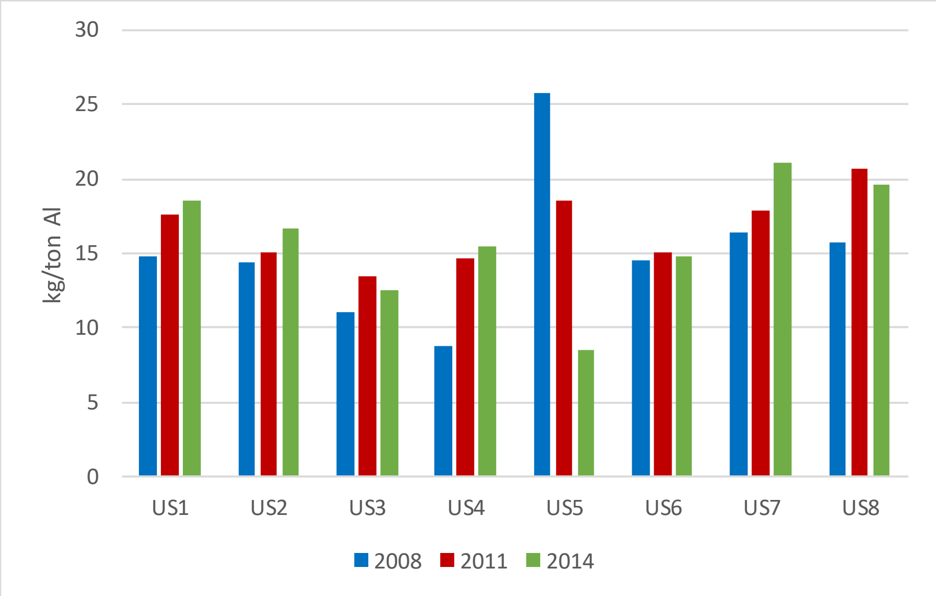
Figure 2.3 and Figure 2.4 display the SO_2 emissions per unit of aluminium production in the EU and the US. The figures show that SO_2 emissions in Norway, Sweden and the Netherlands are significantly lower than in the other countries. For Norway and Sweden, this can be explained by the fact that installations in these countries are equipped with a wet desulphurisation process, due to local environmental issues, i.e. acid rain.

Figure 2.3. SO_2 emissions per unit of production in primary aluminium plants in the EU



Source: Developed by the authors based on E-PRTR data.

Figure 2.4. SO_2 emissions per unit of production in primary aluminium plants in the US



Source: Developed by the authors based on data from the US EPA NEI database.

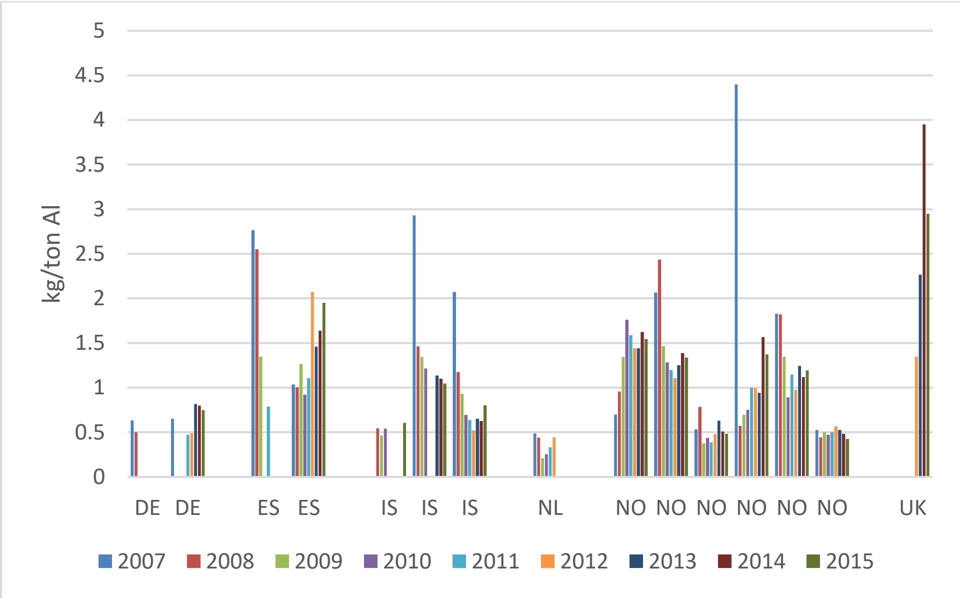
Figure 2.4 shows that one company in the US has reduced specific SO_2 emissions significantly between 2008 and 2014. For the other observations in the EU and the US, no particular trends can be observed. Generally, SO_2 emissions in the US appear to be slightly higher – there are more observations above 15 kg/tonne Al – than in Europe. This is related to the higher sulphur content in US petroleum refining residues. The individual permits of the US facilities would have to be examined in order to assess how the reported emissions compare to defined emission limit values. In Europe, more than half of aluminium companies operate below or close to the level of 15 kg SO_2/tonne Al, which is the upper emission level associated with BAT 69 from the BAT Conclusions for non-ferrous metals (EU, 2016[25]). For these facilities, this means that no further significant improvements can be expected at the end of the four years implementation period for the BAT Conclusions, i.e. in 2020. The remaining facilities will have to improve their environmental performance by 2020, for example by adopting new emission reduction techniques, in order to achieve compliance with the legally binding BAT-AEL.

2.3.3. PM_{10} emissions from aluminium production in the EU and the US

PM_{10} emissions per unit of production in primary aluminium production facilities in Europe are presented in Figure 2.5. Due to the E-PRTR reporting threshold of 50 tonne/year, a complete set of observations is not available. No observations are available for the two German, two French and one Swedish facility. For some of the other facilities, observations are not available for all the historical years. Full records are only available for one facility in Spain, one in Iceland and six facilities in Norway. Hence, drawing conclusions is difficult.

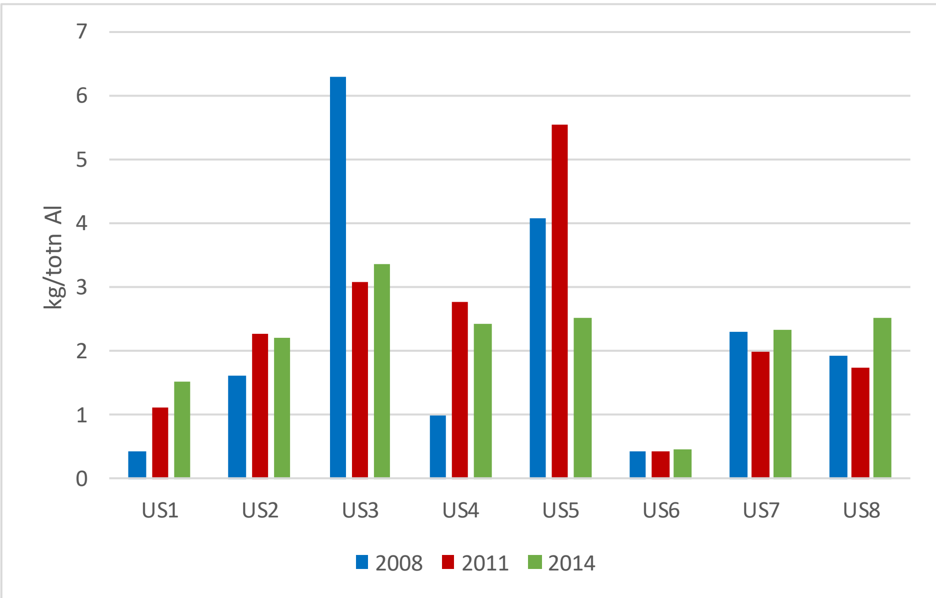
For the US, observations are available for all eight plants that still are operational (see Figure 2.6). In 2014, most US facilities operated at emission levels slightly higher than in Europe, but there was one facility, based in South Carolina, performing as well as the least emitting European facilities. The individual permits of the US facilities would have to be examined in order to assess how the reported emissions compare to defined emission limit values.

Figure 2.5. PM_{10} emissions per unit of production in primary aluminium facilities in Europe



Source: Developed by the authors based on E-PRTR data.

Figure 2.6. PM_{10} emissions per unit of production in primary aluminium facilities in the US



Source: Developed by the authors based on NEI data.

The more recently reported emissions from the European aluminium facilities are often close to the upper emission level associated with BAT 65 and 67 established in the BAT Conclusions for the non-ferrous metals industries (EU, 2016[25]), of 1.2 kg PM_{10} per tonne of aluminium for total PM_{10} emissions from electrolysis. There are other facilities in Europe – and in the US - that operate at levels below the lower end of the EU BAT-AEL range. But, based on Figure 2.5, it appears that some European facilities may still be above the upper BAT-AEL. After a case-by-case assessment by their competent authorities, these will possibly have to adopt new BAT or in other ways strengthen their environmental performance in order to reach compliance with the BAT-AEL before the compliance deadline for the BAT Conclusions for the non-ferrous metals industries, i.e. in 2020.

Annex 2.A. The production process for primary copper production

There are two production routes for primary copper, relating to the two different types of ores used: the pyrometallurgical route and the hydrometallurgical route. Approximately 80% of global copper production is based on the pyrometallurgical route, which uses ores with a high sulphur content and is a relevant source of SO_2 emissions. The remaining 20% is based on the hydrometallurgical route, using oxidized ores. The quantitative analysis in this chapter concentrates on the most common route, i.e. the pyrometallurgical route, as this is more relevant with regards to SO_2 emissions. The ores used for the hydrometallurgical route are free of sulphur.

The pyrometallurgical route has several production steps. Copper ores are delivered to the copper production facilities as concentrates with a copper content of 20-30%. These concentrates also have a high sulphur content. There is then a sequence of processes, converting concentrates into matte (smelting), matte into blister copper (converting), blister copper into anode copper (fire refining and anode casting), anode copper into cathode copper (electro refining) and finally melting and casting (final products). Other activities include drying of concentrates, slag granulation and recycling, auxiliaries, etc. Different types of installations exist for smelting and converting, with different levels of environmental performance.

A typical primary copper facility produces about three tonnes of sulphuric acid for one tonne of copper. Critical parameters for SO_2 emissions control are an efficient capturing of SO_2 streams and a high conversion rate at the sulphuric acid plant. Existing literature reports of conversion rates as high as 99.97% in new facilities (EIPCCB, 2017[34]).

Figure 2.7represents a generic, albeit simplified, copper facility with its various SO_2 streams and indicates the most relevant BAT from the EU BAT Conclusions for the non-ferrous metals industries (EU, 2016[25]) and selected BAT-AELs from the EU BREF on large volume inorganic chemicals - ammonia, acids and fertilisers (LVIC-AAF) (EIPPCB, 2007[26]) (BAT Conclusions have not yet been developed for this BREF). Sulphur is oxidised to SO_2 at different points in the production process, giving rise to different SO_2 streams. These are indicated by the yellow, orange and red arrows in the figure:

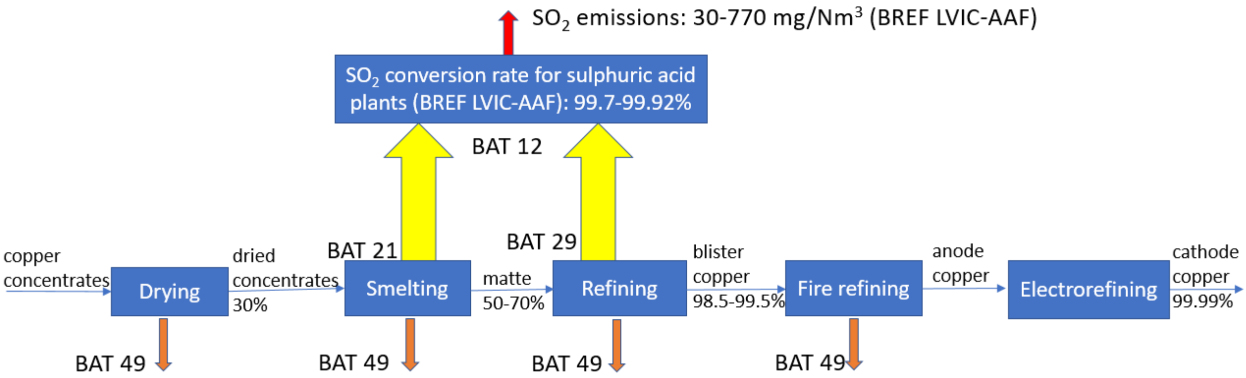
i. The yellow arrows represent flue gas streams with a high SO_2 concentration, which are converted in the sulphuric acid plant. They are thus not emitted into the air. The EU's LVIC-AAF BREF establishes conversion rates of 99.70-99.92% associated with BAT (EIPPCB, 2007[26]). A good performance of the sulphuric acid plant requires that the SO_2 concentration is sufficiently high. As a consequence, not all SO_2 streams are suitable for sulphuric acid production.

ii. The orange arrows represent various SO_2 streams which are not guided to the sulphuric acid plant. These streams are either emitted to the atmosphere or they are collected (note: not visualised in the figure) and treated with an end-of-pipe flue gas cleaning technology, e.g. a wet scrubber. In the EU BREF on non-ferrous metals (EIPCCB, 2017[34]), these emissions are subject to BAT 49, i.e. emissions concentrations should be within the BAT-AEL range of 50-500 mg/Nm^3. It should be noted that not all the streams apply to all production facilities.

iii. The red arrow represents SO_2 emissions to the atmosphere from the sulphuric acid plant. BAT-AELs for this stream are specified in the EU's LVIC-AAF BREF (EIPPCB, 2007[26]) and range from 30 to 770 mg/Nm^3 of SO_2.[7]

Figure 2.7. Simplified representation of a primary copper smelter

Based on the EU BAT Conclusions for the non-ferrous metals industries and the EU BREF on large volume inorganic chemicals - ammonia, acids and fertilisers (BREF LVIC-AAF)[7]



BAT 12: Recover sulphur by producing sulphuric acid or liquid SO_2

BAT 21: Optimise the use of the energy contained in the concentrate using a flash smelting furnace

BAT 29: Use a flash converting furnace to reduce diffuse emissions from the matte conversion process

BAT 49: Reduce SO_2 emissions from copper production to 50-500 mg/Nm^3

Note: In addition to the BAT presented in the figure, the EU BAT Conclusions for the non-ferrous metals industries include other BAT for prevention or reduction of diffuse emissions, such as: BAT 25 on diffuse emissions from pre-treatment, including drying operations; BAT 26 on diffuser emissions from smelting operations; BAT 27 and 28 on diffuse emissions from converting operations; BAT 31 and 32 on diffuse emissions from slag treatment; BAT 33 on diffuse emissions from anode casting; and BAT 27-45 on reduction of dust emissions from various processes. While the figure emphasises the use of selected techniques, such as flash smelting and flash converting furnaces, the BAT Conclusions also present techniques such as enclosed charging systems, enclosed furnaces, hoods/enclosures, system of secondary hoods in addition to the main hood of converters, addition of materials through the hood, covered launders, etc.
Source: Developed by the authors based on (EU, 2016[25]) and (EIPPCB, 2007[26])

Companies typically report on the emissions depicted by the orange and red arrows. Emissions monitoring data for each of these streams might include: (i) the average concentration (mg/Nm^3); (ii) the flue gas volume (Nm^3/hour); and (iii) the operating time (hours). By multiplying these three elements with each other, one can easily compare total emissions at the stack to the BAT-AEL. Companies might also report on fugitive emissions, but this is not represented in Figure 2.7.

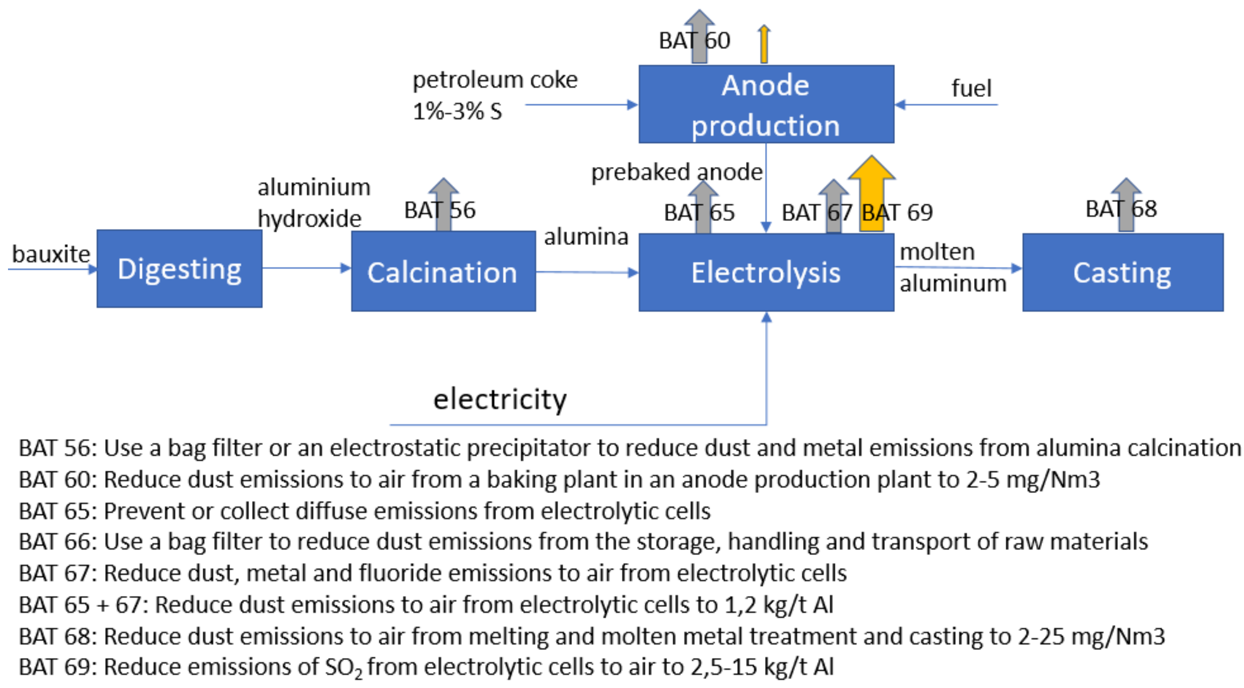
Each of the red and orange arrows represent emissions monitored at separate emission points. To estimate total missions at facility level, these individual streams would have to be aggregated, as is done for reporting to a PRTR. It varies across facilities whether emissions and emissions control measures are collected in a centralised abatement plant or not.

Annex 2.B. The production process for primary aluminium production

A simplified version of the process of primary aluminium production based on prebaked anodes, relevant emissions sources as well as the most essential BAT from the EU BAT Conclusions on non-ferrous metals (EU, 2016[25]) are depicted in Figure 2.8. The primary raw material is bauxite, from which aluminium hydroxide is extracted in a digestion process. Subsequently, alumina (Al_2O_3) is produced through calcination. The reduction of alumina to aluminium is carried out in electrolytic cells, also called pots, in which a carbon source is added to support the chemical reduction. Different types of electrolytic cells are in operation. The main difference is in the way a carbon source is added and how the alumina is added. In Søderberg cells (i.e. cells with only one big anode, housed in a steel container) carbon anodes are made in situ in a continuous process from a paste of calcined petroleum coke and coal tar pitch, using the heat produced in the cells and the electric current through the anode. Alternatively prebaked anodes can be used. Prebaked anodes are also produced from petroleum refining residuals. They can be produced at the same location, or they can be supplied by an external supplier.

Figure 2.8. Simplified representation of the aluminium production based on pre-baked anodes

Based on the EU BAT Conclusions for the non-ferrous metals industries



Note: *Grey arrows refer to dust emissions and yellow arrows to SO_2 emissions. In addition to the BAT presented by the figure, the EU BAT Conclusions for the non-ferrous metals industries include other BAT for prevention and control of emissions from aluminium production.*
Source: Developed by the authors, based on (EU, 2016[25])

SO_2 emissions in aluminium production are related to the production and consumption of prebaked anodes and/or to the consumption of Søderberg paste, typically containing 1-3%

of sulphur. The quantity of SO_2 emissions released during the production of prebaked anode depends on the raw materials and the fuel used. Emissions are often in the range 0.5-2 kg/tonne aluminium (0.5 kg for gas and 2 kg for fuel oil), depending on the fuel used (EIPCCB, 2017[34]). However, the electrolysis is the major source of SO_2, as this involves that the anodes are consumed and thus that sulphur is released as SO_2. Abatement technologies include the use of low sulphur refining residuals or wet scrubbing of the flue gases. In the EU, this emission source is controlled by BAT 69 from the BAT Conclusions on non-ferrous metals (EU, 2016[25]). The emissions associated with the uptake of this BAT are in the range 2.5-15 kg/tonne aluminium.

PM emissions occur at different locations and most of them are abated by using bag filters or electrostatic precipitators. In the EU, five emission sources are regulated for the use of prebaked electrolytic cells, and similarly for the use of Søderberg cells, by the BAT Conclusions on non-ferrous metals (EU, 2016[25]). Amongst others, it sets out a BAT-AEL of 1.2 kg t/Al (for existing plants) for the reduction of dust emissions to air from electrolytic cells (BAT 65 and 67).

Notes

[1] See http://prtr.eea.europa.eu/#/home.

[2] The emission data in the E-PRTR is required to cover all emissions from the facility and so this should normally include fugitive emissions. This might be a source of data asymmetry when comparing emissions from different plants and especially with plants outside the EU. Fugitive emissions may represent an important share of emissions, however, not all installations and all Member States collect data related to fugitive emissions and those that report may do that with variable levels of precision and accuracy. This is because quantification of fugitive emissions is not implemented as standard practice. There are methods available, but the uncertainty might be relatively high and therefore the level of confidence in results might be low (EC, 2006[136]).

[3] See https://www.epa.gov/air-emissions-inventories.

[4] See http://snifa.sma.gob.cl/v2/Fiscalizacion.

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

[6] Capacity of closed plant = total capacity of open plants x average of SO_2 emissions in closed plant / SO_2 emission in open plants and PM_{10} emissions in closed plant / PM_{10} emission in open plants

[7] The LVIC-AAF BREF (EIPPCB, 2007[26]) establishes BAT-AELs ranging from 30 to 680 mg/Nm^3 SO_2, but the upper level was corrected to 770 mg/Nm^3 in the BREF on the non-ferrous metals industries (EIPCCB, 2017[34]).

Part II. Country and region chapters

Chapter 3. **European Union**

The European Union (EU) has had various forms of BAT policy for more than 30 years. This is embedded in the Industrial Emissions Directive (IED) and facilitates Member States' determination of legally binding emission limit values in environmental permits based on BAT Associated Emission Levels (BAT-AELs). The effectiveness of the IED is continuously assessed through industry operators' mandatory reporting of compliance with permit conditions to Member States' competent authorities and can be evaluated based on PRTR data. In addition, the European Commission and the Member States frequently conduct studies exploring various methodologies for the assessment of the IED's impact on emission trends. While the IED ensures a holistic approach to environmental protection and has a highly inclusive and participative approach to establishing BAT, industry associations and environmental NGOs believe that the methodologies for determination of BAT and BAT-AELs could benefit from further standardisation, transparency and better balancing of stakeholder interests. This chapter exemplifies the effectiveness of the IED through two case studies on copper smelting and one on leather tanning.

3.1. BAT in the European Union

BAT requirements in the European Union (EU) date back to the 1984 Directive on the combating of air pollution from industrial plants (EU, 1984[35]), and were later core elements of the Integrated Pollution Prevention and Control (IPPC) Directive, which was adopted in 1996 (EU, 1996[31]), and subsequently the 2010 Industrial Emissions Directive (IED) (EU, 2010[23]). This means that the EU has had over 30 years to refine and improve its approach to BAT.

Although first carried out under the IPPC Directive, the Seville Process was formally established under the IED and provides for BAT reference documents (BREFs) and BAT Conclusions to be developed. As part of this process, representatives from the European Commission, the EU Member States, European industry and environmental NGOs convene in Technical Working Groups at the Joint Research Centre's European IPPC Bureau in Seville, where they provide input to the drafting of BREFs through extensive dialogue and exchange of information. A BREF provides guidance to decision makers involved in the implementation of the IED; BAT Conclusions lay down the key parts of a BREF. As of January 2019, BREFs have been developed for 31 industrial sectors, with BAT Conclusions established for 14 of them. A complete list of the EU BREFs and BAT Conclusions is available on the website of the European Commission’s Joint Research Centre[1] and in the OECD’s report *Approaches to Establishing BAT Around the World* (OECD, 2018[36]).

The IED, as with the previous IPPC Directive, aims to achieve a high level of protection of human health and the environment as a whole by preventing and controlling industrial emissions based on the application of BAT. The IED regulates the environmental impacts of more than 50 000 of the largest industrial installations across the EU. Installations undertaking industrial activities, as listed in Annex I of the IED, are required to have an integrated environmental permit. The permit conditions, including the emission limit values (ELVs), must be based on BAT and are determined by national permitting authorities. The ELVs are set to ensure that under normal operating conditions, emissions do not exceed the range of emission levels associated with BAT (BAT-AELs), which are legally binding under the IED regulatory regime. The ELVs are typically expressed as mg/Nm3 for air emissions and mg/l for water emissions, and as an average over a given period.

The IED is the result of the merging of the IPPC Directive and six other pieces of EU legislation. In addition to unifying the IPPC Directive with other directives, the objective of developing the IED was to strengthen the link between the BREFs and environmental permits. Whilst the BREFs developed under the IPPC Directive identified sectoral BAT and associated performance levels, these were not interpreted as having the same legal force as under the IED. The IPPC Directive, Article 9(4), merely required that: “emission limit values (in permits) shall be based on the best available techniques”. This led to some inconsistency in the implementation of the IPPC Directive and was one of the primary reasons for the creation of the IED, which introduced legally binding BAT Conclusions and created a stronger link between these and permit conditions: Article 14(3) of the IED stipulates that “BAT Conclusions shall be the reference for setting the permit conditions” and Article 15(3) states that “the competent authority shall set emission limit values that ensure that, under normal operating conditions, emissions do not exceed the emission levels associated with the best available techniques as laid down in the decisions on BAT Conclusions”. The IED foresees a maximum four years compliance deadline following the publication of the BAT Conclusions in the Official Journal of the EU.

In line with the Article 192(1) of the Treaty on the Functioning of the European Union (2016[37]), which forms the legal basis of the IED, individual EU Member States may set national environmental requirements, including ELVs in permits, that are more stringent than the BAT-AELs stated in the BAT Conclusions. Article 18 of the IED foresees the link with ambient environmental quality standards, such as those set under the Water Framework Directive (EU, 2000[38]), and thus indicates that "additional measures shall be included in the permit[2]" where compliance with an environmental quality standard requires locally stricter conditions than those achievable by the use of BAT.

3.2. Policy evaluation

3.2.1. Governmental evaluation projects

The IED's Recital 13 states that the European Commission should aim to update BREFs no later than eight years after the previous publication, in order to reflect technical progress. BREF reviews are conducted as part of the Seville Process, and are an important means to evaluate whether the techniques currently defined as BAT indeed are still the best available means to ensure that defined objectives are met.

In addition, the effectiveness of the IED is assessed in multiple ways, including through provisions for continuous evaluation in the IED, in studies commissioned by the European Commission and by EU Member States, and through the European Commission's Regulatory Fitness and Performance (REFIT) programme (EC, n.d.[39]). REFIT provides a methodology for evaluating the effectiveness, efficiency, coherence, relevance and the EU added value of its legal instruments, and aims to keep EU law simple, remove unnecessary burdens and adapt existing legislation without compromising on policy objectives.

In addition to ensuring the annual reporting of industry operators on compliance with permit conditions, EU Member States' competent authorities conduct environmental inspections of installations to examine the full range of relevant environmental effects from the installations concerned (Article 23 of IED). Both reporting by operators and inspections by competent authorities provide insights into the IED's effectiveness at Member State level. According to the European Environmental Bureau, the data from such reporting are not made sufficiently widely available to the public.

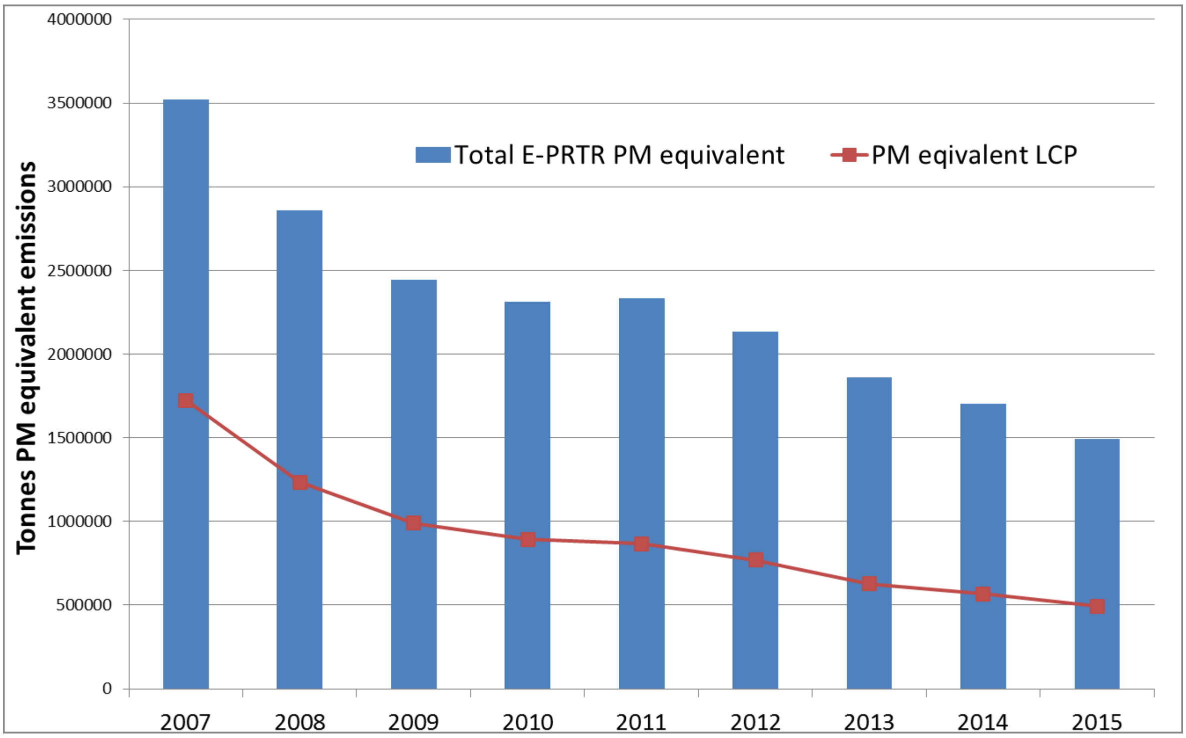
The Member States are required to provide information on the implementation of the IED to the European Commission (Article 72 of IED). By 7 January 2016, and every three years thereafter, the European Commission must submit a report reviewing the implementation of IED to the European Parliament and to the Council, based on the information provided by the Member States (Article 73 of IED). The first such report was submitted in 2017 (EC, 2017[40]), and concluded, amongst others, that:

i. The IED is a good example of better regulation. It merged and simplified seven pieces of EU legislation and created a rather unique, highly transparent and collaborative process for preparing BREFs;

ii. While it is too early to see the practical results of the change to the IED, progress is encouraging;

iii. Trends in industrial emissions appear promising. For example, particulate matter (PM) equivalent emissions into air from large combustion plants have declined gradually over the period 2007-15 (see Figure 3.1).

Figure 3.1. PM equivalent emissions from large combustion plants in the EU, 2007-15



Source: (EC, 2017[40])

Looking to the future, the Commission's report goes on to say that a full evaluation of the IED should be considered in 2020, seeing as the Commission will have received further reports from Member States and most BAT Conclusions will have been adopted by then. This evaluation would allow drawing conclusions on how the work on implementing the IED should evolve in the longer term (EC, 2017[40]). This evaluation has now been launched and should be complete in 2020.

Other European Commission studies have also contributed to evaluating the impact of the IED, such as those below:

i. "Industrial policy indicators" (EC, 2018[41]) aims to gather information and develop appropriate indicators to track the progress in the policy area of industrial emissions, focusing on the IED, the activities within its scope and the environmental pressures they generate (i.e. resource use, emissions to air and water). The outputs of the work are a set of indicators together with the methodology for developing and updating them and data sources for producing the indicators.

ii. "Summary on IED contribution to water policy" (EC, 2018[10]) concludes – despite data gaps and methodological uncertainties – that the IED and BREFs have had, and are likely to continue having, positive impacts on the quantity of emissions to water and, perhaps to a lesser extent, reducing water usage. A similar study on the contribution of the IED to meeting EU circular economy objectives is currently being conducted.

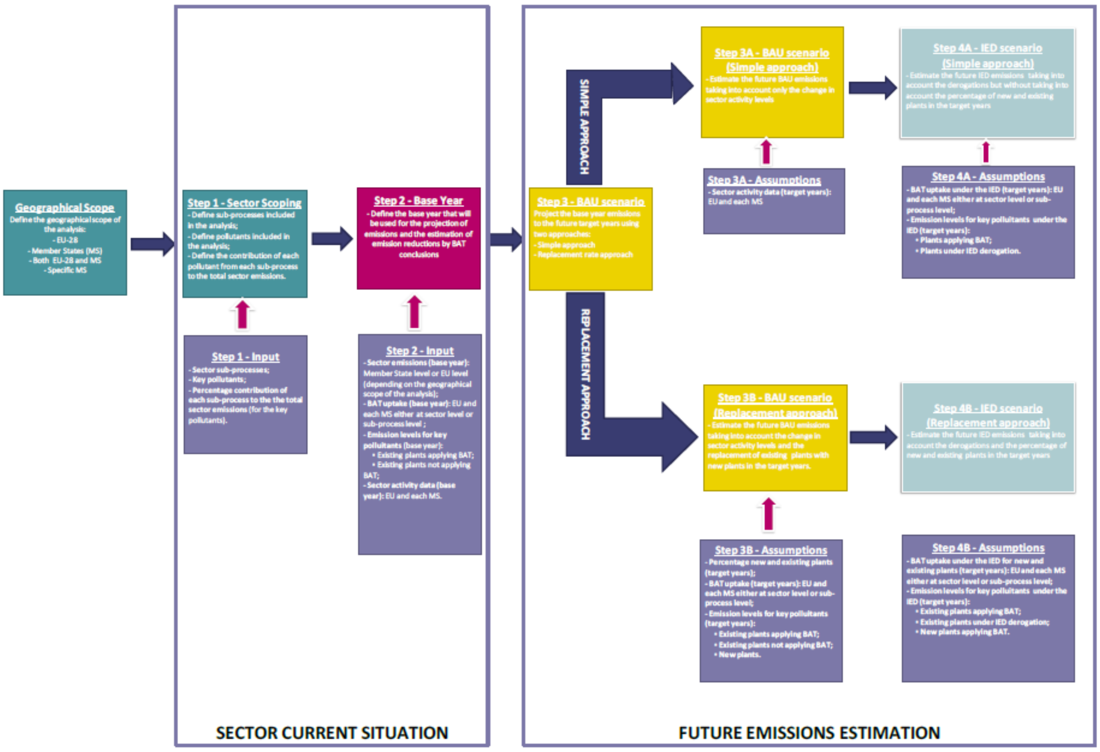
iii. "Ex-post assessment of costs and benefits from implementing BAT under the Industrial Emissions Directive" (EC, 2018[42]) presents a high-level assessment of the impact of the BAT Conclusions for the iron and steel sector on emission trends. This assessment is based on three different methodologies and solely publicly available data. The study also includes a detailed process-level assessment which compares the benefits of the BAT Conclusions for the iron and steel sector to the costs of techniques implemented by industry operators, based on public and private datasets. The study highlights some of the limitations of the methodologies examined, e.g. that access to data from industry operators can be an obstacle to process-level cost-benefit analyses, and that the three methodologies used for high-level assessments of emission trends led to low confidence in the predicted impacts.

iv. "Application of IED Article 15(4) derogations" (EC, 2018[43]) assesses Member States' use of IED Article 15(4), which allows competent authorities to use derogations, i.e. to set, under certain specific circumstances, less strict emission limit values in the permit than the emission levels associated with the BAT.

v. "Analysis and development of methodologies for estimating potential industrial emissions reductions and compliance costs of BAT Conclusions adopted under the Industrial Emissions Directive" (EC, 2016[44]) aims to identify existing methodologies to quantify emission reductions under the BAT Conclusions *and* the associated costs of techniques. Assessing the feasibility of the methodologies through case studies, the study concludes on the importance of using methodologies adapted to each individual industrial sector, and recommends direct contact with competent authorities and/or operators in order to gain access to environmental performance and emissions monitoring data, enabling a thorough cost-benefit analysis.

vi. "Assessing the potential emission reductions delivered by BAT Conclusions adopted under the directive on industrial emissions (IED)" (EC, 2015[45]) seeks to develop an adequate methodology for ex ante estimations of the potential emission reduction delivered by the BAT Conclusions under the IED at EU and Member State level, comparing emissions under an IED scenario to a business as usual scenario (see Figure 3.2). The study identifies limited availability of quality data as a main obstacle to conducting robust assessments: whilst there were good emissions data from E-PRTR for each sector, there were very limited data on the application of BAT (BAT uptake) and permit conditions.

Figure 3.2. Methodology for assessing the potential emission reductions delivered by BAT Conclusions adopted under the IED



Source: (EC, 2015[45])

vii. “Contribution of industry to pollutant emissions to air and water" (AMEC Environment & Infrastructure UK Limited, 2014[46]) sets out to, inter alia, quantify the contribution of IED-regulated industries to overall emissions, assess whether there were any ‘unregulated’ sectors that appeared to make a significant contribution as well as suggest measures that could prevent or reduce emissions from unregulated activities. The results of this study suggest that the IED is an effective instrument in regulating a significant proportion of Europe’s total pollutant emissions. The headline figures, which take into consideration all sources, show emissions from activities regulated by the IED are approximately 23% by mass of the total loading to the atmosphere and 2% by mass of the total loading to water.

The European Commission has also conducted an “Identification and documentation of Industrial Emissions Success Stories”, setting out to identify and document 'success stories' resulting from the application of the IED and its seven predecessor directives. The success stories cover initiatives from the last decade and reflect cases that are selected based on their environmental and health achievements and, where possible, in conjunction with economic and social achievements. The success stories pertain to the cement, ceramics, waste, printing, leather, mineral fertilizers, chemical, metals, tyre recycling and energy sectors, as well as to mercury emissions and the protection of environment and health in general. They were communicated online in June 2018[3].

Furthermore, the European Environment Agency, which is an EU agency providing independent information on the environment, has conducted the study "Greening the power sector: benefits of an ambitious implementation of Europe's environment and climate policies" (EEA, 2018[47]). The study presents an ex ante evaluation of the benefits of implementing the most stringent end of the range of the BAT-AELs established by the BAT Conclusions for large combustion plants (EU, 2017[48]). They find that this would lead to a reduction of emissions of 91% for SO_2, 82% for particulate matter and 79% for NO_x by 2030, compared to 2016 levels, while implementing the least stringent BAT-AELs only would result in emission cuts of 66 % for SO_2, 56% for particulate matter and 51% for NO_x. According to EEA, the BAT associated with the most stringent emission levels are technically and economically achievable.

In addition to the EU-wide evaluation exercises, some studies have been carried out at the Member State level. For example, the English Environment Agency's report "Updated Impact Assessment of the Industrial Emissions Directive (IED)" (AMEC Environment & Infrastructure UK Limited, 2012[49]) concluded that the IPPC Directive and the IED have led to reductions in emissions to the environment, notably fugitive emissions to air (including dust and odour), environmental risks associated with operational management and storage of raw materials and wastes, overall levels of energy, water and resources consumed by installations affected by the IED and the IPPC Directive, and overall volumes of waste produced. Further, it concluded that the two directives have resulted in greater levels of characterisation and control of certain raw materials (notably biocides) - which may lead to a decrease in the environmental risk of accidental pollution and pollutant releases - in addition to an increase in the level of formalised environmental management systems (which could lead to operational cost savings), greater levels of resource efficiency, continual improvement, increased and more accurate reporting on environmental performance and corporate environmental governance.

3.2.2. Stakeholder opinions

Directorate-General for the Environment, European Commission

Representatives from the Directorate-General for the Environment (DG ENV) consider the IED to be the primary contributor to reported emissions reductions from industry, whilst acknowledging that there are many other EU and national instruments that also apply to industrial installations. Though individual stakeholders may find specific aspects of the IED and the BREF process challenging, DG ENV believes that stakeholders generally have a positive perception of the EU's industrial emissions policy, reflected by their willingness to participate in the identification of BAT, both through the Technical Working Groups and the IED Article 13 Forum. (The Article 13 Forum assesses the draft BREFs developed by the Technical Working Groups.)

DG ENV emphasises many attributes of the IED:

i. The IED takes a holistic approach to environmental impacts, by addressing emissions to air, water and land as well as the consumption of water, energy and materials and the generation of waste, in order to achieve a high level of protection of the environment as a whole (stated in Article 1).

ii. The IED establishes a hierarchy of desirable controls by requiring that Member States ensure that, industrial installations first take all appropriate *preventive* measures against pollution (Article 11(a)).

iii. The BAT Conclusions have a strong legal status, forming the reference for setting permit conditions (IED Article 14 (3)). Emission limit values in permits are set within the BAT-AEL ranges (IED Article 15(3)).

iv. The IED also provides the flexibility to recognise the circumstances where the uptake of BAT may take longer by allowing for derogations, i.e. for competent authorities to set less strict emission limit values in specific cases. (Article 15(4))

v. Public access to information and participation in permit procedures are important components of the IED, both in terms of engagement and promotion of ambition levels.

In considering the theoretical limitations of the IED as currently applied to EU industrial installations, DG ENV recognises that there can be wider issues, for example:

1. Whilst being a highly effective legal instrument, BAT only relate to emissions from core industrial processes. Wider life cycle, or value chain, considerations are dealt with in other parts of the EU's environmental acquis, i.e. the accumulated legislation, legal acts and court decisions which constitute the body of EU law. For example, the production of 'chemical X' would be constrained to use BAT to produce that chemical, but the IED would have no legal locus on whether the production of 'chemical X' was environmentally desirable per se. Therefore, the identification of BAT under the IED considers just one component of the wider environmental impacts – of the entire value chain – that can derive from anthropological activities.
2. In a similar vein to the ‘life cycle limitations’ as outlined above, the IED is spatially restricted to considering the activities carried out within the perimeter fence of specified industrial installations. So, where installations have been purposely located to integrate with the wastes or by-products generated by another adjacent installation, the IED may not be the most suitable regulatory instrument. This should be contrasted with the wider environmental benefits that the EU aspires to in its ‘circular economy strategy’.

The German Federal Environment Agency

According to the German Federal Environment Agency (Umweltbundesamt, or UBA), the EU industrial emissions policy generally has an important effect on national environmental legislation, notably since the publication of the IED, which made the BAT Conclusions legally binding. Representatives from UBA state that the EU’s industrial emissions policy has gained increasing importance in Germany over the last five years, due to changes in national politics. While Germany used to be one of the frontrunners when it comes to environmental legislation, the country’s environmental legislation is no longer fully up to date with the latest BAT Conclusions.

The application of different tools to prevent and control industrial emissions in Germany makes it difficult to attribute specific effects and observations to the IED. For the textiles sector especially, several tools are applied to prevent and control industrial emissions next to permitting based on the IED, such as eco-labelling, subsidies for research, pilot projects, etc. However, according to UBA, the reported effects from these tools as a whole correspond to the objectives of the IED.

UBA emphasises that an important attribute of the IED is that the legislation also influences the environment and human health outside the EU, where the untapped emissions reduction potential is considered much higher than in the EU. UBA has received numerous requests to start cooperative projects on the implementation of BAT outside Europe. The countries involved include, amongst others, China, India, Iran, Pakistan and the Russian Federation. Projects of bilateral and multilateral cooperation open up the possibility for UBA to develop and cultivate networks or permanent cooperation with governmental and non-governmental organisations, authorities or even key personalities by advising partners in the target countries - especially in non-EU countries - in order to jointly pursue environmental protection and sustainable development goals at the international level. UBA believes that a main advantage of the IED to these countries is the introduction of a collaborative, multi-stakeholder approach to the adoption of BAT. This allows for industry, NGOs and the government to build a common understanding of the challenges associated with industrial pollution, and to collectively discuss available pollution prevention and control techniques.

The UK environment agencies

Experts from the English Environment Agency and the Scottish Environment Protection Agency emphasise that an important attribute of the IED is its provision of a profound and sound basis for setting binding emission limit values. This is however off-set slightly by the possibility to derogate. Another limitation is the lack of government incentives and/or support and the limited time frame for implementation, notably for sectors with very large integrated plants. These plants often face investment programmes that take longer than the four years implementation period provided under the IED.

The English Environment Agency highlights that emission trends at the national level are impacted by a combination of national and supranational policies and measures, including permitting, carbon taxation (which may affect process fuel and to some extent energy consumption) and eco-labelling (if it includes production-related criteria), and it is thus difficult to isolate the reduction caused specifically by the IED.

Industry associations

Cefic (the European Chemical Industry Council) perceives the EU’s industrial emissions policy as being effective. Representatives from the association emphasise that the IED forces EU Member States to align their national law with the BAT Conclusions, while still leaving some flexibility to uptake BAT, contributing to a high level of environmental protection and improvement of environmental quality.

Cefic considers the Seville Process a crucial success factor. The Seville Process builds on a strong involvement of all players - authorities, NGOs and industry - allowing for a balanced result and an intense data collection which reflects the reality. This, however, also makes it a time-consuming and resource-intensive process. Yet, Cefic considers the Seville Process worth the effort.

Cefic emphasises that overall, significant emission reductions in Europe are observed, including in the chemical industry. The industry association believes that an estimation of the benefits of the IED, let alone an individual BREF, is difficult and hard to quantify.

Eurometaux (the European non-ferrous metals association) also perceives the EU’s industrial emissions policy as being effective. The industry association states that the BREFs and BAT Conclusions provide a solid, profound and acknowledged basis for setting permit conditions, contributing to a high level of environmental protection and improvement of environmental quality. They believe the IED is a very important instrument to regulate industrial emissions, and maintaining a level playing field within the EU by aligning environmental performance requirements for industrial installations, despite the differences in implementation across EU Member States, notably with regards to procedures, timeline, on what basis derogations are granted, etc. Eurometaux argues that while it is not sure how these differences affect the effectiveness of the IED, the European Commission strives towards consistency of derogations across EU Member States.

Further, the IED allows Eurometaux to interact with companies in their sector, through the association's contributions to the revision of the BREF for the non-ferrous metals industries and the implementation of the BAT Conclusions. Eurometaux finds that the BREF and the BAT Conclusions reflect the reality of the non-ferrous metals sector. Nonetheless, Eurometaux indicates some ways in which the Directive could be improved. Eurometaux, along with Cefic, stresses that there should be room to discuss and improve the methodology for deriving BAT-AELs as part of the Seville Process, aiming at broader consensus on the methodology and thus on the BAT-AELs. The derivation of BAT-AEL ranges should become more transparent and systematic, whether it includes a statistical analysis or not.

Eurometaux also observes that BAT-AELs are based on available emissions data and supporting data. If there is no data available, no BAT-AELs are being set, although the pollutant might be considered key.

Finally, Eurometaux highlights that in case of sufficient data, BAT-AELs should only be set when the data concerns a key environmental issue[4]. Eurometaux notices that different parties might have diverging views on which issues that should be considered Key Environmental Issues. Better clarifying and agreeing on a standard methodology for establishing the Key Environmental Issues[5] and better disseminating information on the outcomes of this procedure to the Technical Working Groups, would strengthen the Seville process, and thus the IED's effectiveness. Eurometaux further considers that, in determining Key Environmental Issues, scientific evidence and technical knowledge should be given priority. According to Eurometaux, the precautionary principle[6], should be applied only where knowledge and evidence are not sufficient.

Non-governmental organisations

The European Environmental Bureau (EEB), which is a network of over 150 environmental citizens' organisations based in more than 30 countries, considers that the IED has laid down a good framework for multi-stakeholder involvement and for an integrated approach ensuring a high level of environmental and human health protection. The EEB further supports the BAT criteria set in Annex III of the IED, while at the same time sees the need for clarification of these criteria to ensure the quality of the BAT determination process, ambitious outcomes in terms of environmental protection and a level playing field for the industry concerned. Furthermore, the EEB believes that the Seville Process suffers from an imbalance of the various interests represented, as operators outnumber NGOs and innovative technique providers largely are absent. Although the Seville Process is supposed to be based on consensus, the EEB finds that is not always clear how consensus is reached in practice; this seems to be largely left at the discretion of the European Commission. EEB considers that contrary to NGO and industry representatives, EU Member States have an opportunity to influence the decision making through political means, notably through the final vote on the text for the BAT Conclusions. The EEB therefore finds that there is a need for rules enabling a more balanced representation of interests as well as for consensus-based decision-making on critical issues. The organisation further suggests that a conflict-of-interest policy be developed, so that the experts involved in the exchange on behalf of governments do not have links to the industry concerned, as supported by Greenpeace (Greenpeace European Unit, 2015[50]).

The EEB further argues that the Seville Process suffers from an inherent conflict of the BAT notion itself, between the terms "availability", i.e. the economic viability and technical reliability for the operator, and "best", meaning the most effective in achieving the highest level of environmental performance. According to EEB, NGOs insist that the main objective of setting BAT Conclusions should always be the intended outcome for the environment, whilst they find that industry can be more concerned with the cost impacts. The EEB suggests to keep the Seville Process as an exclusively techniques-driven process and to shift the proportionality balance (i.e. BAT ambition levels and achieved benefits, versus costs due to complying with strict BAT-AELs) to the permitting level, where a specific derogation procedure under IED Article 15(4) is foreseen. According to the EEB, one currently observes a mix-up of both concepts and decision-making steps.

The EEB finds that the main hurdles to the adequate functioning of the Seville Process and the IED are posed by the following elements:

i. Recent measures to restrict the development of BAT Conclusions to the Key Environmental Issues rather than for all relevant pollutants listed in the IED.[7] EEB believes that alongside relevant pollutants, the BAT Conclusions shall address any other impacts of industrial facilities, such as energy consumption.

ii. The absence of a standardised procedure for the derivation of the BAT-AEL range, especially the upper end of the range, which is linked to currently observed average performance levels, but not necessarily to the performance levels that truly are "best". EEB finds this issue to be important as the upper end of the BAT-AEL range is in some cases considered the default option for setting ELVs in environmental permits.

iii. The approach taken in the selection of reference plants and techniques considered as part of the determination of BAT, which is based on data from currently operating plants, making it difficult to set BAT-AELs on the basis of techniques that have not yet been implemented in the EU or on the optimal abatement potential of a given technique. As a consequence, the EEB believes that BAT-AELs form politically negotiated levels achieved by the well, or average, performing plants in the EU, rather than levels that are technically feasible and that have a better environmental outcome.

iv. The hierarchy between prevention and control techniques is not necessarily respected in practice.

v. There is sometimes a lack of policy coherence between environmental quality standards and the BAT Conclusions; e.g. the Water Framework Directive (EU, 2000[38]) requires a total phase out of any loss and discharge of particularly hazardous substances, while the BAT Conclusions often still allow emissions (in given concentrations) of these substances, without absolute load limits.

vi. Rather than only covering industrial activities operating above certain thresholds, e.g. thermal power plants with a thermal input of more than 50 MWth, the EEB believes that the IED should apply to *all* industrial activities that provide certain services or products, e.g. all energy producers (based on all sources) of a certain scale.

vii. Limited and non-timely access to adequate continuous emissions monitoring data due to the low quality of databases on industrial emissions at EU level. For example, the industry operators' annual compliance reports submitted to permitting authorities are not made publicly available. The EEB considers that setting up more adequate monitoring systems and user-friendly IT databases and/or agreed permit report templates could enable easy and timely gathering of information on performance and underlying drivers, for the purposes of benchmarking, effectiveness assessment, research, policy development, and enhanced access for, and awareness-raising and engagement of, the public as regards information on permit conditions and BAT compliance. Further, developing improved PRTR systems or adopting good practices for Member State competent authorities in relation to improved access and public participation in environmental permitting would facilitate the promotion of BAT implementation (EEB, 2017[51]).

viii. Whilst EU Member States usually consult industry representatives, the EEB finds that they do not necessarily have a formalised procedure involving NGOs to balance out the views put forward. Furthermore, according to the EEB, the Member States do not necessarily enable the effective participation of NGOs by providing adequate and timely access to information (see paragraph vii) or the necessary resources.

3.3. Available sources of data

3.3.1. Emissions monitoring data

PRTR

The EU Pollutant Release and Transfer Register (E-PRTR)[1] is the Europe-wide register that provides accessible key environmental emissions and waste transfer data from industrial facilities in EU Member States as well as in Iceland, Liechtenstein, Norway, Serbia and Switzerland. The information provided via E-PRTR includes the quantities of pollutant releases to air, water and land, as well as off-site transfers of waste and pollutants in wastewater. It covers 91 key pollutants, since 2007. The latest year covered (as of February 2019) is 2016. Some information on releases from diffuse sources is also available in E-PRTR.

A facility must report data under the E-PRTR if it fulfils all of the following three criteria:

i. The facility falls under at least one of the 65 E-PRTR economic activities in Annex I of the E-PRTR Regulation (EU, 2006[52]).

ii. The facility has a capacity exceeding at least one of the E-PRTR capacity thresholds in Annex I of the E-PRTR Regulation (EU, 2006[52]).

iii. The facility releases pollutants which exceed reporting thresholds for air, water and land in Annex II, or transfers waste off-site which exceed thresholds set out in Article 5, of the E-PRTR Regulation (EU, 2006[52]).

The European Commission is undertaking work to better link the IED and E-PRTR reporting by Member States. The resulting EU registry of industrial installations will, in the future, supplement the E-PRTR mass emission data with additional IED information, e.g. links to permits and monitoring data, inspection reports and competent authorities. According to the European Environmental Bureau (2017[51]), even more data could ideally be provided as part of the E-PRTR, such as annual compliance reports as per Article 14 of the IED on permit conditions, baseline reports, more detailed emissions monitoring data and other information that would enable improved benchmarking and compliance assessment, in addition to activity data or production outputs.

Most EU countries report PRTR country-specific data on their own websites, such as Flanders (Belgium)[8], Germany[9] and the UK[10]. Norway has a more complete PRTR portal which also provides facility-specific information as well as data on diffuse emissions linked to industrial activities: output information (production volumes / activity data), flow rates, the permit limit versus monitored performance, and PDF versions of key documents (permits, inspection reports and annual compliance reports).

Emissions monitoring data at installation level

EU Member State competent authorities are responsible for implementing the IED. They therefore hold information provided by operators to demonstrate compliance with their permit conditions, including emissions monitoring data. In order to ensure the effective implementation and enforcement of the IED, operators have to report annually to the Member States' competent authority on compliance with permit conditions (for all IED installations, Article 14(1)d of IED and Article 62 of IED for waste incineration plants). According to IED Article 24(3)b, the data submitted by operators, which includes emissions monitoring data, shall be made publicly available, including via the internet. Further, IED Article 24 emphasises the importance of public access to information on, and participation in, permit procedures. (Note: The IED is covered by general EU confidentiality provisions, but this does not normally affect the disclosure of emissions data.)

However, according to the European Environmental Bureau (EEB), practice varies across Member States, potentially impacting effective public participation in decision making on industrial activities. EEB (2017[51]) reveals that more than half of the EU28 countries fail to meet even the minimum requirements under Article 24(3)b, while other Member States excel by providing systems that are both highly transparent and intuitively user friendly. An assessment of the quality of the websites available shows that Norway and Ireland have created systems for sharing information that rank as the best in Europe. The system put in place by Bulgaria is also commended (EEB, 2017[51]).

The European non-ferrous metals association (Eurometaux) states that monitoring data were made available for the revision of the BREF on non-ferrous metals (EIPCCB, 2017[34]). Emissions monitoring data for the non-ferrous metals sector were published on the password-protected web portal BATIS[11] (Best Available Techniques Information System) and in the BREF for the sector. BATIS is an electronic system which contains all the information exchanged in the context of drawing up or reviewing a BREF. Although emissions monitoring data submitted to BATIS in essence is considered public data, the web portal is only available to members of the Technical Working Groups and not to the wider public. If data are considered confidential, it can be uploaded to specific, locked folders in BATIS, but this is rarely the case, as the involved stakeholders' expectations to transparency are generally high. The data published in the BREF for the non-ferrous metals industries are accessible for the wider public.

In Germany, installation level monitoring data are reported and managed at a local level (in the 16 regional governments, known as Länder), and thus not centralised, nor published online. To access the data, one would have to send a request to the Länder, and in some cases also pay a fee. The German Federal Environmental Agency (UBA) publishes some aggregated data on their emissions data webpage[12].

In the UK, aggregated emission monitoring data was presented in the English Environment Agency's report "Regulating for people, the environment and growth", (Environment Agency, 2017[53]), showing, amongst others, a decrease in emissions since 2000 from the industries they regulate:

i. A decrease of nitrogen oxides (NO_x) by 71%

ii. A decrease of sulphur oxides (SO_x) by 93%

iii. A decrease of small particles (PM_{10}) by 50%

iv. A decrease of greenhouse gases by 39%

3.3.2. Activity data

At the EU level, the E-PRTR Regulation has optional fields for operators to submit data on production volume, number of installations, number of operating hours per year and number of employees, in addition to contain a text field for textual information or the website address of the concerned facility or parent company. However, as these fields are not mandatory, they are scarcely used. The Norwegian PRTR, also based on the E-PRTR Regulation - forms an example of best practice and publishes production volume information and other output data

The scene-setting chapters of BREFs, in particular the fourth section called "techniques to consider for the determination of BAT", also give a certain amount of activity information and the penetration of certain techniques in the given sector where this is relevant to establishing the environmental significance of the industrial sector. In addition, Eurostat[13] has industry activity expressed at sector level in monetary units. These data are sometimes difficult to correlate to the activities covered by IED installations. Further, capacity data may be included in permits.

The European Commission states that the most accurate activity data likely are held by Member State competent authorities. Nonetheless, not all countries have such data available; for example, the competent authorities of Germany and UK do not. Further, the industry associations Cefic and Eurometaux report not having activity data, i.e. historical data on production capacities, available for their respective industries.

3.3.3. Other metrics

Industrial operators are required by the IED (Article 7) to inform the competent authority in the event of any incident or accident significantly affecting the environment. Trends in the number of incidents and/or accidents could be an indicator of the IED's effectiveness. There is however no official repository for submitting incidents or accident reports to the European Commission for IED installations, as there is for Seveso establishments. Seveso establishments are companies that have quantities of hazardous substances on their premises that exceed established threshold values. They are subject to the Seveso-III-Directive (2012/18/EU) (EU, 2012[54]). This Directive aims at the prevention of major accidents involving dangerous substances. eMars is the official reporting repository for submitting accident reports for these installations. eMARS[14] contains statistics on the number of accident reports by year, Seveso site classification, industry type and information on accidents involving special circumstances.

Some other data are available at the Member State level. For example, UBA has assessed the impacts of heavy metal emissions, from industry and other sources, on air quality and ecosystems in Germany (Schröder et al., 2017[55]). The study models emissions and immissions (i.e. the concentration of pollutants in ambient air), and assesses the reductions delivered by BAT Conclusions. In a next phase, UBA will assess whether it is possible to identify a link between improvements of air quality and the implementation of BAT.

Some environmental quality data are also available. This relates in particular to air quality monitoring data (e.g. EU air quality index[15]), data on water quality (e.g. WISE[16]). Other databases exist on the use and classification of chemicals (ECHA[17]) and improved reporting on hazardous substances in materials and waste is currently under development.

Further, some EU Member States publish all permit-related information online, such as the UK[18] and Ireland[19]. However, according to the EEB, their attempts to locate permits for plants in fifteen other EU Member States were unsuccessful, either because websites allowing for permits to be directly downloaded did not exist, because certain information was missing or because sub-national authorities made it unclear if and where the data was available.

3.4. Case studies

3.4.1. BAT implementation at a copper smelting plant in Germany

The Aurubis production site in Hamburg is located on an area of about 870 000 m^2 on the Elbe island Peute, only about four kilometres as the crow flies from Hamburg's city hall. The plant was constructed in 1908 in Peute, as an industrial inland harbour area in the Veddel district. The production facilities were continuously expanded and steadily modernised. Today, Aurubis's Hamburg site is one of the world's state-of-the-art primary and secondary copper smelters. The main raw materials in copper production are copper concentrates and recycling materials (including electrical and electronic scrap). Pure copper is produced from the different raw materials following pyrometallurgical smelting and refining and copper electrolytic refining. Additionally, precious metals, nickel sulphate, lead as well as iron silicate products and sulphuric acid are obtained from – in some cases – very complex input materials in the scope of multi-metal recycling. Aurubis uses the properties of copper and other metals to enable recycling without a loss of quality.

In view of the variety and the complexity of feed materials treated, the operations in Hamburg cover:

- Primary copper smelter including concentrate dryers (steam and natural gas), Flash smelting furnace, Peirce-Smith converters, electric slag cleaning furnace and anode furnaces. It processes copper concentrates from various mines of the world as well as copper scrap in the converters;
- a three-line double catalysis sulphuric acid plant complex for the treatment of SO_2 gases of the different plant sections;
- electrolytic copper refinery for copper cathode production;
- secondary smelter with electric furnace and converters for the treatment of lead/copper containing secondary materials including internal recycles;
- pyrometallurgical lead refinery for the production of refined lead;

- precious metals refinery, including top blown rotary converter furnaces, electrolytic processes and hydrometallurgical processes for refining gold, silver, selenium, tellurium and platinum group metals concentrate;
- production facilities for metal salts (copper sulphate and nickel sulphate);
- continuous casting plant for copper billets and slabs/cakes; and
- copper wire rod plant.

The Aurubis copper smelting plant in Hamburg has taken several measures to reduce diffuse emissions as well as stack emissions of SO_2 and dust (including hazardous metals in the dust). Notably, the smelter installed several hoods to collect the diffuse gases, e.g. on charging and tapping points. Additionally, some furnaces were encapsulated, and storage areas were enclosed. The smelter also started treating all collected gases in modern bag filter systems as well as additionally reduced SO_2 emissions by adding adsorbents in the gas stream. Some of the measures are listed below:

- A covered storage area for bulk secondary materials with integrated crushing, screening and enclosed conveyor belts. This also includes an exhaust system for the crusher, a sieve and belts and dedusting in a bag filter with a capacity of 70 000 Nm3/h.
- Capture of secondary gases during primary converter charging, skimming or metal pouring is ensured by a secondary hood system at each converter, closed ladle and launder by removable hoods.
- Common system for secondary gas capturing and cleaning is installed for a total gas flow of 930 000 Nm3/h, including the following sources: converter secondary hoods; ventilation hoods at flash smelting furnace and electric slag furnace; the tap holes, launder ventilation of smelting furnace and ventilation hoods of anode furnaces. The collected gases are treated in a bag filter. For SO_2, dry lime is injected into the system before the bag filter.
- Project for collecting and cleaning the diffuse emissions in the anode furnace and casting machine area was completed. It consisted of enclosing parts of the plant, suctioning of the off-gases and cleaning them in a new bag filter with lime injection.
- House-in-house concept: the units (holding furnace, converters and casting facilities in secondary copper production) installed inside, closed production buildings that are not only provided with capture hoods, but also accommodated in a largely sealed enclosure which is vented to a filter system. All pouring, casting and transfer operations mainly occur within this enclosure, which is equipped with a trolley crane (charging trolley) for this purpose. In this way, diffuse emissions from the filled ladles during transfer from the converter to the holding furnace are effectively trapped by tornado hoods.
- New lead refinery for recovery of high-purity lead from lead-bearing recycling intermediates and concentration of precious metals for further processing in the precious metal plant. Reduction in fugitive emissions achieved as a result of the optimised material flow and the efficient hall ventilation concept.

This combination of techniques led to a significant reduction of emissions and concentrations in the surroundings of the smelter between 2009 and 2017. The changes in specific emissions, i.e. emissions per tonne of copper output, are displayed in Table 3.1.

The annual output of the plant is 455 406 tonnes of copper, based on an input of 1 700 440 tonnes of material (Aurubis, 2018[56]).

Table 3.1. Specific emissions from the Aurubus copper smelting plant in 2009 and 2017

Pollutant	Specific emissions, 2009	Specific emissions, 2017
SO_2	5.1 kg/t	4.4 kg/t
Dust	94 g/t	95 g/t
Copper	15.3 g/t	14.3 g/t
Lead	4.5 g/t	3.5 g/t
Arsenic	1.1 g/t	0.9 g/t

Source: (Aurubis, 2018[56])

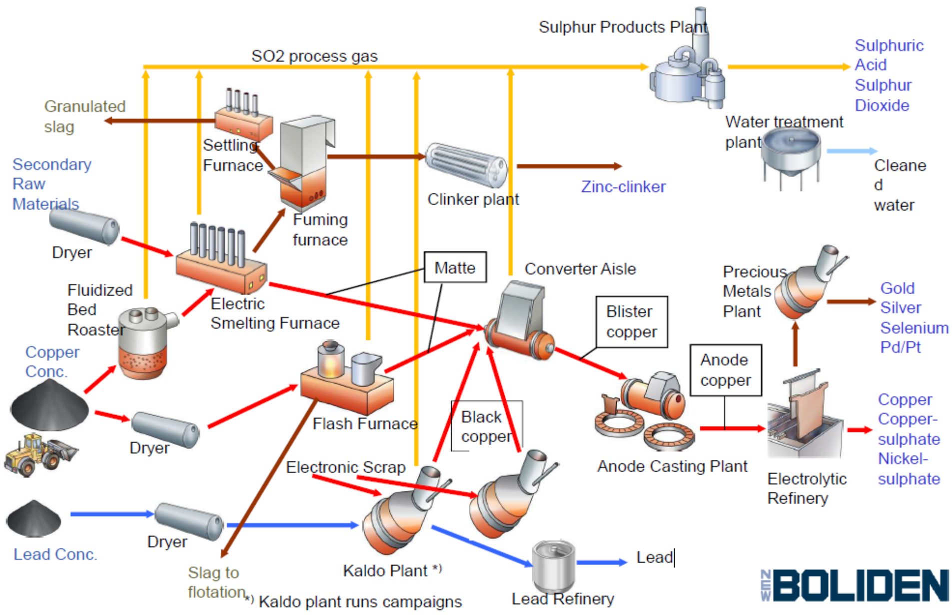
The reductions in emissions of hazardous metals like arsenic, cadmium and lead led to positive effects on the environment and human health. In 2017, the Aurubis plant generally complied with the emission limits determined by the German Technical Instruction on Air Quality Control (BMU, 2002[57]), established in line with BAT-AELs defined under the IED (Aurubis, 2018[56]).

3.4.2. BAT implementation at a copper smelting plant in Sweden

The Boliden's Rönnskär smelter, located in northern Sweden, extracts metals and chemicals from mineral concentrates and recycling materials. The main products are copper, lead, gold, silver and zinc clinker, with by-products such as liquid sulphur dioxide, sulphuric acid, selenium and nickel sulphate (HELCOM, 2002[58]). The process flow sheet of the smelter is presented in Figure 3.3.

Over the period 1998-2000, the Rönnskär smelter underwent a transformation of its operations and technologies, using BAT to turn the plant into a state-of-the-art smelter, producing and recycling base and precious metals, including high-purity copper, at a low cost and with minimal environmental impact (HELCOM, 2002[58]). The transformation process, titled Rönnskär +200 Expansion Project, led to 100 000 tonnes increase in copper production capacity, resulting in a total capacity of 240 000 tonnes. The project required investments of SEK 2 000 million (Swedish kronor; or approximately USD 220 million, using currency rate 1 USD = 9.24 SEK), out of which an estimated 30% covered the cost of environmental considerations (HELCOM, 2002[58]).

Figure 3.3. Process flow sheet for the Rönnskär smelter in Sweden



Source: (Boliden, 2017[59])

Following the expansion project, the Rönnskär smelter relied on a range of different process equipment and techniques, including BAT technologies identified under the EU IPPC Directive (EU, 1996[31]), Best Environmental Practices defined under OSPAR Recommendation 98/1 for the Non-ferrous Metal Industry (OSPAR, 1998[60]), as well as the Convention on the Protection of the Marine Environment of the Baltic Sea Area (the Helsinki Convention) (HELCOM, 1992[61]).

The Rönnskär smelter went through another transformation a decade later, investing in e-scrap recycling technology, including an elaborate process gas cleaning system. With an investment of SEK 1.3 billion (or approximately USD 140 million), the plant ensured an increase in e-scrap recycling capacity from 45 000 tonnes to 120 000 tonnes per year, allowing for a significant growth in metals production (additional two tonnes of gold, 32 tonnes of silver and 14 500 tonnes per year), further reduction of releases to the environment and improved energy efficiency (Ahmadzai, 2018[62]).

Since the beginning of the expansion project in 1998 until 2017, emissions to air and discharge to water demonstrated a major decline, although production increased. As an example, emission of dust to air saw a 52 % reduction, while discharge of metals (Cu, Pb, Zn, Cd, Hg and As) to water was reduced by 74% (Boliden, 2017[59]). During the same period the production of copper increased by 43%.

The improvements were triggered by new permit conditions that were imposed due to expansion projects for increased production beyond the limits of the previous permit (before 1998), as well as other investment and expansion decisions made by the company. When environmental investments have been decided upon, compliance with the BAT Conclusions have been one of the factors taken into account. Some examples of major environmental improvements between the years 1998-2017 are listed below:

- upgraded infrastructure: expanded harbour and closed belt conveyors system for copper-concentrates in order to reduce diffuse dust emission (1999);

- closed converter hall and new bag filter for ventilation air in the hall (2000);
- process water pipes pumping polluted water from the different process unites to water treatment plant where lifted above ground (2000);
- new sulphuric acid plant including two new processes for Hg-cleaning (2001);
- large production expansion (+70%) with a new flash furnace and modernised process units (1998-2000);
- improvement in gas cleaning at lead plant to reduce mercury emissions (2002);
- major improvements in energy efficiency (2000, 2006);
- new gas treatment adopted for dioxins (2005, 2007, 2016);
- large reservoir installed to be able to buffer storm water even during very heavy rains (2013);
- new electrostatic precipitators to improve gas cleaning and reduce emissions to air (2015);
- new water treatment plant (2016);
- several storages and other measures for efficient indoor handling of material; and
- constant work to improve "best practice" in maintenance and operation of equipment.

The current (2018) license for the Rönnskär smelter permits an annual production of up to 350 000 tonnes of copper (Cu), 90 000 tonnes of lead and 60 000 tonnes of zinc products (Zn). The complex smelter has, in addition, a precious metal production of gold and silver. Associated emissions of sulphur dioxide (SO_2) from 1 January 2019 shall not be greater than 3 500 tonnes per annum. The permit limited emissions of dust to 40 t/y; Cu to 2 t/y; Zn to 8 t/y. Cadmium and Mercury emissions are limited to 0.075 t/y and 0.060 t/y, respectively. Metal discharges from the Smelter to the receiving water are summarised in Figure 2.7 (Boliden, 2017[59]). The Rönnskär smelter generally complies with emission levels according to EU BAT Conclusions for the non-ferrous metals industries (EU, 2016[25]). All new projects and investments are performed according to BAT. Recently, major investments have been made in a new water treatment plant and new gas cleaning filters.

Table 3.2. Discharge of metals to the receiving water (2017)

	Cu, tonnes	Pb, tonnes	Zn, tonnes	Cd, kg	As, tonnes	Hg, kg	Ni, tonnes
Release	0.49	0.17	1.32	24	0.10	3.2	0.08
Provisional permit	0.8*	0.35	2.5	60*	0.50	20	0.15

Note: *for 2016-2017
Source: (Boliden, 2017[59])

3.4.3. BAT implementation in the European leather tanning sector

The leather tanning process is associated with considerable levels of water discharge, waste and emissions to air, due to high consumption of water, chemicals and energy. Starting from the 1970s, members of a European leather tanning association, consisting of more than 1000 members, have taken co-ordinated action to reduce water pollution from their operations, with leather tanning companies located in the same area investing in joint waste-water treatment plants. In response to emission limit values applied under the IED, local and regional leather tanning consortia have enhanced the performance of these wastewater treatment plants, reaching total pollution abatement levels of more than 93% for all main pollutants. Specific measures have been taken for some of the most hazardous pollutants. For example, by enabling the recovery of chromium from wastewater and reusing this metal in the tanning process, the consortium has obtained a 99% reduction of chromium concentrations (EC, 2018[63]).

Moreover, the tanneries have initiated collaboration with chemicals and technology suppliers, to identify ways to substitute a number of other hazardous chemicals and to introduce new processes. As a consequence, the use of hazardous chemicals has been significantly reduced, if not eliminated. Additional measures have been taken to use chemicals with low volatile organic compound (VOC) content, leading to a decline in VOC emissions of 40%, or 10 000 tonnes a year, with up to EUR 38 million in societal benefits (EC, 2018[63]).

Furthermore, over the last decade, the member companies of the leather tanning association have reduced their water consumption by about 20% and improved waste recovery to 62-77%. Finally, they have ensured a considerable increase in the energy efficiency of the tanning process, resulting in annual savings of EUR 1.9 million and 11 300 tonnes of CO_2 emissions avoided per year. The associated societal benefits are approximately EUR 500 000 per year (EC, 2018[63]).

3.5. Conclusion

The results from several IED reporting requirements, as well as studies conducted by the European Commission, provide insights into the IED's effectiveness and attributes. These include the integrated environmental approach, a profound and solid legal basis for BAT, the flexibility to derogate, public access and participation, a level playing field for industry and sound inspection practices. The European Commission's Directorate-General for the Environment also highlights precedence for pollution prevention (over pollution control) as a main advantage of the IED.

Effects of the IED are harder to quantify, but trends in industrial emissions at national and EU level appear promising. This is illustrated by the analysis of E-PRTR data on SO_2 and PM emissions from copper and aluminium facilities for the period 2007-2015 in Chapter 2. The analysis demonstrates, for example, that SO_2 emissions from copper facilities in the EU decreased by 16% over the period 2009-2015, in spite of production increase of 5% over the same period. (Further analysis would be needed, however, to determine whether this is due to the IED.) Moreover, the analysis shows that emission levels from these sectors are mostly lower in the EU than in the US and in Chile.

As there are many other EU and national instruments that apply to industrial installations and affect their emissions, it can often be hard to state to what extent improvements in emission trends can be attributed to the IED.

It is possible that measures could be taken to further strengthen the IED and its implementation. According to some stakeholders, this would include ensuring more transparent, standardised procedures to determine BAT and BAT-AELs as well as Key Environmental Issues, and to strengthen the balancing of stakeholder interests as part of these procedures. Further, stakeholders request more transparent and accessible reporting of industrial emissions at installation level as well as data on production volumes and compliance with permit conditions.

Notes

[1] See http://eippcb.jrc.ec.europa.eu/reference/.

[2] "…without prejudice to other measures which may be taken to comply with environmental quality standards" (EU, 2010[23]).

[3] See http://ec.europa.eu/environment/industry/stationary/publications.htm.

[4] According to the BREF Guidance Document (EU, 2012[132]) Technical Working Group members shall identify key data and issues for deriving or updating BAT conclusions. Key Environmental Issues are issues for which BAT conclusions have the highest likelihood of resulting in noteworthy additional environmental benefits.

[5] This was attempted in a study by the European Union (EU, 2016[131]).

[6] The precautionary principle is embedded in the Treaty of the Functioning of the European Union (EU, 2016[37]).

[7] However, it should be noted that this does not prevent local permitting authorities from setting permits conditions for a wider range of issues.

[8] See https://www.vmm.be/lucht, https://www.vmm.be/water/afvalwater.

[9] See https://www.thru.de/thrude/.

[10] See https://data.gov.uk/dataset/pollution-inventory.

[11] See http://eippcb.jrc.ec.europa.eu/batis/.

[12] See https://www.umweltbundesamt.de/daten/.

[13] See https://ec.europa.eu/eurostat

[14] See https://emars.jrc.ec.europa.eu/en/emars/statistics/statistics.

[15] See https://www.eea.europa.eu/themes/air/air-quality-index.

[16] See https://www.eea.europa.eu/data-and-maps/data/wise-wfd.

[17]See https://echa.europa.eu/information-on-chemicals.

[18] See https://www.gov.uk/government/collections/industrial-emissions-directive-ied-environmental-permits-issued.

[19] See http://www.epa.ie/terminalfour/ippc/index.jsp?disclaimer=yes&Submit=Continue.

Chapter 4. United States

The United States (US) regulates industrial emissions through a set of technology-based performance standards. Emissions monitoring data in the US are available through the Toxic Release Inventory (TRI), the National Emissions Inventory and the WebFIRE database. Information on air pollution technologies and emissions limit values pertaining to individual facilities can be accessed through the RACT/BACT/LAER Clearinghouse, and some activity data can be downloaded from the US Geological Survey's Mineral Commodity Summaries. In addition to outlining the characteristics of these databases, this chapter contains three case studies. These display the effects of National Emission Standards for Hazardous Air Pollutants for the lead smelting and aluminium production sector, and the decline of emissions from the pharmaceutical sector as a result of the implementation of green chemistry.

4.1. BAT and environmental permitting in the United States

The United States (US) has several programmes that apply technology-based performance standards at national, state and local levels. Each programme has its own considerations and objectives prescribed by federal environmental legislation, including the Clean Air Act (US EPA, n.d.[64]), Clean Water Act (US EPA, 2002[65])and the Pollution Prevention Act (US EPA, n.d.[66]). There are no standardised BAT or technology reference documents that apply across programmes, although data gathered and analysed during the development of the standards are documented. Proposed and final regulations are published in the Federal Register.[1]

Standards are generally in the form of quantified emission limit values (ELVs) established in medium-specific environmental permits. The ELVs can be based on, inter alia, the National Emission Standards for Hazardous Air Pollutants (NESHAP), which are derived from Maximum Achievable Control Technology (MACT). The complete list of NESHAPs, as well as of the US' New Source Performance Standards, is available in the OECD's report *Approaches to Establishing BAT Around the World* (2018[36]) and online[2]. For new and modified plants, emission limit values for criteria air pollutants, such as SO_2 and PM_{10}, are determined under the New Source Permitting programme, in compliance with the National Ambient Air Quality Standards (NAAQS) (US EPA, n.d.[27]), and based on Best Available Control Technologies (BACT) or Lowest Achievable Emissions Rates (LAER), depending on whether the plant is located in an area that does – or does not – attain the NAAQS.

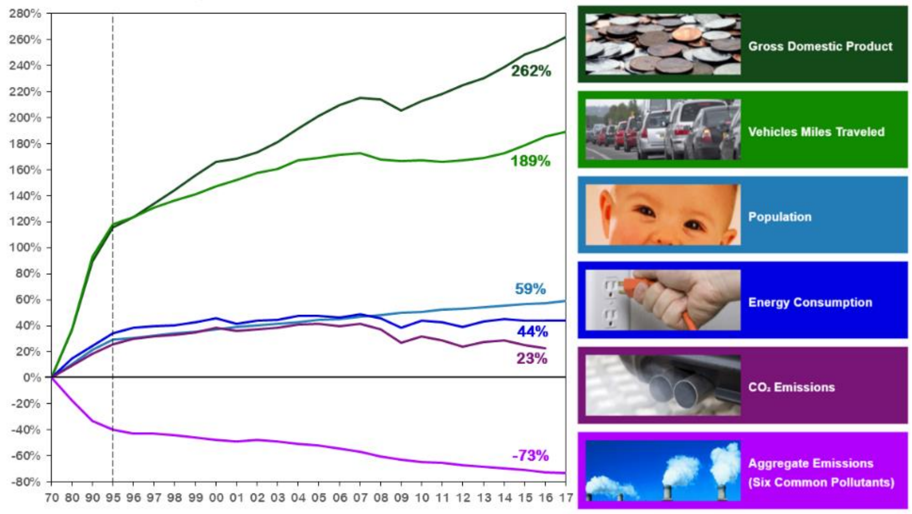
4.2. Policy evaluation

4.2.1. Governmental evaluation projects

The US has numerous ways to determine the success of environmental programs to reduce pollution and achieve air quality goals. The Clean Air Act requires that the US Environmental Protection Agency (EPA) periodically review requirements to consider the most current health, environmental and technological information, and, if warranted, improve the requirements.

The US EPA also examines data on emissions and air quality. The impact of federal and state regulations on emissions of pollutants to air are described in the EPA report "Our Nation's Air 2018" (US EPA, 2018[67]). The report shows that combined air emissions of carbon monoxide, sulphur dioxide, nitrogen oxides, volatile organic compounds, direct particulate matter ($PM_{2.5}$ and PM_{10}) and lead dropped by 73% from 1970 to 2017. Moreover, the US economy continued to grow throughout the same period, with an increase in gross domestic product of 262%, as shown in Figure 4.1.

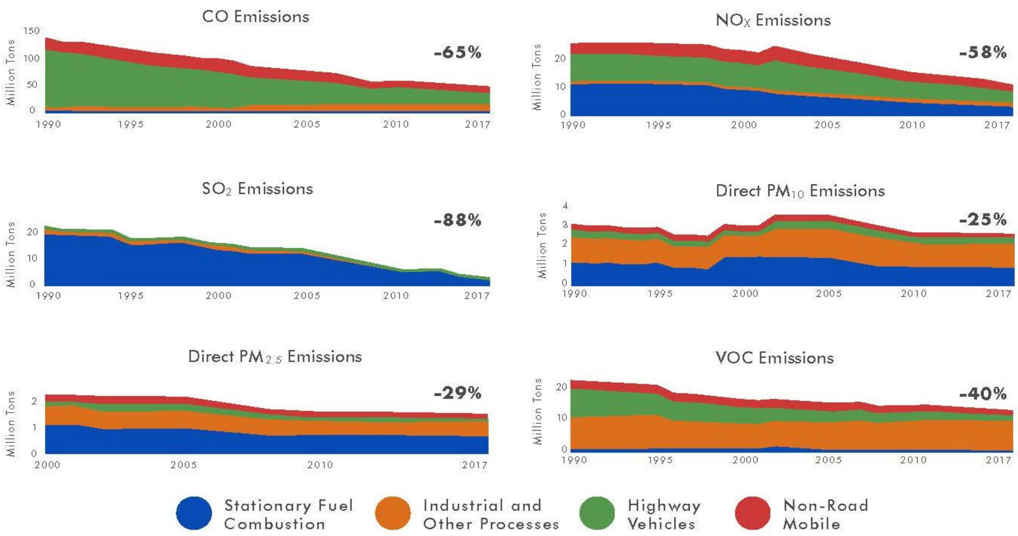
Figure 4.1. Comparison of economic growth and emissions to air in the US, 1970-2017



Source: (US EPA, 2018[64])

The reductions by pollutant from 1990 to 2017 are shown in Figure 4.2. According to EPA, these reductions are driven by federal and state implementation of stationary and mobile source regulations. While some pollutants continue to pose serious air quality problems in areas of the US, nationally, air pollutant concentrations have dropped significantly since 1990. The amount of decline in concentration nationally varies by pollutant, ranging from 22% to 88%. The number of days with unhealthy air quality is also trending downward, meaning better health and quality of life (US EPA, 2018[68]).

Figure 4.2. Trends in air pollution emissions in the US, 1990-2017



Source: (US EPA, 2018[64]

EPA also conducts scientifically reviewed studies of the impact of the Clean Air Act on the public health, economy and environment of the US3. These studies ask how the overall health, welfare, ecological, and economic benefits of the Clean Air Act programmes compare to the costs of these programs. EPA has issued three reports following a process of study development and outside expert review. These studies all found that the benefits of the programmes and standards significantly exceed the costs. More than forty years of experience with the Clean Air Act has shown that the US can build its economy and create jobs while cutting pollution to protect public health.

4.3. Stakeholder opinions

4.3.1. US Environmental Protection Agency

According to EPA, in order to directly assess the impact of each regulatory action on a sector or a facility, a cause and effect relationship between a regulation and a change in emissions may warrant gathering of information which may not be readily available regarding other factors, such as:

i. Why a facility made a change to their operations: Sectors may have made changes in response to the given regulation, other regulatory actions, or business reasons such as equipment upgrades to improve efficiency or increasing/decreasing production in response to market conditions. In the US, there are not only national regulations, but also regulations set by state and local governments. Some requirements are applied on a case-by-case basis at the facility level, such as under the New Source Review permitting program, meaning that facilities within a sector are likely to have different sets of regulatory requirements.

ii. What type of change a facility implemented: Facilities often have multiple options to reduce emissions to comply with a regulatory requirement. While some may implement a technology solution, others may change products or work practices.

iii. When a facility implemented a change: It is also challenging to relate the timing of a facility change to a regulatory requirement. Facilities may know well in advance of an upcoming compliance deadline. For example, if an emission reduction occurs two years in advance of a compliance deadline, without further research, it is unknown if the change was due to the regulatory requirement.

iv. Who made a change in response to the regulation: Only facilities or specific processes that meet the criteria specified in the regulation (e.g., emissions-based) are required to comply. Assessing the data available for the entire sector would include facilities that were and were not subject to the regulation, further confounding interpretation of the data for this purpose.

4.4. Available sources of data

4.4.1. Emissions monitoring data

The Toxic Release Inventory

The US Environmental Protection Agency's (EPA) Toxic Release Inventory (TRI)[4] is a pollution prevention tool used extensively for tracking environmental performance. It was established to increase the public's awareness of and access to information on toxic chemicals released or managed as waste in their communities. TRI data have been available annually since 1987. The TRI contains information on the quantities of certain toxic chemicals released annually from stationary facilities to air, water and land, or otherwise managed as waste. This information is reported by certain facilities that manufacture, process or otherwise use toxic chemicals on the TRI list above annual thresholds.

The TRI chemical list currently includes 692 discrete chemical substances and more than 30 chemical categories[5]. The TRI does not cover every pollutant addressed under the National Ambient Air Quality Standards and their precursors. These pollutants include lead (Pb), carbon monoxide (CO), nitrogen oxides (NO_X), volatile organic compounds (VOCs), sulphur dioxide (SO_2), particulate matter 10 microns or less (PM_{10}), particulate matter 2.5 microns or less ($PM_{2.5}$), and ammonia (NH_3), which is an important PM precursor. The two exceptions are lead (and lead compounds) and ammonia. Lead is a criteria pollutant and lead and lead compounds are also included on the TRI list of chemicals. Ammonia is also included on the TRI chemical list, and includes anhydrous ammonia and aqueous ammonia from water dissociable ammonium salts and other sources.

The TRI database holds facility level information on releases to all environmental media, i.e. air, water and land, transfer of waste to off-site locations, waste management such as recycling, treatment and energy recovery, and pollution prevention. The latter includes descriptions of measures facilities have taken to prevent pollution and reduce the quantity of toxic chemical releases to the environment. This allows for TRI to serve as a tool for identifying effective environmental practices and giving attention to facilities that successfully have taken measures to prevent pollution (US EPA, n.d.[69]).

Facilities are required to report to TRI if they meet the three following criteria:

i. The facility is in a TRI-covered industry sector or category, i.e. manufacturing, coal/oil electricity generation, hazardous waste management, federal facilities and certain mining facilities.

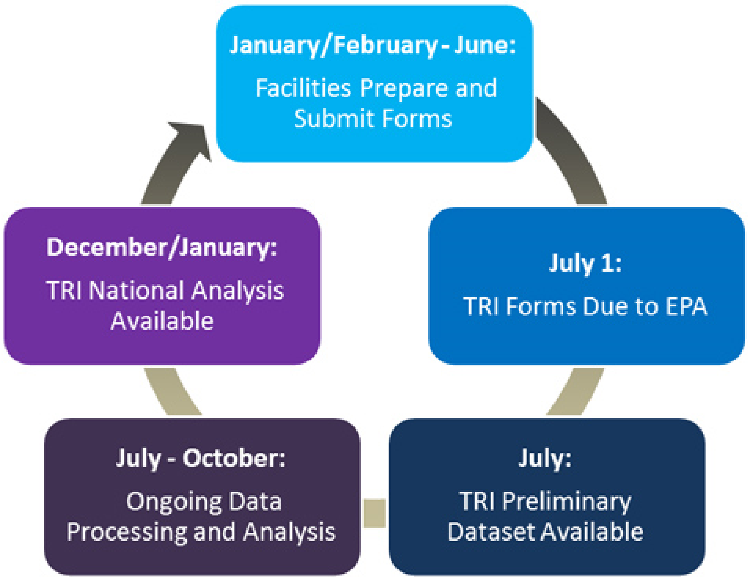
ii. The facility has the equivalent of at least ten full time employees.

iii. The facility manufactures, processes or otherwise uses more than a certain amount of a TRI chemicals per year.

Mass quantities reported to TRI may be based on monitoring or on other emissions estimation methods, such as emission factors or a mass balance approach. As part of their reporting, facilities indicate which method was used to estimate each value reported. The EPA has facilitated the annual reporting of data through the online tool TRI Made Easy. Facilities report data by 1 July every year for the previous year. The EPA conducts data quality checks and compliance assistance activities for all reported data. The annual TRI reporting cycle is illustrated by Figure 4.3.

Based on the reported data, the EPA's TRI Programme publishes a National Analysis report at the end of every year. As of 2018, these reports include interactive data visualisation tools. The programme also develops other tools that further facilitate the consultation, interpretation and use of TRI data for various data uses. This includes mapping tools, such as the "Where You Live" feature, data access tools, such as the TRI Explorer and downloadable files adapted to different types of data users, and granular factsheets including information on the location, chemical and industrial sector of each polluter. In addition, the TRI website has specific emphasis areas for different stakeholder groups: TRI for Tribes, TRI for Communities, TRI for Colleges and Universities.

Figure 4.3. Annual TRI reporting cycle



Source: US EPA

The National Emissions Inventory

Air emissions data are also available in the EPA's National Emissions Inventory (NEI)[6]. NEI contains comprehensive air emission data for pollutants addressed under the National Ambient Air Quality Standards, known as criteria air pollutants, and their precursors. These pollutants include lead (Pb), carbon monoxide (CO), nitrogen oxides (NO_x), volatile organic compounds (VOCs), sulphur dioxide (SO_2), particulate matter 10 microns or less (PM_{10}), particulate matter 2.5 microns or less ($PM_{2.5}$), and ammonia (NH_3), which is an important PM precursor. The NEI also contains comprehensive air emission data for hazardous air pollutants associated with EPA's air toxics programmes, of which there are currently 187.[7] There is some overlap in chemical coverage between NEI and TRI, but coverage is not identical. There are no thresholds for reporting to NEI. The NEI data pertain to stationary and mobile sources, and support air quality modeling and analysis.

The NEI data are submitted to the EPA by state and local agencies, which collect data for each unit in their area that generates emissions, including mobile and stationary sources. For some elements of the NEI, reporting by the state and local agencies is voluntary, and data are derived from other EPA programmes. For stationary point sources, the data are reported at the process level within a facility. For non-point sources, which are typically smaller yet pervasive sources (such as residential heating, asphalt paving and commercial and consumer solvent use), emissions are reported at a geographic (county) level. The mobile sources for which emissions are reported include both on-road vehicles and off-road mobile sources, such as construction equipment, lawn and garden equipment, aircraft ground support equipment, locomotives, and commercial marine vessels.

NEI data are collected and published every three years. NEI data are available for 2008, 2011, 2014. The 2017 NEI is currently under development. Uses of the NEI data include input to EPA's air quality and exposure modelling and assessments. Pollutant emissions summary files for earlier NEI are also available.

The WebFIRE database

Under certain NESHAPs and New Source Performance Standards, facilities are required to measure and report emissions data to EPA via an electronic reporting interface. These reports are contained in the WebFIRE online database[8]. Reports include emissions performance tests, notifications of compliance status, and periodic reports, such as excess emissions reports and demonstrations of on-going compliance. There are no thresholds for WebFIRE reporting. WebFIRE allows users to prepare batch downloads of facility information.

WebFIRE contains emission factors developed by EPA for criteria and hazardous air pollutants for industrial and non-industrial processes. For each emissions factor, WebFIRE contains descriptive information such as industry and source category type, control device information, the pollutants emitted, and supporting documentation (e.g. test reports).

4.4.2. Activity data

Facilities do not report activity data (e.g. amount of secondary lead produced). Depending on the sector, data may be available from the US Department of the Interior, US Geological Survey's Mineral Commodity Summaries (US Geological Survey, 2018[29]). For example, this includes annual secondary refinery production data (tonnes of lead produced) for almost the entire metal industry, but not for individual facilities.

4.4.3. Other metrics

The EPA's Air Markets Program Data (AMPD)[9] contains information on, inter alia, production outputs and technology attributes of power plants and other industrial facilities that report under EPA's market-based programs. The website allows performing real time query searches to obtain detailed information on various BAT used in a given sector. For example, the website contains information on specific attributes for large combustion plants, such as types of boilers, categories and subcategories of techniques. For mercury abatement, information on the various types of chemical ingredients used as chemical additives can easily be consulted. The AMPD demonstrates that with adequate IT technology, it is feasible to publish continuous emissions monitoring data online within one month.

EPA also maintains the RACT/BACT/LAER Clearinghouse[10]. This is a searchable database by pollutant or sector that contains case-specific information on the air pollution technologies and emissions limitations that have been required to reduce the emission of air pollutants from stationary sources. This information has been provided by State and local permitting agencies.

4.5. Case studies

4.5.1. NESHAP for Secondary Lead Smelting under the Clean Air Act

The secondary lead smelting industry produces elemental lead or lead alloys from scrap sources, primarily lead-acid batteries. Most of the lead in a battery is a lead oxide powder. The smelter furnace (blast, reverberatory, or rotary furnace) melts the lead metal scrap and reduces the lead oxide to lead metal. The lead is then refined in pot furnaces and cast.

Emission sources in secondary lead smelting include:

- Process emissions from the smelting furnace main exhaust.

- Process fugitive emissions from furnace feed stock drying kilns, furnace charging, furnace metal and slag tapping, and refining and casting operations.
- Fugitive dust emissions from plant roadways, battery breaking areas, furnace areas, refining and casting areas, and material storage and handling areas.

In 2011, 15 secondary lead smelters were operating in the United States and one was under construction. This number is down from 23 smelters in 1995.

The NESHAP for secondary lead smelting is adopted under the Clean Air Act and requires the control of lead compounds and fugitive emissions. These regulatory controls also lower emissions of other HAP (hazardous air pollutant) metals and particulate matter (PM). Links to full information about this regulation, including other HAPs addressed, are available[11].

Under the Clean Air Act, the initial NESHAP for the secondary lead smelting industry, adopted in 1995, is technology-based (e.g. based on Maximum Achievable Control Technology, or MACT). Existing secondary lead smelters were required to comply with this NESHAP by 23 June 1997. New facilities had to comply by 23 June 1995, or upon start-up of operations, whichever was later. The technology basis for the original lead compound emission standards (MACT) is as follows:

i. Emission capture systems and fabric filtration to control process emissions and process fugitive emissions. The lead compound emission standard was 2.0 milligrams (measured as lead) per dry standard cubic metre (milligram per dry standard cubic meter, mg/dscm).

ii. Work practices and enclosures to minimise fugitive dust emissions, including paving and sweeping of roadways; partial enclosure and wet suppression of storage piles; and vehicle washes at the exit of any material storage or work areas. As an alternative, total enclosure of all material storage and process work areas with the enclosure ventilated to a control device and vehicle washes at the exit to the enclosure.

The Clean Air Act requires EPA to conduct a risk and technology review eight years after setting the technology-based standards to (i) evaluate developments in practices, processes, and control technologies; and (ii) consider whether more stringent standards are needed to reduce risk to human health and the environment to provide an ample margin of safety.

In the course of the risk and technology review for the secondary lead smelting NESHAP, EPA found from test data and other information collected from the affected industry that lead concentrations in stack emissions were far below, and in most cases orders of magnitude below, the concentration limit requirement in the initial NESHAP. The average reported concentration was 0.16 mg/dscm with a median of 0.04 mg/dscm. This is significantly lower than the average lead concentration of 0.94 mg/dscm found in stacks prior to the 1995 NESHAP. More information about the technologies found in the industry and EPA's technology review is available in the Summary of the Technology Review for the Secondary Lead Smelting Source Category (US EPA, 2011[70]).

The risk and technology review for the secondary lead smelting industry resulted in a revised NESHAP, adopted in 2012, which existing secondary lead smelters were required to comply with by 6 January 2014. New lead smelters had to comply by 5 January 2012 or upon start-up of operations, whichever was later. The revised NESHAP had the following implications:

i. More stringent standards were warranted both to provide ample protection of public health and to account for technological developments since the original NESHAP. The revised standards include:

a) More stringent emission concentration standards for process emission sources based on improved fabric filter technology and the use of high efficiency particulate air filters installed downstream of fabric filters. The revised standards allow only one tenth of the lead compound emissions (measured as lead) as the original NESHAP standards.

b) For existing sources, the concentration of lead compound emissions (measured as lead) in any single process vent gas must not exceed 1.0 mg/dscm and the flow-weighted average concentration of lead compounds in all combined vent gases must not exceed 0.20 mg/dscm.

c) For new sources, the concentration of lead compounds (measured as lead) in any process vent gas must not exceed 0.20 mg/dscm.

ii. The facility must operate all sources of process fugitive and fugitive dust emissions within total enclosures that are maintained under negative pressure and vented to a control device. The facilities are also required to adopt a list of specified work practice standards to minimize fugitive emissions.

Under the NESHAP for secondary lead smelters, facilities must annually measure and report emissions concentrations of lead compounds (measured as lead) from process vents, but they may apply for a 24 month extension if emissions are below a concentration threshold. Emissions reports from some secondary lead smelters are included in the EPA's WebFIRE database. The earliest reports are from 2014.

EPA estimated that the 1995 NESHAP would reduce national metal HAP emissions (primarily lead compounds) from the source category by 53 tons per year and of PM by 135 tonnes per year. Information gathered by EPA for the risk and technology review indicated emissions had declined in the previous 15 years due to the national standards, state standards and industry's initiative. Emissions at many facilities were lower than allowed by the 1995 NESHAP. Further, the EPA estimated that the 2012 revised NESHAP would reduce lead emissions nationally by 6.5 tonnes a year from process and process fugitive sources and by 5.8 tonnes a year from fugitive dust sources, compared to emissions in 2009. EPA estimates that these controls will also reduce emissions of PM (combined total of fine and coarse PM) by 122 tonnes per year. Further analysis would have to be conducted to assess whether actual emissions correspond to these estimates.

4.5.2. NESHAP for Secondary Aluminium Production under the Clean Air Act

The secondary aluminium production industry produces aluminium metal from scrap sources, primarily from beverage cans, foundry returns, and dross, to make other aluminium products such as alloy ingots, billets, notched bars, shot, hot metals, and hardeners. Emission sources include aluminium scrap shredders, thermal chip dryers, scrap dryers / delacquering kilns / decoating kilns, clean charge furnaces, sweat furnaces, dross-only furnaces, rotary dross coolers and secondary aluminium processing units. A secondary aluminium processing unit is composed of all group 1 (i.e., processing other than clean charge and/or performing reactive fluxing) furnace emission units and all in-line fluxer emission units. In 2015, the EPA estimated that 161 secondary aluminium facilities were operating in the US, with 53 of them being major sources of HAP. A major source is a source that emits, or has the potential to emit, any single HAP at a rate of 10 tons (i.e. 10

times 907 kg) per year or more, or 25 tonnes per year or more of any combination of HAP. In 1999, the EPA estimated at least 400 facilities engaged in secondary aluminium production, with 86 facilities being major sources of HAP.

The NESHAP for secondary aluminium production is adopted under the Clean Air Act and regulates both major and area (i.e. non-major) sources of HAP, but area source facilities are regulated only for emissions of dioxins/furans (D/F). For major source facilities, the NESHAP regulates PM emissions as a surrogate for metal HAP emissions from aluminium scrap shredders, scrap dryers/delacquering kilns/decoating kilns, dross-only furnaces, rotary dross coolers, and secondary aluminium processing units. Controlling PM emissions also controls emissions of HAP metals. This surrogate approach to emission limits is used to allow easier and less expensive measurement and monitoring requirements. Major source facilities are also regulated for D/F, total hydrocarbons (THC) as a surrogate for organic HAP, and hydrogen chloride (HCl) which also addresses other HAP acid gases. Links to full information about this regulation, including other HAPs addressed, are available online[12].

Under the Clean Air Act, the initial NESHAP is technology-based (e.g. on Maximum Achievable Control Technology, or MACT) and was promulgated in 2000. Existing secondary aluminium production facilities were required to comply with the NESHAP by 24 March 2003. New facilities had to comply by 23 March 2000, or upon start-up of operations, whichever was later. The technology basis for the original emission standards (MACT) are the following:

i. Fabric filters to control PM, lime-injected fabric filters to control PM and HCl, and afterburners to control D/F, depending on the emissions unit. All affected sources with add-on controls are also subject to design requirements and operating limits to limit fugitive emissions.

ii. Using the PM and metal HAP emission standards as an example, the emission limits for scrap shredders and rotary dross coolers are in grains PM per dry standard cubic foot of exhaust (grains per standard cubic feet, gr/dscf). The standards for the other PM and metal HAP emission sources are in pounds (libra, unit of mass, lb) of PM per ton of feed material. A summary of the PM Emission Standards for New and Existing Emission Units is given in Table 4.1, with metric units included for added information. These PM standards, as well as emission standards for the other pollutants, can be found in Table 1 of Subpart RRR of Part 63 — Emission Standards for New and Existing Affected Sources (Legal Information Institute, n.d.[71]).

Table 4.1. Summary of PM Emission Standards for New and Existing Emission Units

Emission Unit	Limit (US Units)	Limit (Metric Units)
New and existing aluminium scrap shredders	0.01 gr/dscf	0.02 g/dscm
New and existing scrap dryer/delacquering kiln/decoating kiln or Alternative limit if afterburner has a design residence *time of at least 1 second and operates at a temperature of at least 1400 ° F (760 °C)*	0.08 lb/ton of feed 0.30 lb/ton of feed	0.04 kg/tonne of feed 0.15 kg/tonne of feed
New and existing dross-only furnaces	0.30 lb/ton of feed	0.15 kg/tonne of feed
New and existing in-line fluxer	0.01 lb/ton of feed	0.005 kg/tonne of feed
New and existing in-line fluxer with no reactive fluxing	(No limit; work practice of no reactive fluxing.)	(No limit; work practice of no reactive fluxing.)
New *and existing rotary dross cooler*	0.04 gr/dscf	0.09 g/dscm
New and existing clean furnace (Group 2)	(No limit; work practice of clean charge only and no reactive fluxing.)	(No limit; work practice of clean charge only and no reactive fluxing.)
New and existing group 1 melting/holding furnace (processing only clean charge)	0.80 lb/ton of feed	0.40 kg/tonne of feed
New and existing group 1 furnace	0.40 lb/ton of feed	0.20 kg/tonne of feed
New and existing group 1 furnace with clean charge only	0.40 lb/ton of feed	0.20 kg/tonne of feed
New and existing secondary aluminium processing units (consists of all group 1 furnaces and all in-line flux boxes at the facility)	Weighted average limit (lb/ton of feed) calculated based on the applicable emission limit and amount of feed processed in each emission unit.	Weighted average limit (kg/tonne of feed) calculated based on the applicable emission limit and amount of feed processed in each emission unit.

Source: (Legal Information Institute, n.d.[71])

EPA estimated that the 2000 NESHAP would reduce national metal HAP emissions from the source category by 36 tonnes per year and of PM by 2 889 tonnes per year. Dioxin/furan emissions would be reduced by 0.43 kg/yr; HCl emissions would be reduced by 11 224 tonnes/yr, and polycyclic organic matter emissions would be reduced by 9 tonnes/yr. There would be no reduction of total hydrocarbon (THC) emissions, a surrogate for organic HAP, because all sources with a THC emission limit were equipped with the technology representative of the MACT-level of control before the MACT standard was finalised. Further analysis would have to be conducted to assess whether actual emissions correspond to these estimates.

The Clean Air Act requires EPA to conduct a risk and technology review eight years after setting the technology-based standards to (i) evaluate developments in practices, processes, and control technologies and (ii) consider whether more stringent standards are needed to reduce risk to human health and the environment to provide an ample margin of safety. In 2015, EPA completed a risk and technology review of the secondary aluminium NESHAP, which originally had been promulgated in 2000 and later amended in 2002, 2004, 2005, 2015, and 2016. The review concluded that more stringent standards were not needed to protect public health and the environment, or to account for technological developments since the original NESHAP. The risks to human health were less than the upper limits of acceptable risk for cancer risks, and for chronic or acute non-cancer health effects. EPA also found no significant potential for adverse environmental effects.

In the technology review, EPA investigated developments in practices, processes, and control technology through a literature review, discussions with industry representatives, and questions included in a questionnaire sent to all companies covered by the NESHAP. The EPA determined that no technology developments provided emission reductions that were significantly greater than the current process and add-on control technologies. Details of the findings are summarised in the Memorandum Regarding Technology Review for the Secondary Aluminum Production Source Category – Final Rule (US EPA, 2015[72]). No changes have been made to the emission limit values from the 2000 NESHAP.

Under the NESHAP, major source facilities must perform an initial compliance test and then test every five years thereafter. Emission reports from some secondary aluminium production facilities are included in the EPA's WebFIRE database.

4.5.3. Green Chemistry in Pharmaceutical Manufacturing under the Pollution Prevention Act

This case study addresses the Pollution Prevention Act (US EPA, n.d.[66])and examines the impact of implementation of green chemistry practices on releases and total production related waste of TRI chemicals reported by facilities in the pharmaceutical manufacturing sector to the TRI Programme. TRI is uniquely well-suited for assessing the progress made by different industry sectors in implementing green chemistry practices and the effectiveness of such practices in preventing pollution. Since 2012, EPA has explicitly asked industry operators to report on the use of green chemistry to TRI. Some US states have made it mandatory to implement green chemistry practices, and others provide tax benefits to industry operators that do so. Information on measures labelled as green chemistry are provided in the EPA's national analysis reports.

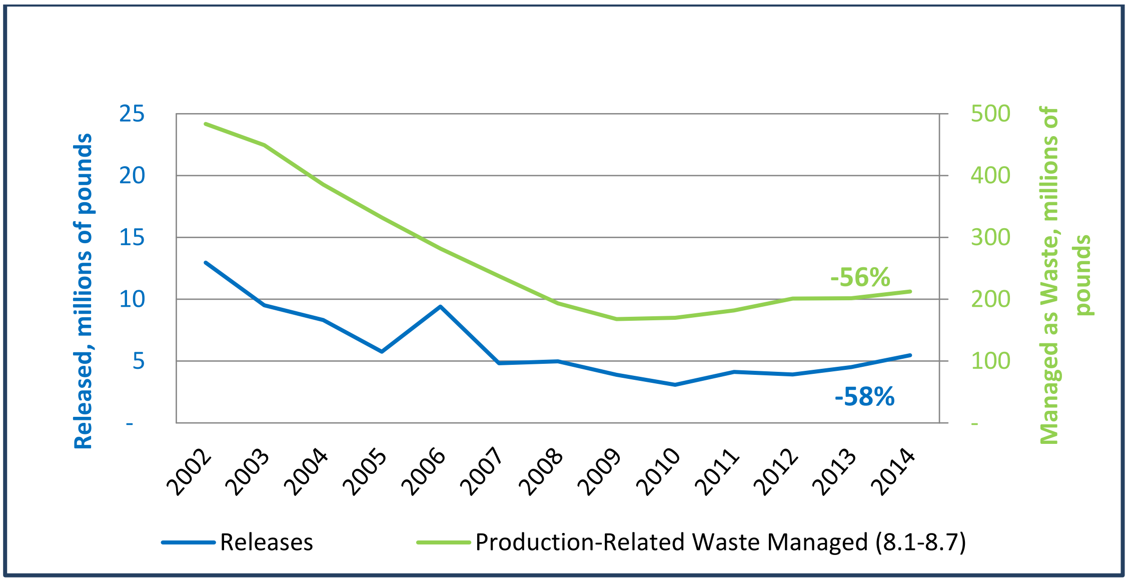
Under the Pollution Prevention Act, source reduction is US EPA's preferred method of managing chemical waste, as it is based on the premise that the ideal way to deal with pollution is not to create it in the first place. Source reduction is any practice that reduces, eliminates, or prevents the creation of pollution and, therewith, its release into the environment or entering a waste stream. It is typically accomplished by changing the processes, products or materials that generate pollution in the first place. A highly effective means to reduce or even prevent pollution at its source is through implementation of green chemistry practices. Green chemistry is that discipline within the field of chemistry which seeks to prevent formation of pollution through the design and implementation of manufacturing syntheses that require little or no use of toxic reagents (e.g. solvents) or feed stocks, use minimal energy, and produce the desired product in high yield without formation unwanted by-products or wastes (Gaona, 2018[73]).

Experts from US EPA stipulate that green chemistry is a (if not the) best available technique for preventing pollution at its source. Evolution of green chemistry originated in the early 1990s, and since then chemical manufacturers, particularly pharmaceutical manufacturers, have implemented green chemistry practices to varying degrees. For this analysis, the pharmaceutical manufacturing sector is chosen to illustrate this point and is defined based on North American Industry Classification System code 325411 (Medicinal and Botanical Manufacturing) and 325412 (Pharmaceutical Preparation Manufacturing).

Implementation of green chemistry advances in pharmaceutical manufacturing began in the 1990s, or in some cases, earlier. Pharmaceutical firms have reported that implementation of green chemistry practices in their manufacturing processes have significantly reduced the quantities of toxic chemicals they use, release to the environment, or otherwise manage as waste. EPA conducted a study that assessed this claim using the TRI database and available literature (DeVito, Keenan and Lazarus, 2015[74]). The EPA study examined the sector's trends in releases as reported to TRI starting with a base year of 2002 based on information in the literature indicating that green chemistry was beginning to become more widespread in the sector at that time.

The study showed that the quantities of toxic chemicals reported annually by pharmaceutical manufacturing facilities to EPA's TRI Programme as released to the environment and managed as waste have declined steadily; by 58% for releases from 2002 to 2014 and by 56% for waste managed as illustrated in Figure 4.4.

Figure 4.4. TRI Chemicals Released and Managed as Waste Reported by the Pharmaceutical Industry

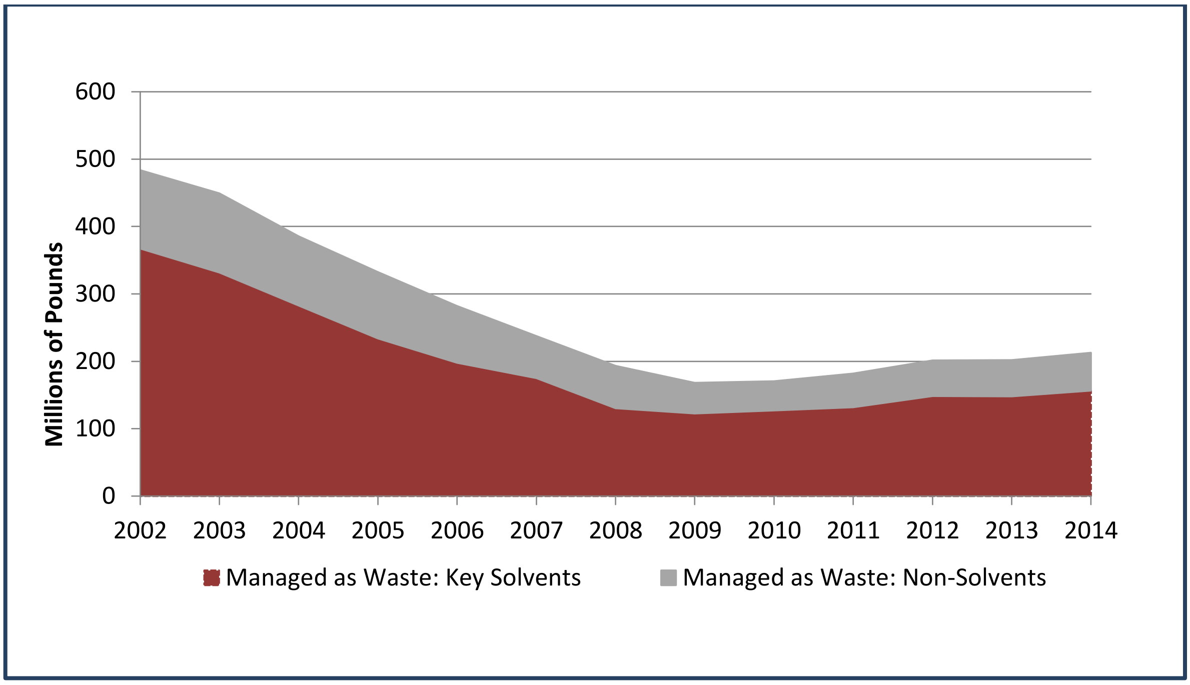


Source: Developed by US EPA's Toxics Release Inventory

The study assessed the impacts of other factors such as outsourcing, production levels, regulations, and shifts to other waste management practices and found while these factors may influence the trend, they are not the drivers. Implementation of pollution prevention practices, particularly green chemistry practices, appears to be the major contributor to the downward trend observed in toxic chemicals released and managed as waste.

Quantities of chemicals managed as waste (including released, treated, recycled, and used for energy recovery) from the sector as reported to TRI pertain largely to solvent chemicals used during the manufacture of pharmaceutical products. Methanol, dichloromethane, toluene, dimethylformamide, and acetonitrile alone account for three-quarters of the declining trend in the quantities of waste managed from 2002 through 2014 as illustrated in Figure 4.5.

Figure 4.5. Quantities of Key Solvents Managed as Waste vs Quantities of all Other TRI Chemicals Managed as Waste by the Pharmaceutical Industry



Note: The "key solvents" included in this figure are: methanol, dichloromethane, toluene, dimethylformamide, and acetonitrile. Waste managed includes quantities released, used for energy recovery, recycled, and treated.
Source: Developed by US EPA's Toxics Release Inventory

While other chemicals released and managed as waste also declined at a similar rate, these five solvents are driving the sector's downward trend. A reduction in the use and quantities of solvents reported as released or otherwise managed as waste is consistent with what is expected, based on the published research on green chemistry advances in pharmaceutical manufacturing.

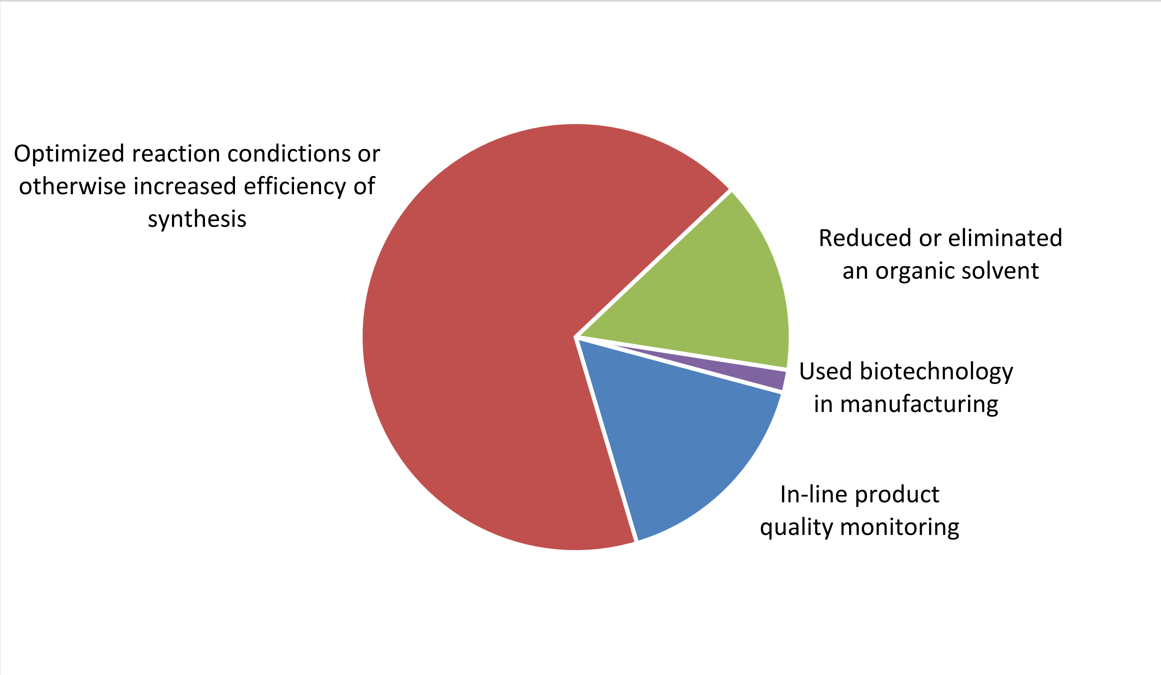
To further assess the role of green chemistry in the observed release reductions, the source reduction information reported to TRI can be examined. For TRI reporting, facilities are required to disclose any source reduction activities that they implemented during the reporting year. Facilities indicate the type of source reduction activity implemented by selecting from a list of 49 different codes. Six of these codes are specific to green chemistry activities, and are listed below:

i. introduced in-line product quality monitoring or other process analysis system;
ii. substituted a feedstock or reagent chemical with a different chemical;
iii. optimized reaction conditions or otherwise increased efficiency of synthesis;
iv. reduced or eliminated use of an organic solvent;
v. used biotechnology in manufacturing process; and
vi. developed a new chemical product to replace previous chemical product.

Examining reporting of these codes by pharmaceutical facilities further illustrates the role of green chemistry in pharmaceutical manufacturing. Of all source reduction activities reported for 2012 (which was the first year that green chemistry codes were added to the

TRI list of source reduction codes) through 2016 by pharmaceutical facilities, 23% of the codes were green chemistry codes. When compared to other sectors, including other parts of the chemical manufacturing sector, all other sectors reported that less than 10% of their source reduction activities were green chemistry activities, with most sectors reporting less than 5%. This indicates that the pharmaceutical sector is implementing green chemistry activities more frequently than other sectors, providing further evidence that green chemistry is a driver of the observed reductions in releases and other waste management quantities. The distribution of the types of green chemistry activities implemented by the pharmaceutical sector is shown in Figure 4.6.

Figure 4.6. Green Chemistry Activities Reported to TRI by Facilities in the Pharmaceutical Manufacturing Sector, 2012-2016



Source: Developed by US EPA's Toxics Release Inventory

4.6. Conclusion

Compared to many other countries, the US has considerable data available on industrial emissions, production and abatement techniques, and is disaggregated at the level of each installation or process. The TRI contains data for all environmental media, and additional data on emissions to air is available in the NEI. Detailed activity data are made available through the US Geological Survey's Mineral Commodity Summaries, not only for the US, but also, inter alia, for the European Union. Further, the US EPA ensures that data are easily accessible, such as through the Air Markets Program Data for data on emission abatement techniques installed, and the RACT/BACT/LAER Clearinghouse for information on air pollution technologies and emissions limitations pertaining to specific facilities.

The quality and quantity of data available in the US greatly facilitates the assessment of the effectiveness of the US technology-based performance standards for industrial emissions. However, as noted by the EPA, an accurate assessment of the direct impact of each regulatory action on a sector or a facility, determining a cause and effect relationship between a regulation and a change in emissions, requires additional data.

Inter alia, considering the various technology-based emissions standards – established at national, state and local level - that inform the permit conditions of individual facilities in the US, the emission limit values of each facility would have to be consulted, together with corresponding emissions monitoring and activity data, in order to assess the effectiveness of the standards. This is illustrated by the analysis of trends in SO_2 and PM_{10} emissions from copper and aluminium production in Chapter 2. The analysis demonstrates that NEI data could be used to assess the impact of standards on emission trends if facility-specific information on permit conditions is available.

Moreover, the case studies presented in the chapter demonstrate that valuable assessments of the effectiveness of US technology-based performance standards can be carried out at the sector level. The case study about the NESHAP for secondary lead smelting demonstrates an estimated, step-by-step reduction of lead compounds and PM emissions, driven by the original 1995 NESHAP and the revised 2012 NESHAP. The study on secondary aluminium production shows that the original 2000 NESHAP was sufficiently stringent to reduce air emission to a level ensuring the protection of public health and the environment. Finally, the third case study illustrates the reduction in releases and total production-related waste of TRI chemicals in the pharmaceutical manufacturing sector, primarily due to the implementation of green chemistry practices.

Notes

[1] See https://www.federalregister.gov/.

[2] The NESHAPs can be consulted at https://www.epa.gov/stationary-sources-air-pollution/national-emission-standards-hazardous-air-pollutants-neshap-9; the New Source Performance Standards can be consulted at https://www.epa.gov/stationary-sources-air-pollution/new-source-performance-standards.

[3] See https://www.epa.gov/clean-air-act-overview/benefits-and-costs-clean-air-act.

[4] See https://www.epa.gov/toxics-release-inventory-tri-program.

[5] See https://www.epa.gov/toxics-release-inventory-tri-program/tri-listed-chemicals.

[6] See https://www.epa.gov/air-emissions-inventories.

[7] See https://www.epa.gov/haps/what-are-hazardous-air-pollutants.

[8] See https://cfpub.epa.gov/webfire/.

[9] See https://ampd.epa.gov/ampd/.

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

[11] See https://www.epa.gov/stationary-sources-air-pollution/secondary-lead-smelting-national-emissions-standards-hazardous-air.

[12] See https://www.epa.gov/stationary-sources-air-pollution/secondary-aluminum-production-national-emission-standards-hazardous.

Chapter 5. **Chile**

Chile has national emission standards for air emissions as well as environmental quality standards that are reflected in permits for industrial installations. In addition, some industries have established voluntary Clean Production Agreements with the Government, suggesting specific emissions reduction measures sometimes based on BAT, which help operators go beyond compliance with national standards. The Chilean Government is currently working on evaluating the effect of the national emission standards, based on an official methodological guide, which provides updated methodologies, parameters and assumptions for technical-economic analysis. Furthermore, the Government seeks to strengthen the national emissions monitoring system. Currently, the Chilean PRTR contains data for 130 substances; additional emissions monitoring data for selected pollutants are available in the Sistema Nacional de Información de Fiscalización Ambiental.

5.1. BAT in Chile

5.1.1. Clean Production Agreements

The BAT concept was first introduced in Chile in the late 1990s in the framework of the Clean Production Agreements (Acuerdo de Produccion Limpia, or APL). The APL framework was strengthened by Decree 156 of 2007 (MMA, 2007[75]), which established a National Clean Production Policy and a Council for Clean Production (Consejo Nacional de Producción Limpia) under the Ministry of Economy. An APL is a voluntary agreement between an industry association and a competent government authority, which sets specific targets and actions to foster clean production, including the use of BAT, which go beyond the minimum legal requirements. APLs often address specific challenges, e.g. recovery of containers to avoid chemical pollution, or wastewater treatment. BAT are suggested as part of an APL, but are not mandatory (OECD, 2016[76]). The APLs may be based on a technical study, seeking to identify emissions reduction opportunities, including by adopting BAT. The cost of such studies are split 70:30 between the government and the industry association. Industry operators cover the cost of necessary investments for implementation of new techniques (Government of Chile, 2012[77]).

Since 1999, 100 four-year-long APLs have been signed with different industry associations. They have engaged in total about 6 000 enterprises, two-thirds of which are from the agricultural sector. APLs can also be territorial, addressing complex environmental problems that go beyond a single industrial sector. In 2011, for example, a territorial APL was concluded for the industrial zone of Puchuncaví-Quintero in the Region of Valparaíso (OECD, 2016[76]). Between 2005 and 2014, the number of enterprises covered by APLs increased from approximately 150 to more than 1600 per year (Government of Chile, 2013[78]). APLs receive modest co-financing from the governmental budget, amounting to USD 4.7 million between 2006 and 2014. The most recent APLs include provisions to evaluate their results, including economic benefits accrued by businesses themselves. While there are positive projections of how APLs can reduce greenhouse gas emissions (18.4 million tonnes by 2020), the overall environmental effectiveness of these agreements is difficult to evaluate (OECD, 2016[76]).

Four Official Chilean Standards have been developed in order to enhance the impact of APLs[1], establishing guidelines for the development, implementation and certification of compliance with the APLs:

i. NCh 2797 (2009), "Clean Production Agreements (APL) - Specifications";

ii. NCh 2807 (2009), "Clean Production Agreements (APL) - Diagnosis, Monitoring and Control, Final Evaluation and Certification of compliance";

iii. NCh 2825 (2009), "Requirements for final evaluation auditors"; and

iv. NCh 2796 (2003), "Vocabulary" applied to this Certification System".

On 22 October 2012, the UN recognised the APLs as the first Chilean Nationally Appropriate Mitigation Action based on which emission reductions were reported. The UN further highlighted the strategy to promote eco-efficiency and sustainability implemented by the Council for Clean Production. Since 2016, the Council, along with the Agency for Sustainability and Climate Change, publicly reports the reductions in emissions achieved through APLs, in accordance with the Directive of the Ministry of Environment. Between 2012 and 2017, the reductions were estimated at 454 427 tonnes of CO_2e, with the APL being the first Chilean mitigation action to report reductions to the United Nations.

Moreover, Chile's National Clean Production Policy (adopted in 2010) sets out to promote cleaner production practices in the public and private sectors, with the objective to modernise production processes and increase the competitiveness of domestic producers. Similarly, the "Clean Production Agenda 2014-18: Alignments for a National Policy" interprets cleaner production as an economic development strategy and emphasises environmental and social opportunities as drivers for increased productivity. It sets, among others, the following targets focusing on SMEs:

i. Involve at least 4 000 new companies, mostly SMEs, into APLs.

ii. Promote clean production practices in micro-enterprises through training and information dissemination.

iii. Design mechanisms of financial support for adoption of cleaner technologies by enterprises, in addition to the funds made available through the Economic Development Agency – a public agency promoting increased competitiveness of Chilean industry, particularly SMEs.

iv. Create a new framework for agreements between companies and their communities to promote socio-environmental responsibility.

5.1.2. Air emission standards

In addition to APLs, Chile has a set of national and sub-national emission standards for industrial emissions to air, adopted under the Clean Air Programme (2010). Standards for industrial discharges to water are currently under development. The following national standards for emissions to air from specific are currently in place:

i. Emission Standard for Thermoelectric Power Plants (MMA, 2011[79]) , seeking to control air emissions of particulate matter (PM), nitrogen oxides (NO_x), sulphur dioxide (SO_2) and mercury (Hg). This standard is in effect for existing and new installations and has spurred investments in abatement and monitoring technology worth hundreds of millions USD.

ii. Emission Standard for Incineration, Co-incineration and Co-processing (MMA, 2013[80]), seeking to control releases of heavy metals, such as mercury, arsenic and lead, and of dioxins, furans, particulate matter (PM), nitrogen oxides (NO_x) and sulphur dioxide (SO_2); and

iii. Emission Standard for Copper Smelters and Arsenic Emission Sources (MMA, 2013[28]) seeking to control air emissions of particulate matter (PM), dioxide sulphur (SO_2), arsenic (As) and mercury (Hg). This standard requires that at least 95% of SO_2 emissions shall be recovered as sulphuric acid.

Starting from 2018, Chile imposes emissions charges for CO_2, PM, NO_X and SO_2 on large energy and industrial facilities – mainly fossil fuel-based electricity plants (not on copper smelters) – that do not meet the national emissions standards. This is considered an important driving force for improving their environmental performance.

Furthermore, Chile has a national emission standard for vehicles. The country has also adopted a range of regulatory requirements for air quality protection in the framework of the Clean Air Programme. This includes a primary air quality standard, aimed to protect human health, for major pollutants, including fine particulate matter ($PM_{2.5}$).

For the period 2014-18, the Ministry of Environment developed an Atmospheric Pollution Control Strategy, replacing the Clean Air Program of 2010, which foresees the declaration of six new saturated areas and completion of 14 Air Pollution Clean-up and Prevention Plans (OECD, 2004[81]). These plans establish sectoral emission standards at the regional or local level. While not prescribing particular technologies, these regional or local, sectoral emission standards are predominantly based on references to end-of-pipe pollution control technology, rather than integrated cleaner production process solutions.

In the absence of emission requirements for many pollutants and categories of stationary sources, Chile is using an "emissions compensation" scheme for areas where ambient air quality standards are exceeded. In these cases, an operator of a new emission source in the area must finance the reduction from other sources of the equivalent of 150% of its emissions. For example, with respect to particulate matter emissions, the commonly used compensation measures are road paving and the creation of green areas. This scheme, applied mostly in the Santiago metropolitan area, appears rather complex in terms of calculating equivalent emission reductions. According to experts from the Ministry of Environment, it is also poorly adapted to situations where air quality standards are not exceeded, as it creates a perverse incentive for establishing new emission sources there. The forthcoming Santiago Respira pollution attainment program, which was under public consultation in 2016, would limit compensation measures to the same polluting activity (e.g. fuel combustion) (OECD, 2016[76]).

5.1.3. Water quality and effluent standards

Since 2011, Chile has adopted national secondary surface water quality standards (designed for ecosystem protection), mostly for nitrogen and phosphorus compounds (eutrophication being an important problem), but only for four river basins (out of 14 significant ones) and two lake catchments. This was done under the General Water and Sanitation Law (Ministry of Public Works, 1988[82]).

Chile also has a national emission standard for inland waters. Moreover, the country is updating its cross-sectoral effluent standards for industrial discharges into marine and continental surface waters and groundwater, including new nutrient standards. These effluent standards will be based on the capacity of reference treatment technologies (without prescribing specific ones); however, employing the suggested technologies will not necessarily guarantee compliance with quality standards in the receiving water bodies.

5.1.4. Environmental permits

An environmental permit is required for any projects or activities that assumedly will have an effect on the environment, as per Article 10 of the Environmental Law (MMA, 1994[83]) and Article 3 of the Regulation on Environmental Impact Assessment System (MMA, 2013[84]). Permits are granted for each installation or process of an industrial facility (Urrutia and Avilés, 2015). Separate permits are required for emissions to air, water and soil. The permits set emission limit values based on national environmental quality standards.

Depending on the characteristics of the activity for which a permit is requested, the industry operator may have to submit an environmental impact declaration or study along with the permit application. The consideration of a permit application usually takes one to two years. Permits are valid for five years, before they have to be reviewed. The permit expires if the permit holder does not begin the planned project within this time period (Urrutia and Avilés, 2015[85]).

Violation of permit conditions may result in a written reprimand, a fine ranging from one to 10 000 annual tax units (approximately USD 1 000 to 10 million), or temporary or permanent shut down of the concerned industrial facility (Urrutia and Avilés, 2015[85]).

5.2. Policy evaluation

5.2.1. Governmental evaluation projects

The Chilean Ministry of Environment has issued an official methodological guide for ex ante evaluation of environmental programmes and regulations (MMA, 2017[86]), with the purpose of measuring the degree of compliance with proposed environmental objectives. The guide provides updated methodologies, parameters and assumptions for technical-economic analysis, seeking to enable improvement and necessary corrections of existing programmes and regulations. The guide has so far facilitated the impact evaluation of important environmental instruments, such as (i) green taxes on vehicles and (ii) the decontamination plans for two cities (Temuco and Padre Las Casas), indicating that the plans have contributed to improving the environmental conditions in the areas where they were applied. An evaluation of the effectiveness of the national air emission standards, based on the official guide, is currently ongoing.

5.2.2. Stakeholder opinions

The Ministry of Environment

According to the Chilean Ministry of Environment, the national air emission standards have contributed to the control of emission of pollutants into the atmosphere, and to reduce environmental impacts on the air quality in the cities where industrial facilites are located. This has in turn improved the quality of life of the population. The Ministry of Environment notes that although the emission standards are applied at the national level, regional differences occur because of regional emission standards as well as local plans and tools for the implementation of the national standards, which are adjusted to local conditions. Besides, some cities also have decontamination plans, which have improved the environmental conditions in the areas where they apply.

The Ministry of Environment believes that the effectiveness of the national emission standards can be strengthened by setting more stringent standards e.g. for SO_x and through enhanced enforcement. However, the evaluation of the effectiveness of the emission standards in Chile is still in the process of implementation and it is thus too early to draw definite conclusions.

As for effluent discharges, experts from the Chilean Ministry of Environment believe the country could benefit from introducing the “combined approach” to setting effluent limit values, stipulated in the European Union’s Water Framework Directive (EU, 2000[38]) and implemented in many EU Member States. The intention of this approach is that when complying with technology-based standards, effluents from any point source of pollution should not lead to exceedance of surface water quality standards, which are established to protect the designated use of the receiving water body (fishing, drinking water supply, bathing, etc.).

Industry

The general manager of the Chilean chemical industry association, ASIQUIM, stresses that although industrial pollution prevention has been regulated in Chile for more than 20 years, it remains a challenge to align the industrial pollution regulations with other relevant regulations applying to the chemical industry, as these are issued by different ministries. According to ASIQUIM, industrial pollution regulations should allow for the continued development of the chemical sector, while protecting the environment and promoting sustainable development.

ASIQUIM's general manager highlights that despite many companies having installed monitoring equipment in their production sites and surrounding areas, there is no comprehensive system for measuring the aggregated effects of different industries and/or cities, other than for dust (PM). According to ASIQUIM, there is room for improving the monitoring system in many respects, such as by optimising the location of the monitoring sites, better organising the data collection, ensuring the independent validation of collected data, and adding new contaminants to the list of monitored substances, taking into account local conditions and levels of industrial development.

According to ASIQUIM's general manager, PRTR data have been made available online as of 2015 for interested stakeholders, together with annual PRTR reports presenting aggregated figures at the national and regional levels. The association has the impression, however, that after more than ten years of collecting PRTR data, the government could make better use of the potential to inform policy and research based on PRTR data. ASIQUIM's general manager highlights that the lengthy procedure for consideration of permit applications (one to two years, or more in some cases) is a key limitation of the current permitting scheme, as it creates uncertainty for investors. As preparing a permit application requires significant time and money, such uncertainty may make investment less attractive.

ASIQUIM signed an APL with the government 10-15 years ago. The agreement has not been reviewed after they accomplished the actions set out. The Chilean chemical industry currently focuses its sustainable development and clean production efforts on the Responsible Care initiative[2].

5.3. Available sources of data

5.3.1. Emissions monitoring data

PRTR

The Chilean PRTR, El Registro de Emisiones y Transferencias de Contaminantes (RETC), includes data on 130 substances[3], reported at facility level. Releases and transfers must be reported only if the emissions of a facility are above the activity and/or pollutant thresholds.

PRTR data available for online consultation is aggregated at the regional level. However, according to the Chilean legislation, members of the public should be able to request access to more detailed data.

Other emissions monitoring data

Further, annual emissions monitoring data for, inter alia, $PM_{2.5}$, PM_{10}, SO_2 and NO_X are available on the website of the Sistema Nacional de Información de Fiscalización Ambiental (Snifa)[4] for the period 2005-2014.

Following the chemical leak in the Quintero and Puchuncaví regions in August 2018, which poisoned hundreds of people, the Chilean Minister of Health requested the World Health

Organization's help to strengthen systems for monitoring of industrial emissions (Dashti, 2018[87]).

5.3.2. Activity data

No national activity data reporting has been identified.

5.4. Conclusion

The Chilean government has developed an official guide to the assessment of environmental programmes, which currently is being used to evaluate the effectiveness of the national air emission standards. This evaluation exercise is an important step to review, and possibly strengthen the effect of, the standards. According to the Ministry of Environment, it would be particularly important to strengthen the standards for SOX emissions, as well as to enhance enforcement of the standards. To date, the emission standards appear to have been effective in certain regions, notably when implemented in combination with city-level decontamination plans.

Chile's environmental quality standards, which are enforced through environmental permits for industry operators, appear to be an adequate tool to limit emissions. However, according to the Chilean chemical industry association, the long assessment period for permit applications constitutes an impediment to investment in industry.

Chile publishes emissions monitoring data in the national PRTR and in the database Snifa, but no activity data. Chilean industry representatives note the need to strengthen Chile's national emissions monitoring systems, and to leverage the untapped potential for PRTR data to feed into policy development and research.

Data from the emissions monitoring database Snifa could be used to analyse SO_2 emission trends for the Chilean primary copper smelting industry for the period 2014-16. The analysis in Chapter 2. shows that SO_2 emissions from this industry (covering seven facilities) dropped significantly from 2014 to 2015, before stabilising. The drop in emissions may have been a result of the adoption of the national Emission Standard for Copper Smelters and Arsenic Emission Sources in 2013. However, as Snifa does not contain emissions data for the years before the adoption of the standard, it cannot be used to determine how the new national standard impacted emission trends.

Notes

[1] See http://www.agenciasustentabilidad.cl/pagina/norma_chilena_ap.

[2] See http://www.asiquim.com/nwebq/conducta-responsable/.

[3] See http://www.retc.cl/datos-retc/.

[4] See http://snifa.sma.gob.cl/v2/Fiscalizacion.

Chapter 6. Israel

Israel uses the BAT reference documents of the European Union to determine legally binding emission limit values in medium-specific, environmental permits for industry operators. Following the issuance of the country's first permits for air emissions (between 2011 and 2016), the Government assessed the expected reductions in annual loads of emissions for each industrial sector due to the implementation of BAT requirements. Furthermore, the Government uses PRTR data to evaluate the effectiveness of its BAT policy. Israel has installation level emissions monitoring and activity data contained in publicly available permit information. Stakeholders point out that measures to strengthen Israel's industrial emissions regulations would include introducing integrated environmental permitting and strengthening the digitisation of monitoring data. Examples of the effects of implementing BAT are shown through three case studies, on non-ferrous metals production, large combustion plants and refining of mineral oil, comparing emissions before and after the introduction of new emission limit values.

6.1. BAT in Israel

6.1.1. Introduction

The BAT concept was first introduced in Israel in 2008, with the publication of the Clean Air Law (2008)[1], which includes a provision to determine emission limit values (ELVs) in permits based on BAT-associated emission levels (BAT-AELs). Israel uses the BAT reference documents (BREFs) developed by the EU, but defines its own ELVs in permits. These shall, as a rule, be within the range of the BAT-AELs stated in the EU's BAT Conclusions developed under the Industrial Emissions Directive (EU, 2010[23]), or – for sectors where BAT Conclusions have not yet been published – the EU BREFs developed under the Integrated Pollution Prevention and Control Directive (EU, 1996[31]). A complete list of the EU BREFs and BAT Conclusions is available in the OECD's report *Approaches to Establishing BAT Around the World* (OECD, 2018[36]).

Israel does not yet have integrated environmental permitting; the Ministry of Environmental Protection (MoEP) issues several separate environmental permits for different activities and environmental media. Cross-media effects are however taken into consideration by EU stakeholders when establishing the BAT and BAT-AELs in the BREFs, and this thus impacts on the ELVs set in Israeli permits.

In April 2014, the Israeli Government agreed to adopt the principles of integrated environmental permitting based on the EU's IED. A memorandum of an Integrated Environmental Licensing Law[2] was distributed, but its promotion was halted due to the position of the Manufacturers' Association of Israel on the matter, and the lack of consensus regarding the allocation of resources for implementation.

6.1.2. BAT and environmental permitting under the Clean Air Law

The Clean Air Law (2008), which entered into force in 2011, establishes provisions relating to air quality and emissions to air. The Law establishes considerations that are to be taken into account by permit writers when issuing emission permits. The Emission Limit Values (ELVs) for each installation are based on a consideration of emissions characteristics, the reduction of the total impact of all emissions to the environment, and the costs and benefits of measures for preventing or reducing emissions as much as possible. The permit conditions are set according to BAT, taking into account the technical characteristics of the emission source, its geographical location and the local environmental conditions. The permit writer may prescribe additional conditions, including conditions stricter than those associated with BAT, to prevent and reduce a continuous or repeated deviation from air quality values or reference values.

The Clean Air Regulations' (2010)[3] Regulation 14 on emission permits states that if a BREF contains several BAT that are applicable to a given industrial installation, the operator of the installation shall state in their permit application which BAT that would lead to the maximum reduction of air pollutant emissions from the installation. 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 BREF on Economics and Cross-Media Effects (EIPPCB, 2006[88]), 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.

Article 17 and Annex 3 of the Clean Air Law establish a list of emission sources for which a permit is required. Annex 3 of the Clean Air Law is based on Annex I of the EU IPPC Directive (EU, 1996[31]) (later replaced by the Industrial Emissions Directive (EU, 2010[23])). A transitory order mandated existing installations to submit applications for emission permits between March 2011 and March 2015. All existing installations had to operate under an emission permit as of 30 September 2016. New installations cannot operate without an emission permit; ELVs in accordance with the BAT-AELs are applied from the beginning of their operations.

An air emissions permit usually include the following elements and requirements:

- ELVs in accordance with the BAT-AELs from the applicable and most recent EU BREF[1]; and for pollutants or processes not covered in the BREF, generally in accordance with the ELVs in the German Technical Instruction on Air Quality Control (TA-Luft), (BMU, 2002[57]).
- A reduction plan to bridge the gaps between the plant's current performance and the BAT-associated performance levels and practices, including BAT-AELs, set out in the applicable BREF.
- Measures for reaching compliance with ELVs and for control of diffuse and fugitive emission sources.
- Handling of storage tanks in line with the EU BREF on Emissions from Storage (EIPPCB, 2006[89]).
- Stack height and sampling infrastructure in accordance with TA-Luft (BMU, 2002[57]).
- 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.
- Conversion from liquid fuels to natural gas.

6.1.3. Permits for industrial discharges to the sea

Industrial discharges to the sea are regulated by the Israeli Prevention of Sea Pollution from Land-Based Sources Law (1988)[4]. Permits have been granted under this Law since the early 1990s. The Law is based on the Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources (1980), under the Barcelona Convention for the Protection of the Mediterranean Sea Against Pollution (1976).

Under the Law, discharge of wastewater into the sea is only permitted for holders of permits granted by the Inter-Ministerial Committee for the Granting of Permits for Discharge to the Sea. The Regulations for the Prevention of Sea Pollution from Land-Based Sources (1990) regulate the procedure for issuing the permits. Permits are only granted in the absence of a land-based alternative, such as connection to the public sewage system, recycling, treatment at the source, etc. If a discharge permit is granted, the industry operator is

[1] According to the Israeli guidelines for air emissions permitting, the ELVs shall be based on the EU BREF that was in effect six months prior to the submission of the application for the permit, or to the renewal or amendment of the permit.

required to install BAT for the treatment of wastewater prior to discharge to the sea, and to comply with the ELVs set in the permit. The Committee may allow for discharge of pollutants categorised as hazardous (listed in the Regulation's Second Schedule) if the permit applicant has proved, to the Committees' satisfaction, that it has applied BAT for treatment of wastewater prior to the discharge into the sea.

The permits are renewed periodically (every 1-5 years). This enables the Committee to tighten the quality and quantity requirements for the discharge of wastewater over time. Since the first permits were granted in the early 1990s, the requirements have gradually become more stringent. Today, the ELVs in the discharge permits are generally compliant with the BAT-AEL ranges defined in EU BREFs, although they were determined individually and not in a systematic manner based on BREF documents such as the permits under the Clean Air Law.

6.1.4. Business licenses for industrial discharge to the public sewage system

Industrial discharges to the public sewage system are regulated by a number of regulations under the Water Law (1959)[5] and the Business Licensing Law (1968)[6], which were adopted between 1974 and 2004. The regulations apply to the prohibition of hard detergents, metals and other pollutants, pH values of industrial wastewater and concentration of salts in industrial wastewater, respectively. A summary of some of the regulations is available in English.[7]

The regulations stipulate binding ELVs for various pollutants discharged into the public sewage system, and apply to all industrial sectors and the majority of common pollutants. When determining the ELVs, technological aspects, i.e. available abatement techniques, were considered. The ELVs are stated in business licenses by the environmental regulator underlying MoEP, and are generally within the range of BAT-AELs specified in the EU BREFs.

The regulation on salt concentrations establishes *the best technological means available* - which are in use and that are economically feasible - for the prevention of risks and hazards and the prevention of pollution of water resources. MoEP sets criteria for how to determine whether available technological means are *in use* and *economically applicable*, based on their accumulated experience.

For some of the regulations (e.g. on salt concentrations, metals and other pollutants), industrial operators may request a temporary exemption from the ELVs. This requires that they they prove to the environmental regulator that they apply BAT to reduce pollutant concentrations in the production process and in wastewater treatment, and that further reduction of the pollutant concentrations would harm the production process, the product quality or the product authorisation.

In addition to the regulations under the Water Law and the Business Licensing Law, Israel has a set of Water and Sewage Corporations Rules (for industrial wastewater discharged to the sewage system), formulated by the water authority under the Water and Sewage Corporations Law (2001). The purpose of the rules is to avoid damage to the sewage system, the sewage treatment processes, the public or the environment. The rules determine *maximum emission values* according to the ELVs set forth in the aforementioned regulations, as well as for a number of pollutants relevant to preventing damage to the sewage system. The rules set out differential tariffs, requiring plants to pay a tariff according to the pollutants they discharge and an additional tariff for deviation.

Finally, ELVs for discharges of effluents for irrigation or directly to the environment are set forth in the Public Health Regulations on Effluents Quality and Wastewater Treatment Standards (2010). These regulations determine the quality of effluents, in order to enable their reuse and to protect the environment. ELVs under the Public Health Regulations are expressed as a maximum concentration of pollutants at a monthly average according to the destination of the effluents: discharge to the environment *or* for irrigation in different areas. The Regulations mainly apply to public sewage treatment plants, but also to a small number of industrial plants that discharge effluent for irrigation or to the environment.

6.2. Policy evaluation

6.2.1. Governmental evaluation projects

After the first round of permitting under the Clean Air Law (2011-2016), MoEP published a report[8] including a quantitative assessment of the reductions in annual loads of air emissions expected in each industrial sector following the implementation of the BAT-based requirements. The report also contains a cost-benefit analysis of the permitting system: on the cost side, MoEP estimated the total investment required by industrial and energy production installations to implement the environmental requirements defined in the permits, as well as the regulatory cost. On the benefits side, the expected reductions in air emissions were outlined and translated into external cost coefficients for the main air pollutants (PM, NO_x, SO_x, VOC, Benzene and NH_3). The analysis demonstrated that the cost-benefit ratio was *three*, meaning that the local economy earned three NIS (New Israeli Sheqel) per NIS of investment by the industry, as a result of improved air quality and reductions in the negative health effects on the Israeli population.

6.2.2. Stakeholder opinions

The Ministry of Environmental Protection

MoEP perceives Israel's BAT policy as being effective, and highlights several advantages of BAT-based permitting, notably that BAT provide a balance between environmental protection and economic interests. Using the EU BREFs allows Israel to align with the environmental regulation of other countries, thus increasing the international competitiveness of Israeli industry. MoEP notes, however, that because the BREFs are developed based on the situation in the EU, they do not take into consideration issues that are unique to Israel, such as the extensive use of treated effluents for irrigation. Another potential disadvantage of the current approach is that the BAT are based on *available*, i.e. widely used techniques, rather than cutting-edge techniques. It might be desirable to introduce, in parallel to the BAT policy, a policy that encourages industry to implement innovative techniques.

MoEP notes that the introduction of an integrated environmental permitting system would enable the permitting authority to better address all aspects of each industrial facility, to prioritise various environmental requirements, and to better consider process-integrated versus end-of-pipe measures. The Ministry also sees potential for improvement as regards environmental inspection as well as the digitisation of monitoring data, for which the following measures could be taken:

- the digital submission of sampling results, either by the operators or by the sampling and analysis laboratories that provide service to the operators, in a format that can be embedded in a database;

- the digital submission of other relevant data and reports; and
- the development of measurable indicators, providing additional tools to assess the policy's effectiveness and to make adjustments as necessary.

Furthermore, MoEP would like to see industry operators shift their environmental performance related investments to measures for prevention at source and efficiency, which improve both environmental and economic performance. This could partially be ensured by establishing more BAT aimed at prevention at source as well as increased efficiency.

MoEP identifies some examples of external factors that might intervene, support or weaken, the effect of Israel's BAT policy, notably the gradual reduction of the use of coal imposed by a decision by the Ministry of Energy and the corresponding decrease of emissions to air of coal combustion. The reduction of these emissions is further supported by the availability of natural gas to plants in Israel.

Industry associations

According to the Manufacturers Association of Israel, Israel's BAT-based policy for air emissions has the following drawbacks:

i. The procedure to determine ELVs in permits lacks a thorough examination of cross-media effects. Although the BAT and BAT-AELs in the EU BREFs are based on a consideration of cross-media effects, permits for Israeli installations are issued separately for each environmental medium and by different regulators within MoEP; thus, the balance between the various emissions is not always taken into account. This is problematic because a maximised reduction of air emissions for example can lead to the excessive generation of waste or wastewater.

ii. The deadline for compliance with ELVs for existing installations is often considered too tight by industry. The Israeli legislation does not stipulate an overarching timeframe for the implementation of the EU BAT Conclusions; rather, the timeframe for the implementation of the measures for bridging the gap between existing techniques and BAT – and for achieving compliance with ELVs – is determined in the individual permits, depending on the extent of the gaps.

iii. Some ELVs have been determined without examining whether it is technically feasible for the concerned installations to adopt the BAT associated with these values. The Manufacturers Association underlines that the BAT-AELs from BREFs published under the EU's IPPC Directive (EU, 1996[31]) are treated as legally binding in Israel, although they are only considered guidance documents in the EU Member States.

iv. Less stringent ELVs can only be set after conducting a cost-benefit analysis (see Section 6.1.2). The Israeli industry believes that the methodology employed to determine the BAT that will have to be adopted by a particular facility is more stringent than what is customary in other countries, and that the MoEP should consider adopting a different methodology.

6.3. Available sources of data

6.3.1. Emissions monitoring data

PRTR

Israel's PRTR includes comprehensive information on emissions of 114 substances (including greenhouse gases) into air, sea, land and water sources, and waste and wastewater transfers from the 570 largest plants in the country. The PRTR is regulated by the Environmental Protection Law: Pollutant Release and Transfer - Registering and Reporting Obligation (2012), and has been operational since 2013. A central principle of the PRTR is to ensure transparency and the publication of environmental information to the public in a convenient and accessible manner. MoEP's PRTR website uses a Geographic Information System where each plant has an "index card" showing detailed information, such as its address, type of activity, plant owner name, ID number, etc., in addition to the data reported, i.e. the type and quantity of pollutants emitted or transferred from the plant. The website also includes an advanced data analysis tool, which allows assessing the data by performing a wide variety of cuttings and queries. The complete database can be downloaded in an Excel file.

The thresholds for PRTR reporting are lower in Israel than in the EU, and industry operators whose emissions of a pollutant are below the thresholds have to report that they emit the pollutant to the environment.

MoEP utilises the PRTR data as a tool to monitor compliance, to support decision-making and policy-making, to identify trends and to examine policy implementation. As part of MoEP’s internal, annual quality control procedure for the PRTR reports from industry operators, a given percentage of the plants are required to provide additional information for verification of the reported data, notably those that have reported a significant change in emission load. MoEP also uses other available sources of information, such as permit application documents, to perform a quality check of the PRTR reports. MoEP annually publishes a report on the PRTR data, as well as submits the report to the Israeli Parliament (The Knesset). The first report was submitted on 30 June 2013, containing emissions data from 2012. The reports are available for public use, providing accessible environmental data free of charge[9].

MoEPs’ latest PRTR report (MoEP, 2018[90]) demonstrates a significant reduction – between 62% and 8%, depending on the pollutant – in the emission of air pollutants between 2012 and 2017, likely as a result of the introduction of BAT-AEL-compliant ELVs in permits. The decrease in annual emission loads of certain pollutants is in line with the changes in the ELVs shown in the case studies in Section 6.4 (see Figure 6.8, Figure 6.10, Figure 6.12 and Figure 6.13).

The decline in industrial air emissions over the last years is illustrated by Figure 6.1 and Figure 6.2, which demonstrate the annual emission loads for pollutants emitted into air by Israel’s energy and refining sectors, respectively, between 2012 and 2017. The pollutants presented are CO_2, SO_X, NO_X and SPM for the energy sector and SO_X, VOC, CO, NO_X, VOC, SPM and benzene for the refining sector.

Figure 6.1. Emissions into air (CO_2, SO_X, NO_X and SPM) from Israel's energy sector, 2012-2017

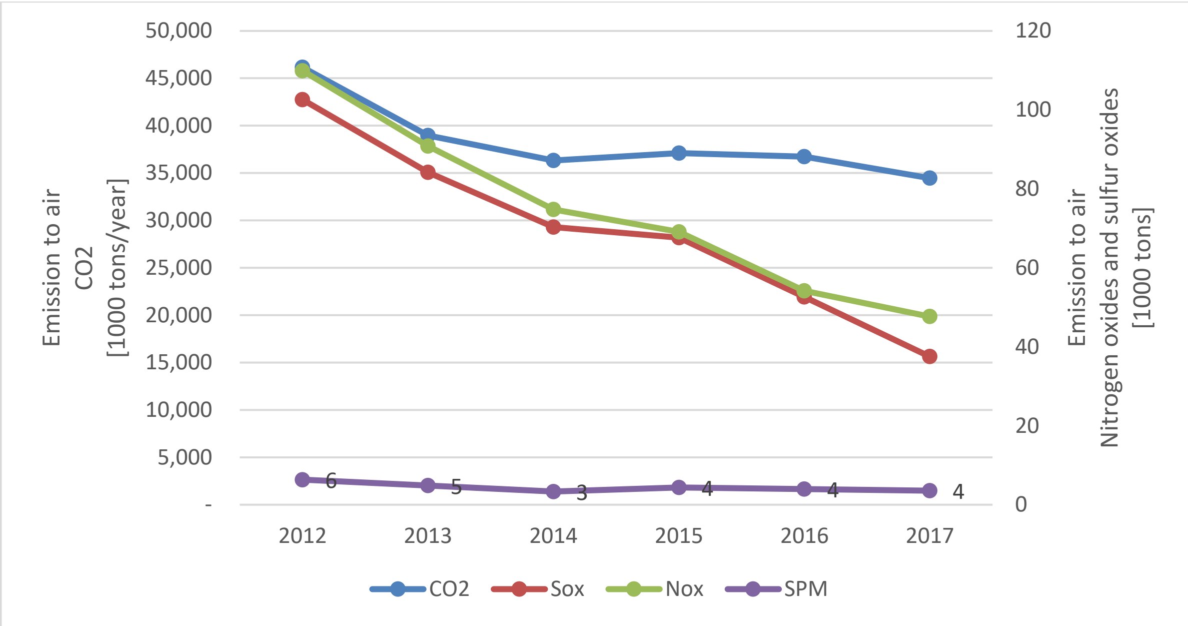
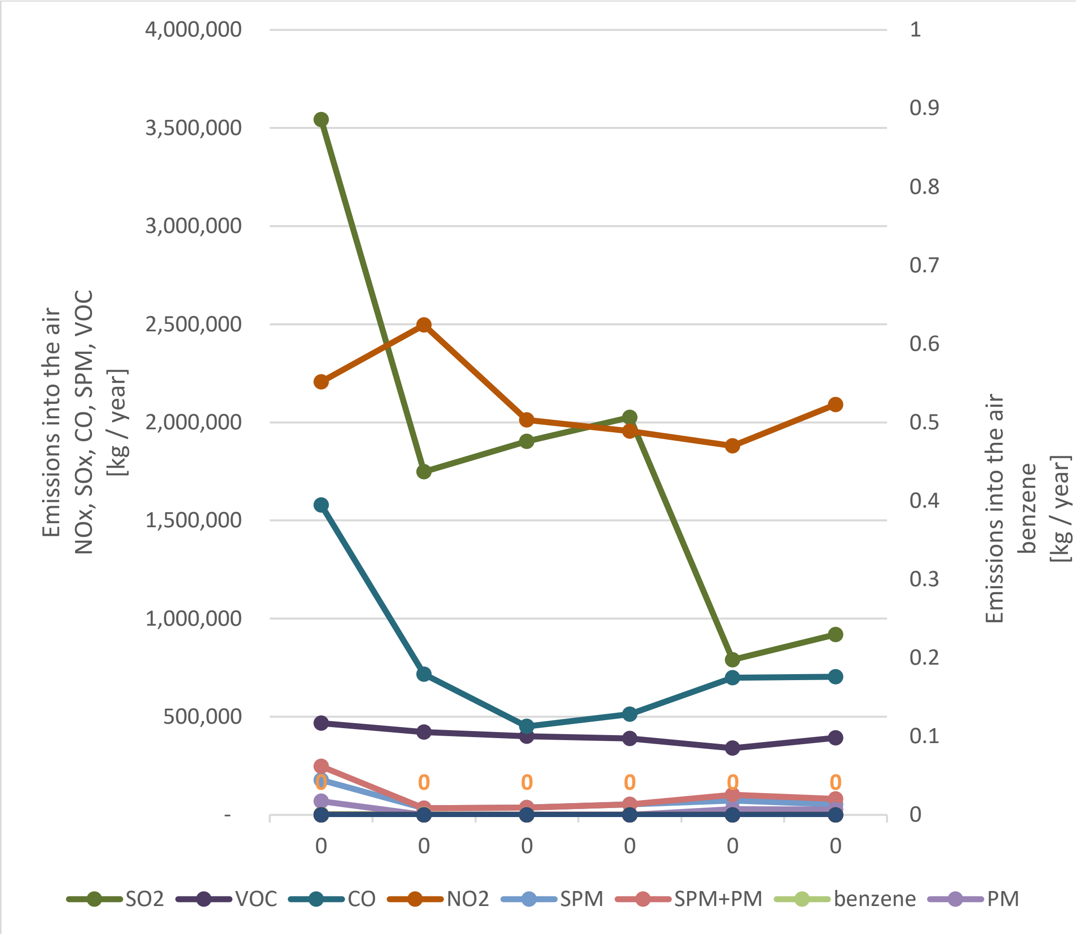


Figure 6.2. Emissions into air (SO_X, VOC, CO, NO_X, VOC, SPM and benzene) from Israel's refining sector, 2012-2017

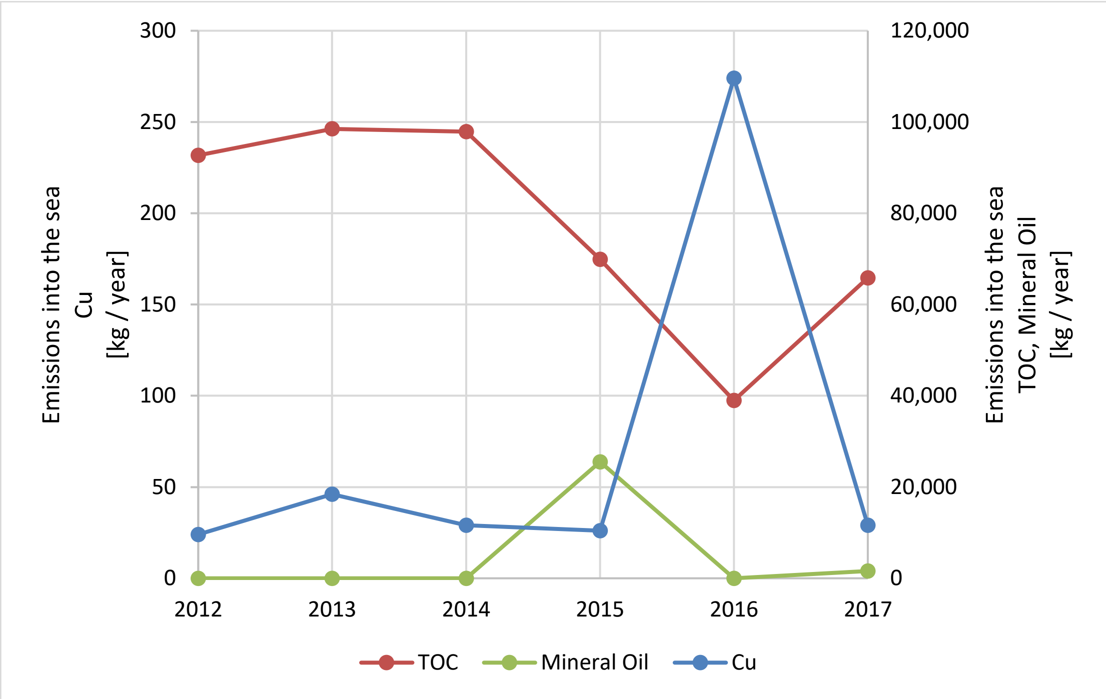


Source: (MoEP, 2018[90])

As for industrial wastewater, the PRTR report from 2017 demonstrates that the discharge of total organic carbon (TOC) into the Mediterranean Sea decreased by more than 95% between 2012 and 2017. This was due to the installation of new technology for the treatment of sludge at the public sewage treatment facility in the Dan region (Shafdan), and the gradual cessation of its discharge to the Mediterranean Sea. The new treatment technology was approved by decisions by the Inter-Ministerial Committee for the Granting of Permits for Discharge to the Sea, which are available on MoEPs' website.

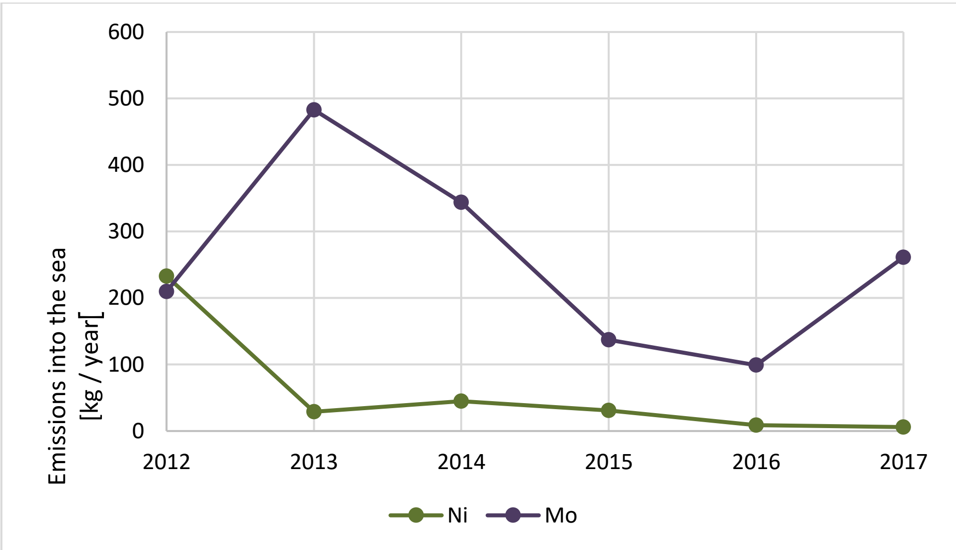
The figures below (Figure 6.3 and Figure 6.4) present the change in the annual emission loads of the main pollutants discharged into the sea by Israel's energy sector, between 2012 and 2017. The pollutants presented include TOC, mineral oil, copper (Cu), nickel (Ni) and molybdenum (Mo). The decreases shown are triggered by the implementation ofELVs based on BAT in permits for discharge into the sea.

Figure 6.3. Emissions into the sea (TOC, Mineral Oil and Cu) from Israel's energy sector, 2012-2017



Source: (MoEP, 2018[90])

Figure 6.4. Emissions into the sea (Ni and Mo) from Israel's energy sector, 2012-2017

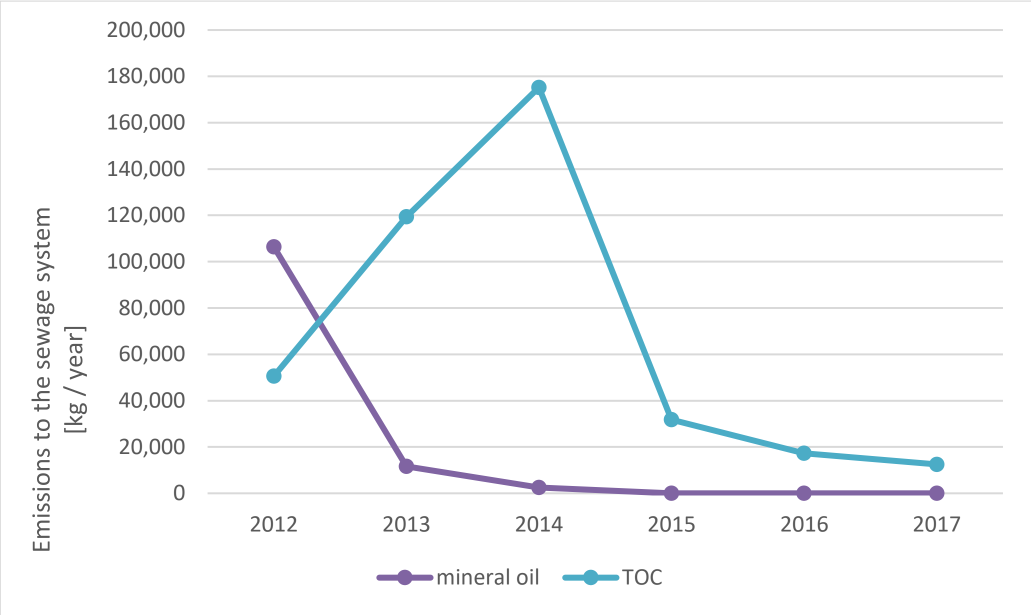


Source: (MoEP, 2018[90])

As for discharge into the public wastewater system, the 2016 PRTR report demonstrated that there was a 16% decline in the quantity of salts in effluents between 2013 and 2016. The decreases are partially due to continued compliance with ELVs based on BAT, and partially due to the reduction of the general salinity of the supply water due to an increase in the share of desalinated seawater in the supply water.

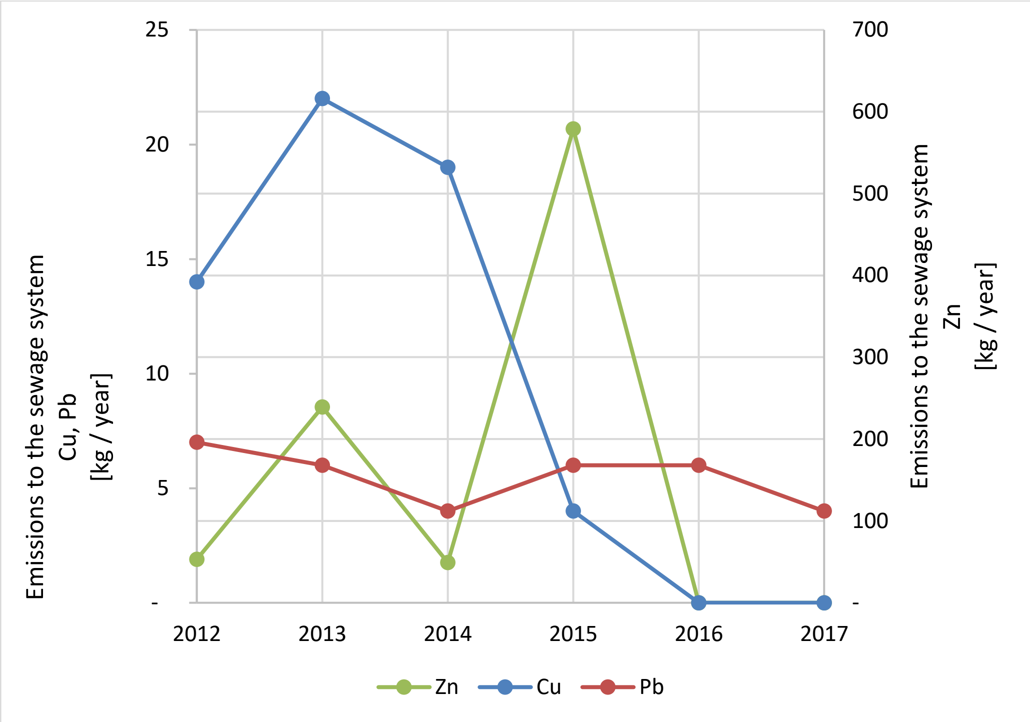
Most Israeli non-ferrous metals plants discharge their industrial wastewater into the public sewage system. Figure 6.5 and Figure 6.6 present the change in annual emission loads of the main pollutants discharged into the public sewage system by Israel's non-ferrous metals sector (for those plants that report to the PRTR) between 2012 and 2017. The pollutants presented include mineral oil, TOC, zinc (Zn), copper (Cu) and lead (Pb). The decreases shown are due to progress in compliance with the BAT-based ELVs defined under the regulations on metals and other pollutants.

Figure 6.5. Emissions of mineral oil and TOC into the public sewage system from Israel's non-ferrous metals sector, 2012-2017



Source: (MoEP, 2018[90])

Figure 6.6. Emissions of Zn, Cu and Pb into the public sewage system from Israel’s non-ferrous metals sector, 2012-2017



Source: (MoEP, 2018[90])

Emissions monitoring data at installation level

Under the air emission permits, operators are required to submit annual reports including monitoring and sampling data. These data are more detailed than the data submitted to the PRTR, and complement the PRTR data with information on emissions from stacks and non-point sources. Equally, under the discharge to the sea permits, operators are required to submit periodic and annual reports including monitoring and sampling data.

The result of stack sampling by operators and MoEP are collected and registered in a computerised system. The results of stack sampling are used to evaluate compliance with ELVs and constitute an information base for analysis and emissions inventories.

Industrial wastewater sampling at the discharge point to the public sewage system, is carried out by the operators and by the water and sewage corporations, and the results are delivered to MoEP.

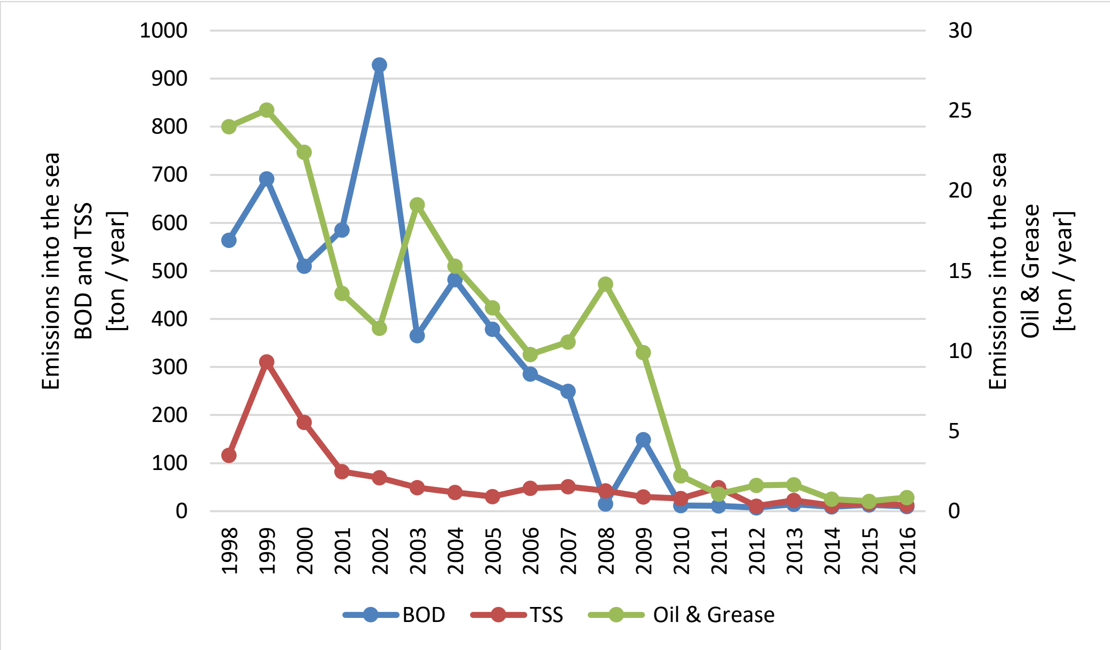
A process is currently underway to digitalise the information from sampling of stacks and industrial wastewater discharged into the public wastewater system, in order to enable the continued preservation and analysis of the data.

Provision of information to the public is done according to the instructions of the Freedom of Information Law (1998), which regulates the right of the public to receive information from the Government. Amongst other things, the law states that "a public authority shall provide the public with information on the environmental quality it possesses, on the website of the public authority, if it exists as aforesaid, and in other ways as determined by the Minister of the Environment”. By virtue of this section, the Minister of Environmental

Protection enacted the Freedom of Information Regulations (2009), containing a provision of information on the environment for public use. According to these Regulations, MoEP publishes raw emissions monitoring data online[10]. Information on the stack sampling results, as entered into the aforementioned computerised system, is published online after quality control[11]. Also according to the Freedom of Information Regulations, the results of sampling of industrial wastewater carried out by the water and sewage corporations are published on each company's website once a year, and are thus also accessible to the public. The reports are published as an Excel file, listing the plants that were sampled in the past year and the deviations from ELVs that were measured in each plant.

Figure 6.7 presents the changes in annual loads for pollutants discharged into the sea from Israel's refining sector, between 1998 and 2016. The main pollutants measured, and thus presented, are BOD, TSS, and oil and grease. The data were collected from the quarterly and annual reports on emissions from the operators and from a continuous monitoring system. The figure shows a reduction of the oil and grease emission load of 98%, a reduction of the BOD load of 96% and a reduction of the TSS load of 89%. The decreases shown are triggered by the implementation of BAT and BAT-based ELVs.

Figure 6.7. Discharges of BOD, TSS and oil and grease into the sea from Israel's refining sector, 1998-2016



Source: MoEP, Marine and Coastal Division

6.3.2. Activity data

Data on the production capacities of industrial installations are included in the individual applications for air emission permits. The permits can be accessed online, for permits for discharge to the sea[12] and air emission permits[13]. The information published to the public includes a search engine for air emission permits according to the name of the plant and the sector.

Plants under air emission permits are required to submit an annual report containing monitoring and sampling data, but also data on changes that occurred in the previous year that led to a change in the emissions, as well as details on annual working hours and quantities and types of raw materials consumed.

6.3.3. Other metrics

Other available metrics describing the state of industrial pollution before and after the implementation of BAT-based permit requirements are:

i. Air quality monitoring data can be accessed online, in the national air monitoring system.[14] The air monitoring system in Israel encompasses more than 140 air monitoring stations across the country. These are operated by various bodies, including MoEP.

ii. Sea water quality data are collected by the Ministry of Health, which monitors the microbiological quality of the coastal waters, and MoEP, which monitors the chemical components. Israel’s chemicals monitoring system comprises national and local monitoring programmes covering the main discharge sources along Israel's coastline. The monitoring plan can be viewed online[15].

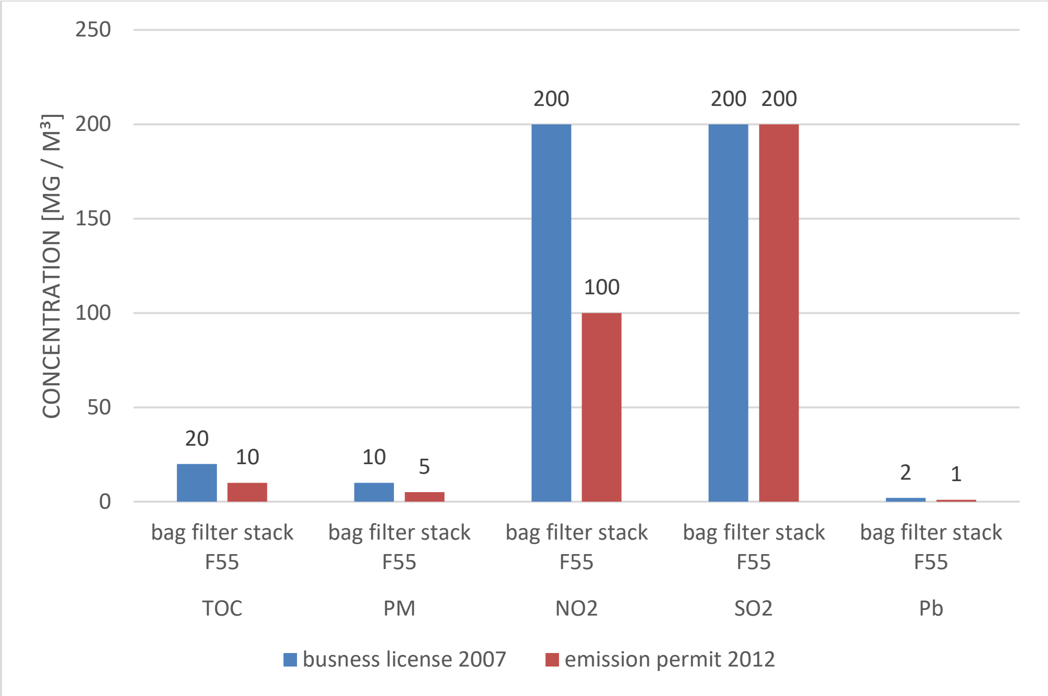
iii. Data on the quality of effluents produced by the public sewage treatment plants.

6.4. Case studies

6.4.1. Non-ferrous metals industry: a lead plant

Hakurnas Lead Works Ltd. is a lead smelter, producing lead and various lead alloys from secondary raw material (recycling lead acid batteries). ELVs for PM, Pb, SO_2, NO_2, CO, TOC, PCCD/F and relevant metals were determined in the emission permit of Hakurnas Lead Works Ltd. under the Clean Air Law. Before the emission permit was issued, air emissions from the company were regulated under the environmental conditions in the business license. Figure 6.8 shows the changes in the ELVs for the main air pollutants from the melting facilities of Hakurnas Lead Works Ltd, between the business license from 2007 and the emission permit from 2012.

Figure 6.8. Changes in ELVs for TOC, PM, NO_2, SO_2 and Pb at Hakurnas Lead Works Ltd. between 2007-2012



Source: MoEP

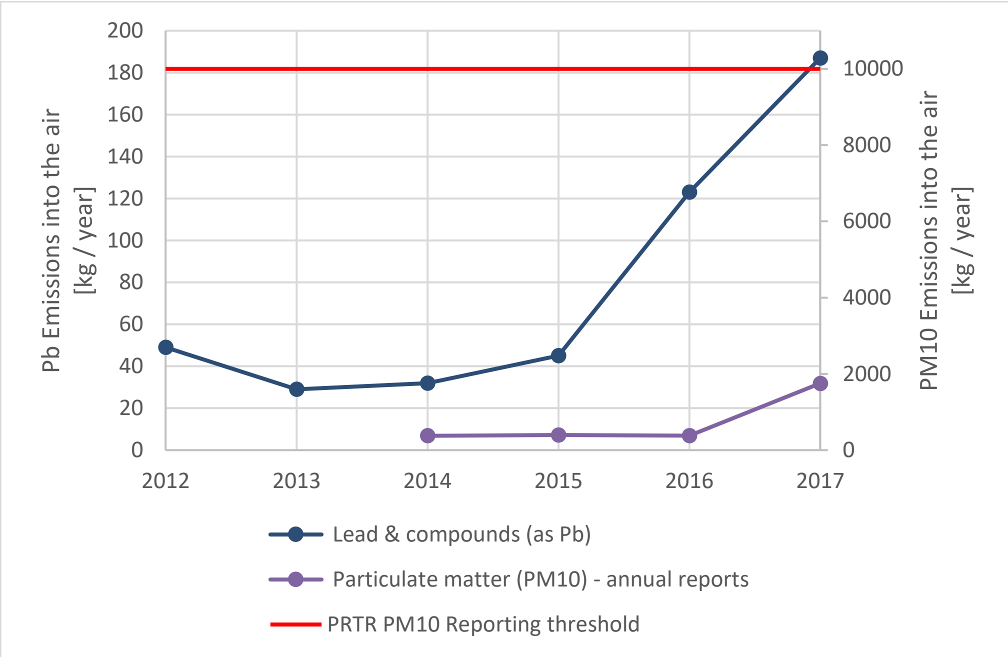
Figure 6.9 shows the annual emission loads for pollutants emitted into air by Hakurnas Lead works Ltd. between 2012 and 2017. The pollutants presented include PM_{10} and Pb. The company's emissions of PM are not reported to the PRTR because they are below the reporting threshold.

The increase in emission loads of Pb reflects sampling issues:

- The calculation of the annual emissions takes into account the average of the last two stack samples, multiplied by the annual operating rate.
- Small changes in the results of the samples – although not significant in terms of how the plant complies with its license and permit conditions – may cause deviation of tens and hundreds of percent in the annual emission rate.

Therefore, as long as the plant meets the emission limit values in its permit, even if there are such changes in the reports between the years, this does not reflect deviations.

Figure 6.9. Emissions of PM_{10} and Pb into air from Hakurnas Lead works Ltd, 2012-2017



Source: (MoEP, 2018[90])

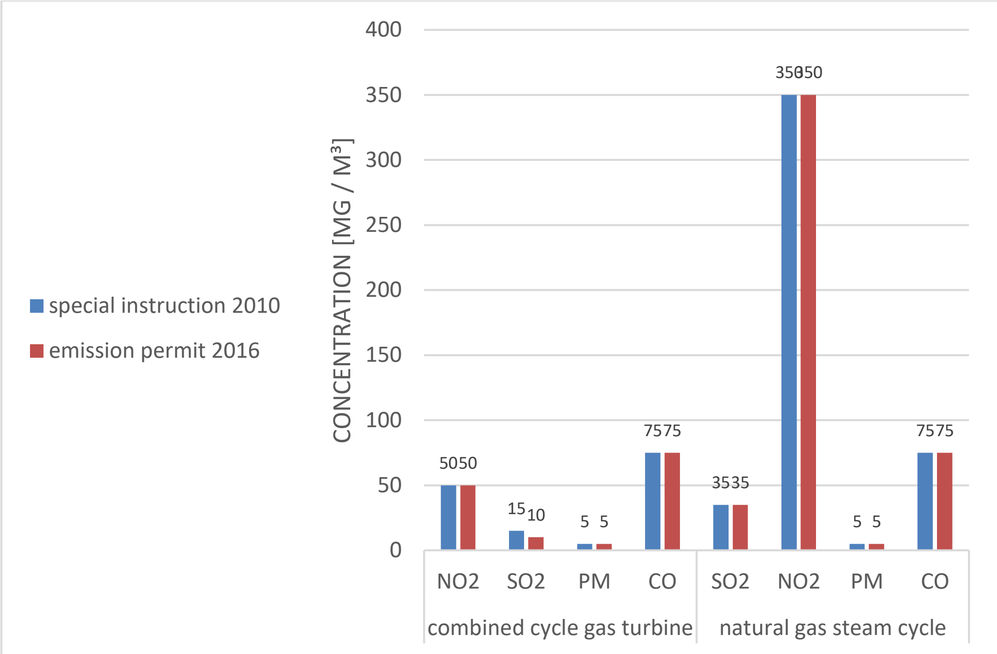
6.4.2. Large combustion plants: The Haifa Power Plant of the Israel Electric Company Ltd

The Haifa Power Plant is one of the five coastal power plants of Israel Electric Company Ltd. in Israel. The power generation units in Haifa power plant include two combined cycle units, two jet gas turbines and two steam units. The generation units on the plant are at a nominal capacity of 1 100 MW.

Prior to the issuance of the emission permit under the Clean Air Law, the air emissions of Haifa Power Plant were regulated by special Instructions under the Abatement of Nuisances Law (1961). These special instructions from 2010 apply to all IEC power plants. The special instructions set ELVs for PM, NOx, SOx, and CO. The emission permit of Haifa Power Plant, as well as those of other power plants from the energy sector, sets ELVs for PM, NOx, SOx, and CO.

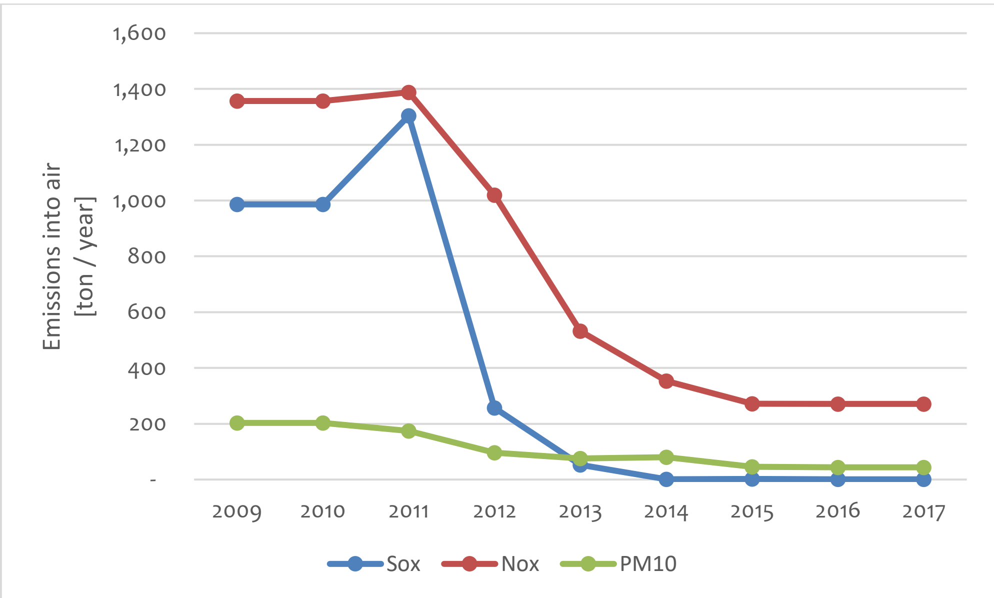
Figure 6.10 shows the changes in the ELVs for main air pollutants from Haifa Power Plant, between the special Instructions from 2010 and the emission permit from 2016. Changes in annual emission loads for Haifa Power Plant, between 2009 and 2017, are presented in Figure 6.11. The data were collected as part of a report on the state of the air quality in Haifa Bay, from the annual reports on emissions and additional data from the installations. The figures show significant changes (reductions) in the annual emission loads in the years 2009-2011. The decreases shown are triggered by the implementation of BAT and ELVs based on BAT.

Figure 6.10. Changes in ELVs for NO_2, SO_2, PM and CO at Haifa Power Plant between 2010 and 2016



Source: MoEP

Figure 6.11. Emissions SO_X, NO_X and PM_{10} into air from Haifa Power Plant, 2009 - 2017



Source: MoEP, "State of the Air Quality in Haifa Bay", June 2017

It should be noted in this context that the two main units at the Haifa Power Plant (combined cycle units) were first put into operation at the end of 2011, and use natural gas. The two units are backed up by two diesel-powered units, with limit running hours, and by two older steam units that initially ran on fuel oil, but that converted to natural gas in 2010. Two older units running on fuel oil were closed in 2010, as part of the environmental regulations that preceded the special instructions from 2010. Thus, some of the reduction in air emissions from Haifa Power Plant occurred prior to 2010.

6.4.3. Refining of mineral oil: Oil Refineries Ltd

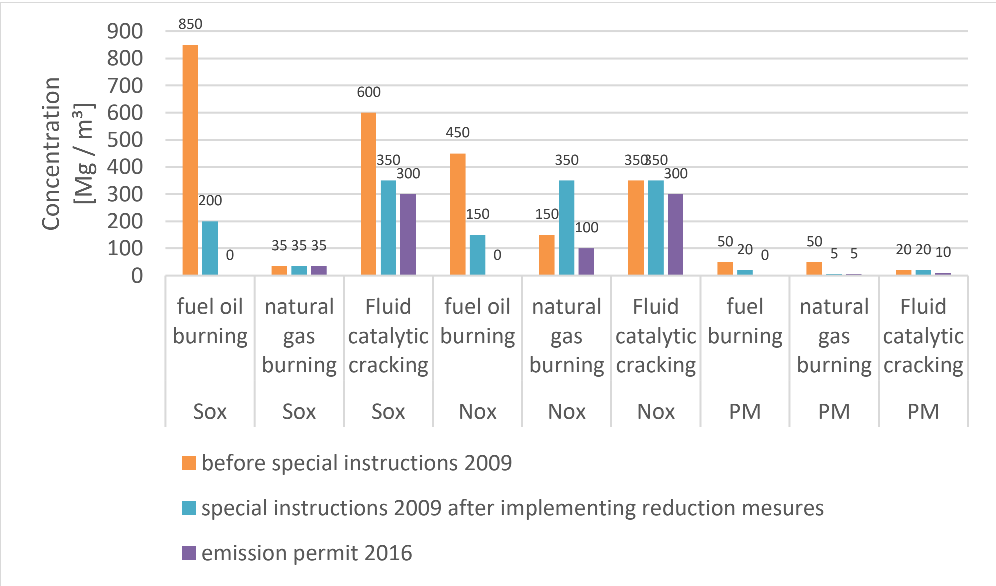
Oil Refineries Ltd. is located in Haifa Bay. The company distils and distributes approximately 60% of the refined petroleum products consumed in Israel. The main raw material is imported crude oil. The refinery produces petroleum products from crude oil and other intermediates through various chemical processes such as distillation, separation and cracking. The final fuel products marketed are, amongst others gasoline, naphtha, diesel, kerosene (jet fuel), fuel oil and liquefied petroleum gas. Some products constitute raw materials in continuing industries, such as in the manufacture of plastics, aromatics, basic oils and waxes, asphalt, etc.

Prior to the issuance of the emission permit under the Clean Air Law, air emissions from Oil Refineries Ltd. were regulated by special instructions under the Abatement of Nuisances Law (1961)[16]. The last update of the special instructions dates from 2009. The emission permit for Oil refineries Ltd., as well as for the Ashdod refinery, sets ELVs for CO_2, PM, NO_x, VOC, benzene, toluene, Ni, V, H_2S, NH_3, CS_2, dioxins and HCl.

It should be noted in this context, that in the emissions permit, the use of gas as a fuel is required as a technique to reduce emissions. The use of liquid fuel is permitted only when there is a malfunction or a lack of supply of natural gas. In addition, the emission permit regulates pollutants and installations that were not specified in the special instructions.

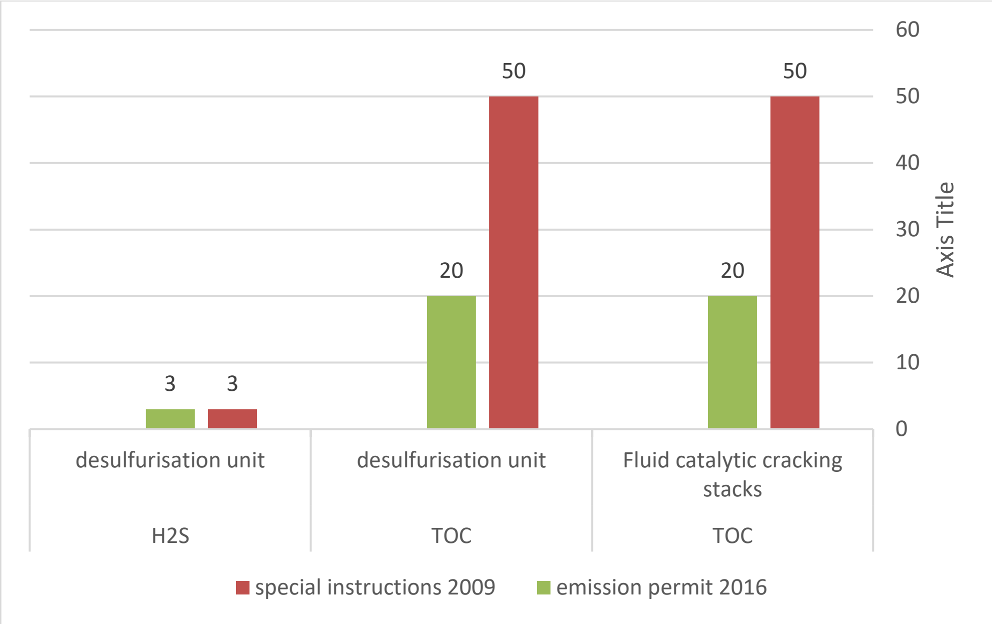
Figure 6.12 and Figure 6.13 show the changes in the ELVs for main pollutants from Oil Refineries Ltd., between 2009-2016. Changes in annual emission loads for the company are presented in Figure 6.14.

Figure 6.12. Changes in ELVs for SO_x, NO_x and PM for Oil Refineries Ltd. between 2009 and 2016



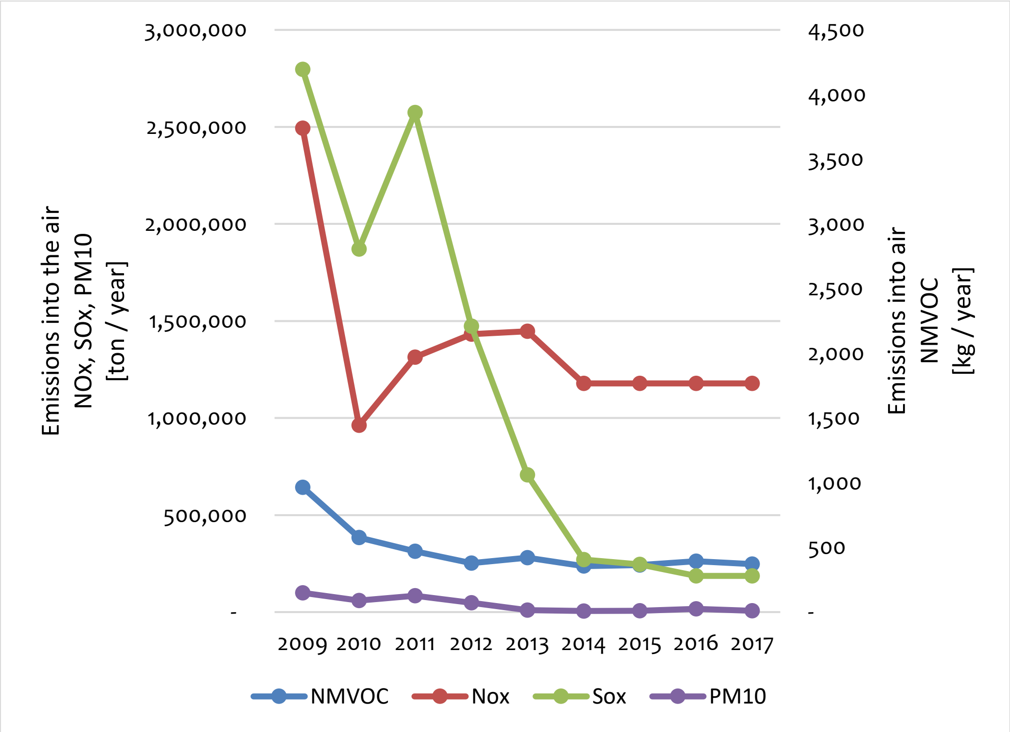
Source: MoEP

Figure 6.13. Changes in ELVs for H2S and TOC for Oil Refineries Ltd. between 2009 and 2016



Source: MoEP

Figure 6.14. Emissions into air (NMVOC, NO_x, SO_x and PM_{10}) from Oil Refineries Ltd, 2009-2017



Source: MoEP, "State of the Air Quality in Haifa Bay", June 2017

6.5. Conclusion

MoEP perceives Israel's BAT policy as being effective in terms of reducing emissions, but notes that there is room for improvement. Suggested measures for enhanced impact of the policy includes digitising operators' submission of sampling results and other data, and developing quantifiable indicators of effectiveness.

MoEP monitors the implementation of its BAT policy based on PRTR data, annual reports and other data. The PRTR data demonstrate a significant decline in emissions to air and water between 2012 and 2017. For instance, NO_x emissions from the power sector decreased by 56% and SO_2 emissions by as much as 64 %. The reductions result from the use of natural gas instead of coal. Most of the CO_2 emissions reduction from the power sector are also due to a transition from coal to natural gas, which is considered BAT and has been supported by the Ministry of Energy. In the refining sector, SO_2 emissions decreased by as much as 79%, while NO_x emissions declined by 7%. This seems to indicate that the introduction of BAT has had a more considerable impact on SO_2 emissions.

One limitation of MoEP's emissions analysis is that activity data are not included. If activities have increased in the period considered, this would mean that the BAT policy has been even more effective than illustrated by the figures in this chapter. However, the opposite may also be true. Another drawback of not considering activities is that the results do not allow for an international comparison.

The three case studies presented in the chapter provide valuable information on the changes in ELVs for key air pollutants, along with monitoring data enabling a comparison of emissions before and after the introduction of new ELVs. Under the influence of Israel's BAT policy, ELVs were tightened – and emissions decreased – in the three installations, but also industry-wide. According to MoEP, in many installations the changes in ELVs led to the implementation of additional techniques, or the replacement of existing techniques. In some cases, the existing techniques or processes were optimised. Only some installations were able to meet the new ELVs without making changes. An important limitation of the case studies in the chapter is that they do not include activity data.

Notes

[1] See http://www.sviva.gov.il/English/Legislation/Documents/Clean%20Air%20Laws%20and%20Regulations/CleanAirLaw2008.pdf.

[2] See http://www.sviva.gov.il/English/env_topics/IndustryAndBusinessLicensing/IntegratedEnvironmentalLicensing/Pages/default.aspx.

[3] See http://archive.sviva.gov.il/infoservices/reservoirinfo/doclib/אוויר/avir28.pdf.

[4] See http://www.sviva.gov.il/English/Legislation/Documents/Seas%20and%20Coasts%20Laws%20and%20Regulations/PreventionOfSeaPollutionFromLand-basedSourcesLaw1988.pdf.

[5] See https://mfa.gov.il/mfa/pressroom/1998/pages/the%20water%20law%20of%201959.aspx.

[6] See http://www.sviva.gov.il/English/Legislation/Documents/Licensing%20of%20Businesses%20Laws%20and%20Regulations/LicensingOfBusinessesLaw1968-Excerpts.pdf.

[7] See http://www.sviva.gov.il/English/Legislation/Pages/WaterAndWastewater.aspx.

[8] See http://www.sviva.gov.il/InfoServices/NewsAndEvents/MessageDoverAndNews/Documents/2018/clean-air-law-report-2018.pdf.

[9] See http://www.sviva.gov.il/PRTRIsrael/Pages/default.aspx.

[10] See http://www.sviva.gov.il/InfoServices/ReservoirInfo/FreedomofInformation/Pages/FreedomofInfoLobby.aspx.

[11] See http://www.sviva.gov.il/InfoServices/ReservoirInfo/MekorotPleta/Pages/default.aspx.

[12] See http://www.sviva.gov.il/InfoServices/LicencesPerMissions/DischargeAndProjection/Pages/default.aspx.

[13] See http://www.sviva.gov.il/subjectsEnv/SvivaAir/LicensesAndPermits/PermitEmission/Pages/default.aspx.

[14] See http://www.svivaaqm.net/Default.rtl.aspx.

[15] See http://www.sviva.gov.il/subjectsEnv/SeaAndShore/MonitoringandResearch/Pages/default.aspx.

[16] See http://www.sviva.gov.il/English/Legislation/Documents/Nuisances%20Laws%20and%20Regulations/AbatementOfEvironmentalNuisancesLaw1961.pdf.

Chapter 7. Korea

BAT and integrated environmental permitting are under implementation in Korea, and no complete assessment of their impact has yet been conducted. The lack of necessary emissions monitoring data currently constitutes an impediment to the adequate evaluation of the effectiveness of the BAT policy. Eventually, industrial operators are expected to conduct an ex post evaluation of BAT implementation. The Government sets out to update the BAT reference documents (BREFs) every five years, based on, inter alia, an assessment of the field applicability of the BREFs. Elements noted as obstacles to enhanced BAT uptake include the lack of involvement of industry operators and the limited capacity of competent authorities. The effects of BAT implementation in Korea are illustrated by two case studies in this chapter, on a waste incineration plant and an electric power plant.

7.1. BAT and environmental permitting in Korea

Korea's BAT policy entered into force with the adoption of the Integrated Pollution Prevention and Control (IPPC) Act in January 2017. The policy targets approximately 1 340 plants in 17 industrial sectors, accounting for 70% of the total pollutant discharge in Korea. An initial Technical Working Group Decision from 2018 established a list of 998 BAT in nine BREFs that were considered satisfactory both in terms of cost-effectiveness and environmental protection. Eight BREFs have not yet been completed. The complete list of Korean BREFs is available in the OECD's report *Approaches to Establishing BAT Around the World* (OECD, 2018[36]) and online[1].

The BAT-AELs in the Korean BREFs form the basis for legally binding Maximum Discharge Levels in integrated environmental permits. As of October 2018, permits have been granted to two plants (see the case studies in Section 7.4), while permit issuance is in progress for an additional 21 plants. The Government aims to issue permits to a total of 1 340 plants by 2024. Various governance systems have been put in place by the Ministry of Environment with the help of the National Institute of Environmental Research, Korea Environment Corporation and Technical Working Groups, in order to encourage industry operators to submit their Integrated Pollutant Control Plan, so as to receive their permits. If this plan is submitted early, various benefits may be given to the operators. According to the IPPC Act, permit requests as well as permit documents shall be made publicly available on a web-based platform[2] once the permit has been issued.

There is no subsidising of BAT uptake for industry operators in Korea. However, Article 9-2 of the IPPC Act allows for the Minister of Environment to award industry operators that maintain the level of discharged pollutants at a level significantly lower than the permissible discharge standards, by extending the interval of the review on conditions of permission or the permissible discharge standards by up to three years. Further, the government helps industry operators conduct an ex ante evaluation of BAT implementation.

7.2. Policy evaluation

7.2.1. Governmental evaluation projects

The effectiveness of the Korean BAT policy is assessed in several ways. First, all plants operating under a permit are expected to conduct an ex post evaluation every year, which addresses, amongst others, the effects of BAT implementation. The methodology for these evaluations is currently being developed. Second, the Ministry of Environment will shortly carry out an assessment of whether the current schedule for granting of permits (five years) should be extended by up to three years (i.e. maximum eight years), based on a methodology of estimating levels of environmental control, described in the Ministry's Notice no. 2017-16. According to the same notice, the 'field applicability' of BAT, i.e. the number of BAT currently in use compared to the number of BAT listed in a BREF, will be assessed quantitatively and qualitatively for each industrial sector. If 90% of the BAT in a BREF are used 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. Finally, also according to the same notice by the Ministry of Environment, factors such as emission levels, monitoring and violation of legal requirements will be assessed qualitatively. The result of the various evaluations will feed into the revision of BREFs, which will take place every five years. A survey conducted in December 2017 asked stakeholders to rate how much they are aware of, and satisfied with, the IPPC Act with a score between 0 and 100 on. The average scores were as follows:

- from 70 experts: 79.8/100;
- from 40 producers of environmental products: 72.5/100;
- from the staff of 192 emitting plants: 66.1/100.

7.2.2. Stakeholder opinions

National Institute for Environmental Research

Experts from the National Institute for Environmental Research note that the implementation of BAT and environmental permits still is at an early stage; eight out of 17 BREFs are not yet implemented and ex post controls and other evaluations can thus not yet be carried out for these. The experts believe that the five year revision cycle of BREFs will allow for the BREFs to be polished in and limitations to be addressed in consultation with key stakeholders. Further, they expect that the BAT policy will help reduce industrial pollution country wide.

Further, the National Institute for Environmental Research stresses that it currently is a challenge to quantitatively evaluate the effects of BAT implementation, due to limited availability of the necessary emissions monitoring data. They expect that permitting and monitoring requirements will allow for more reliable data to be collected.

Another limitation to the BAT and permitting policy's effectiveness is the considerable capacity required by the competent authorities and relevant stakeholders, which only can be achieved over time and through society-wide efforts. The process to implement BAT and integrated environmental permits under the IPPC Act is currently perceived as complex and industry is not yet properly involved. The experts believe that the effectiveness of the BAT policy can be improved by enhancing the capacity of relevant authorities and other stakeholders, and further involving industry stakeholders, in particular from smaller size installations.

7.3. Available sources of data

7.3.1. Emissions monitoring data

The Korean PRTR covers 415 substances.[3] In addition to data on emissions, the PRTR contains data on consumption of chemicals. For some sectors, PRTR data are only reported for a limited list of pollutants. For example, PRTR data for combustion plants only provide information on releases of selected pollutants, such as ammonia, butane, hydrogen chloride, methanol, and sulphuric acid, and without distinguishing between medium and large combustion plants.

In addition to PRTR data, the Ministry of Environment collects emissions monitoring data from all industrial plants, including facility inventory data, self-monitoring data, plant survey data and continuous air and water emissions monitoring data (through the Smoke Stack Tele Monitoring System and Water Tele Monitoring System, respectively). Table 7.1 displays all the existing sources of emissions monitoring data in Korea, besides the PRTR.

Table 7.1. Sources of emissions monitoring data in Korea

	Facility Inventory Data	Self-Monitoring Data	Air Continuous Emission Monitoring Data (Smoke Stack Tele-Monitoring System)	Water Continuous Emission Monitoring Data (Water Tele-Monitoring System)
Data Source	National Institute of Environmental Research	National Institute of Environmental Research	Korea Environment Corporation	Korea Environment Corporation
Start year	1997	1997	2002	2007
Quantity of companies or data involved	4,057 companies	1 million data points every year	1,500 stacks; more than 7 billion data points in total	907 companies
Data collection interval	Yearly	Weekly; monthly; quarterly	Every five minutes; every 30 minutes	Hourly; every three hours
Contents	- General information on each company - Total emissions (flow, TSP, SO_x, NO_x) - Emission facilities - Prevention facilities - Stack information - Fuel	- NH_3- Cu - Br - Hg - Cr - F - CN - THC - HCl - HF - O_2 - Temperature	- TSP - NO_x - SO_x - CO - Flow	- COD - T-N - T-P - SS - BOD - Flow (depends on discharges)

Source: The Korean National Institute of Environmental Research

The data from the emissions monitoring systems presented in Table 7.1 are not available to the public, but only to relevant government staff, due to confidentiality issues. The staff of industrial facilities are merely authorised to upload emissions data and other information for their own plant online, and cannot access data from other plants. The monitoring data are used to produce official data reports per geographic area (not available in English), but not at the facility level.

7.3.2. Activity data

The National Institute for Environmental Research reports that information on production volumes by sector unit is available. However, activity data at facility level are not available.

7.4. Case studies

7.4.1. Steam power plant "G"

Steam power plant "G" is an operating plant with a capacity of 76.9 MW, which uses flaming coal (1,550t/d), heavy oil (732kℓ/d) and Liquefied Natural Gas (LNG) (712,512㎥/d) as fuels. Its main equipment is a boiler for coal (200t/h×2, 240t/h) and another one for heavy oil and LNG (240t/h×2). The major pollutants emitted from the plant are SO_X, NO_X, CO, Trisodium phosphate (TSP), bottom ash, fly ash and heavy metals.

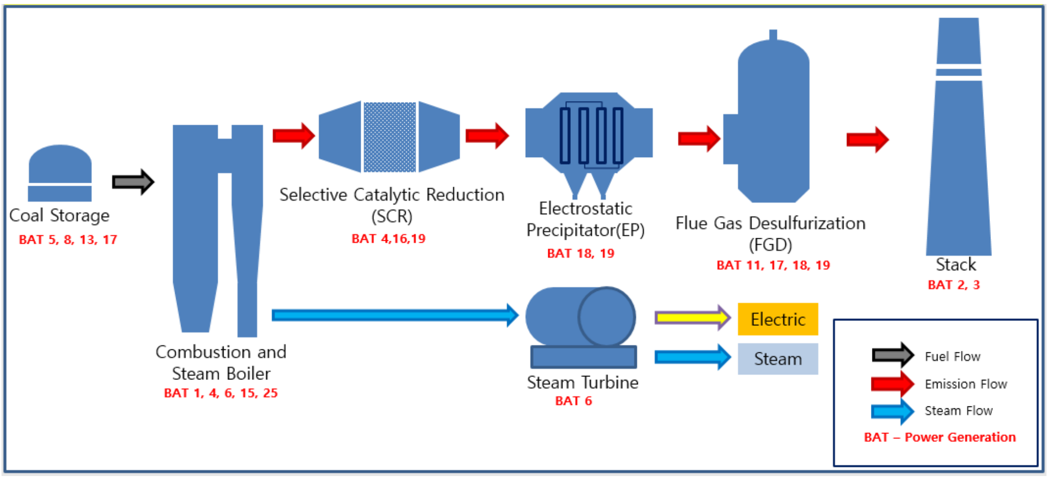
As one of two Korean plants, the steam power plant "G" was granted an integrated environmental permit in 2018. The permit requires compliance with emission limit values for air pollutants (including SO_x, NO_x and dust), water pollutants, odor, noise and vibration.

The permit includes a set of conditions demanding that the plant reduce the environmental impact of these pollutants (e.g. SO_x, NO_x and dust) through the conversion of fuel from soft coal to LNG by 2020 and the conversion to high efficiency catalyst used on NO_x mitigation facility.

There are 53 BAT in the Korean BREF on power generation, including 14 general BAT and 39 BAT that concern discharge facilities. "G" will apply a total of 25 of these techniques, with the most important ones listed below. The BAT applied are also illustrated on the process flow chart in Figure 7.1.

- Use high quality flaming coal (BAT 05: Higher Heating Value over 6 600kcal/kg, Lower Heating Value over 6 400kcal/kg, and sulphur content lower than 0.55%)
- Increase the use of LNG compared to coal (BAT 04: two units converted to LNG facility by 2020)
- Improve electric precipitator using electric field (BAT 18: improvement to high efficiency facility; removal efficiency increased from 98.0% to 99.9%).
- Improve denitrification facility (BAT 16: replace with high efficiency catalyst by 2020)
- Strengthen management of coal crushing and screening facility (BAT 02 and 08: transport facility seal, cleaning once a day).

Figure 7.1. BAT to be implemented by steam power plant "G"



The Korean National Institute for Environmental Research estimates that the implementation of BAT in plant "G" will result in annual emissions reductions of 40% for dust, 40% for NO_x, 48% for SO_x and 41% for heavy metals. This equals a total average reduction of 43% for all four pollutants, from 1 237 tonnes annually before the plant was granted the permit, to 700 tonnes per year after reaching compliance with the permit conditions. Since the measures only were implemented recently, reported emissions data are not yet available.

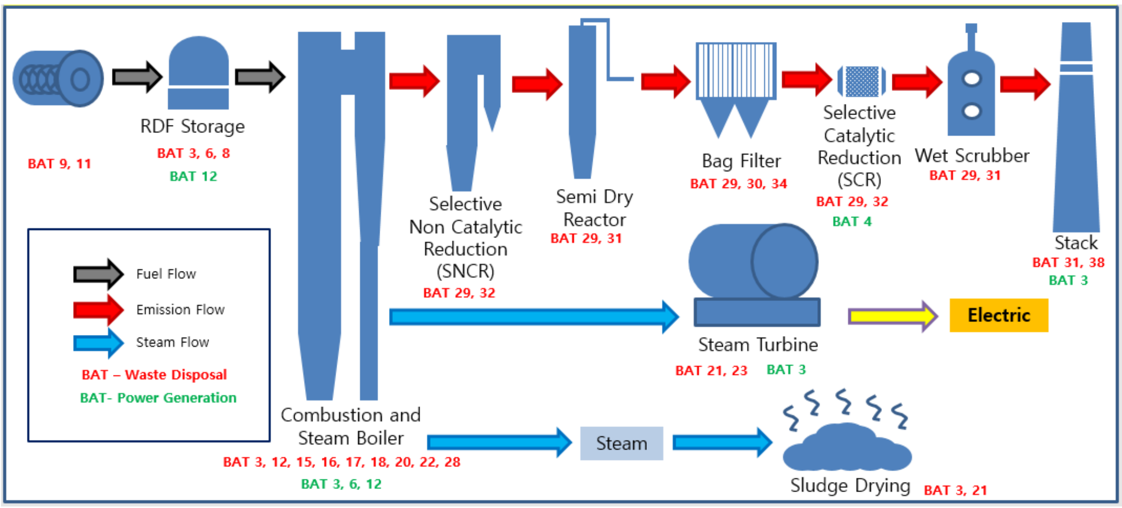
7.4.2. Waste incineration plant "T"

Waste incineration plant "T" is not yet operational, but has gotten its plan for operations approved and has been granted a permit. The plant will consist of one manufacturing facility for Refuse Derived Fuel with a capacity of 200 tonnes per day, one boiler with the same capacity, three drying facilities for organic sludge with a capacity of 100 tonnes per day, and one power generating facility with a capacity of 3.6 MW. The main pollutants from the plant will be SOx, NOx, CO, TSP, HCl, bottom ash, fly ash, dioxins and heavy metals.

As one of two Korean plants, the waste incineration plant "T" was granted an integrated environmental permit in 2018. The permit imposes emission limit values for air pollutants (including SO_X, NO_X and dust), water pollutants, odor, noise, vibration and dioxins. The permit includes a set of conditions requiring that the plant reduce the environmental impact of these pollutants through fuel management (e.g. lower level of chlorine, mercury and SO_X and designation of transport time), monitoring (e.g. dioxin once a month) and public engagement (e.g. a monthly town meeting).

There are 56 BAT in the Korean BREF on waste disposal. The operators of "T" will be adopting a total of 24 BAT from this BREF in addition to 7 BAT from the BREF on power generation (see Figure 7.2), primarily focusing on improving its Refuse Derived Fuel quality, notably in terms of moisture, low calorific power, ash, chlorine and sulphur. Further, "T" will increase its planned stack height from 30 to 70 meters and choose a location that is far from the road. The plant will address odor problems by using advanced biological treatment in addition to physical and chemical processing. To enhance it sludge storage, the plant will install double doors, an electric shutter, a local exhaust system and an air curtain.

Figure 7.2. BAT to be implemented by waste incineration plant "T"



According to the environmental management plan presented as part of the permit request of waste incineration plant "T", a 93% reduction of air pollutants and an 87% reduction of water pollutants is expected compared to the original plan for the plant. Because "T" currently is under construction and not yet in operation, results will not be observed until later.

7.5. Conclusion

The implementation of BAT and integrated environmental permitting is still at an early stage in Korea, with eight of 17 BREFs not yet being developed. It is therefore too early to conduct an ex post evaluation of the effectiveness of these instruments. MoE and the National Institute for Environmental Research have, however, already prepared systems for such evaluations at facility level, as well as anticipated five-yearly reviews of the BREFs. The Ministry has also conducted ex ante estimates of the emission reductions resulting from compliance with ELVs in the two plants for which permits have been issued so far, demonstrating a significant potential for decrease in emissions. With permits being issued to 1 340 plants by 2024, the impact on industrial emissions may therefore increase significantly over the next years and thus contribute to improving air and water quality.

Korean PRTR data, which exist for 415 substances, could be used to assess the impact of BAT-based integrated environmental permitting in the future. Korea also collects facility inventory data, self-monitoring data, and continuous emissions monitoring data for air and water pollutants; however, these data are not publicly available, but presented at aggregated level per geographic area. Facility level activity data are not publicly available either.

The National Institute for Environmental Research expect that new permitting and monitoring requirements will allow for enhanced data collection over time. Furthermore, the Institute points to the need to strengthen the capacity of competent authorities for integrated environmental permitting, and to increase the commitment of industry to the implementation of BAT.

Notes

[1] See http://ieps.nier.go.kr/web/board/5/?CERT_TYP=6&pMENUMST_ID=95&tab=seven.

[2] See http://ieps.nier.go.kr/web/main.

[3] Korean PRTR data are available at http://icis.me.go.kr/prtr/main.do.

Chapter 8. **Russian Federation**

In the Russian Federation, BAT-based integrated environmental permitting is currently under implementation, with 7 000 industrial installations having to apply for permits by the end of 2024. No comprehensive assessment of the BAT policy has yet been conducted. Some emissions monitoring data are currently made available online and in the governmental reports on the State of the Environment. However, the quality of such data will increase with the installation of continuous emissions monitoring in nearly 7 000 installations, starting from 2019. Implementation of BAT in the Russian Federation is facilitated by international co-operation as well as new governmental initiatives such as the Society of BAT Experts. According to the Russian BAT Bureau, measures that would have to be taken to strengthen the effects of the BAT policy include capacity building in permitting authorities, training of industry operators, agreeing on an adequate review cycle for BAT reference documents and identifying indicators for assessing the effects of BAT-based legislation and permitting.

8.1. BAT in the Russian Federation

8.1.1. BAT legislation and projects

In the Russian Federation, a BAT-based policy to prevent and control industrial emissions was introduced in 2014, determined by amendments to the Federal Law no. 219 on Environmental Protection (Government of the Russian Federation, 2014[91]) and related legislative acts, including the Federal Law no. 96 on the Protection of the Atmospheric Air (Government of the Russian Federation, 1999[92]) and the Federal Law no. 7 on Environmental Protection (Government of the Russian Federation, 2002[93]). The policy, which is considered a tool to enhance environmental protection as well as industrial development, entered into force in 2018. The Ministry for National Resources and Environment and the Ministry for Industry and Trade collaborate on the development and implementation of the BAT policy.

The Russian BAT-associated emission levels (BAT-AELs) form the basis for legally binding emission limit values (ELVs) in integrated environmental permits.[1] Information on techniques identified as BAT is presented in BAT reference documents (BREFs). The BREFs are published under the national standardisation system, described by the Federal Law no. 162 on Standardisation (Government of the Russian Federation, 2015[94]). The Ministry for Industry and Trade coordinates the development of BREFs through the Russian BAT Bureau, while the actual drawing up of each BREF is the responsibility of the TWGs. The Russian BAT Bureau has developed 39 sectorial BREFs, which contain requirements to BAT and BAT-AELs, in addition to horizontal BREFs. Prior to the development of the BREFs, a series of national standards on BAT was issued, providing the methodological background for the development and review of BREFs.

The Ministry for Natural Resources and Environment is currently finalizing (as of February 2019) a set of sector-oriented orders to officially approve these BAT-associated emission levels stipulated in the BREFs. The complete list of the 51 Russian BREFs issued in 2015-2017 is available in the OECD's report *Approaches to Establishing BAT Around the World* (2018[36]) and online[2].

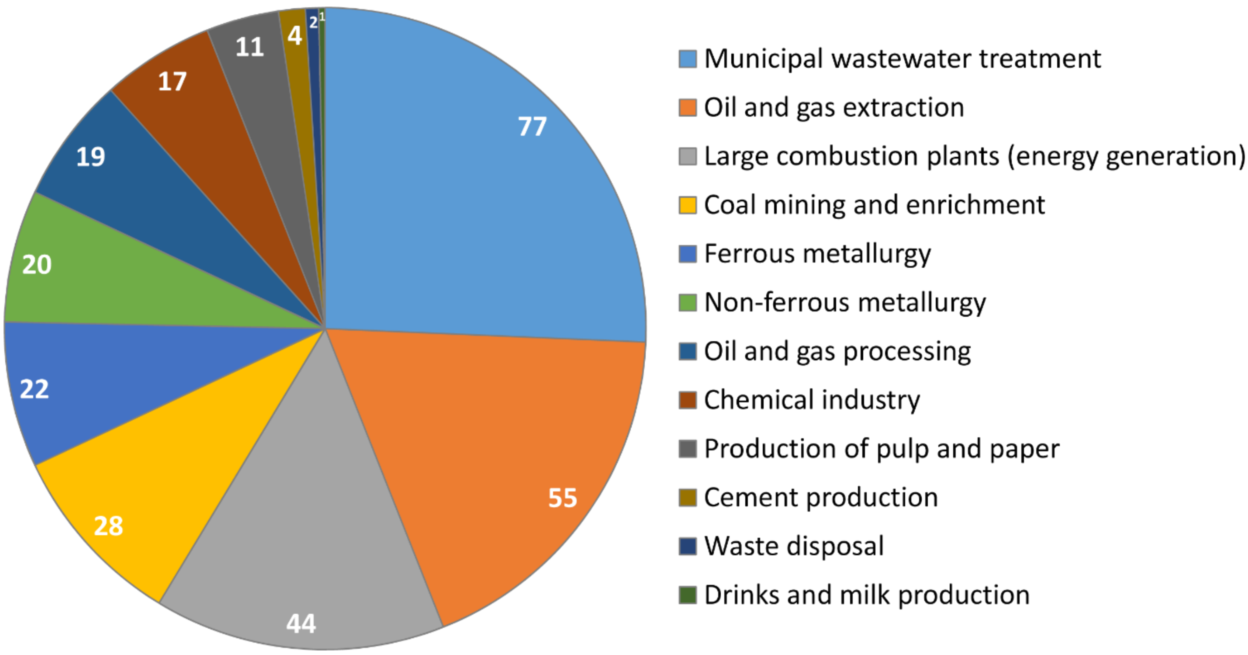
The Ministry for Industry and Trade is currently working on forming a society of BAT experts, consisting of experts that have have sector-related technological and environmental engineering experience. Members of the society will take part in the assessment of Environmental Performance Improvement Programmes (programmes to be drawn up by installations not fully compliant with BAT-AELs, see Section 8.1.2). The experts will represent all BAT sectors and most Russian regions.

To enhance work on BAT, the Government of the Russian Federation has established a federal project on BAT under the new national project called "Ecology" (or "Environment") (adopted in May 2018). The project introduces new political priorities, including for environmental safety, for the next six years. The national project currently consists of eleven federal projects, out of which one concerns BAT. The sub-programme sets out to ensure that all Category 1 installations apply for integrated environmental permits by 2024, and to support the development of the domestic environmental engineering sector, i.e. to equip industry operators with Russian-produced BAT and to make these techniques competitive with foreign techniques.

8.1.2. Integrated environmental permitting

A special order of the Ministry for Natural Resources and Environment (MoNRE, 2018[95]) was passed in 2018 to confirm that Russia's first integrated environmental permits will be issued to 300 installations considered *key polluters*, contributing 60% towards the total national industrial environmental emissions. These installations will have to submit their applications for permits over the period 2019-2022. The sectors with the highest number of key polluters include municipal wastewater treatment, oil and gas natural exploration and large combustion plants (Figure 8.1). The regions with the highest number of key polluters are the Urals, Siberia and the Volga regions (Table 8.1).

Figure 8.1. 300 key polluters in the Russian Federation, by industrial sector



Source: The Russian BAT Bureau

Table 8.1. The three hundred key polluters in the Russian Federation, by region

Region	Number of key polluters
Ural	75
Siberian	70
Volga	50
Central	38
Northwestern	38
Far Eastern	12
Southern	10
Total	293

Source: The Russian BAT Bureau

All other industrial installations classified in Category 1 (similar to IPPC installations in the EU and defined by the Government of the Russian Federation (2015[96])), of which there are close to 7 000, will have to apply for integrated environmental permits by the end of 2024. The permits will be granted by the regional offices of The Federal Supervisory Natural Resources Management Service, underlying the Ministry for Natural Resources and Environment. While ELVs in permits are based on BAT-AELs, more stringent ELVs than the lower range values of BAT-AEL can be set for certain installations as per local environmental concerns. It is not yet decided if information on the content of, and applications for, permits will be made publicly available.

Installations that do not comply with BAT-AELs shall develop Environmental Performance Improvement Programmes (EPIP) to make sure that compliance is reached within maximum seven years. It is expected that about 150 installations of the 300 key polluters, and at least 1 000 of all the 7 000 Category 1 installations, will need to develop such programmes. The BAT Bureau will review the EPIPs, with the help of the society of BAT experts.

In order to raise awareness and build capacity on integrated environmental permitting and the EPIPs, the BAT Bureau has organised 18 ‘business games’ for various industrial sectors and regional permitting authorities, providing training on how to assess industries’ environmental performance, approve EPIPs, issue permits, and reach consensus amongst different stakeholders. The business games allow key stakeholders to review procedures of EPIP approval and permit issuance, identify their weaknesses and address these by seeking to improve the 27 legal acts developed under the Federal Law No. 219 on amending the Federal Law on environmental protection (Government of the Russian Federation, 2014[91]) as well as acts and orders prepared by the Ministry for Industry and Trade. Together, these acts and orders provide guidance to industry on how to implement BAT and operate with permits.

Over the period 2019-2024, a set of incentives for industries implementing BAT will be developed by the Ministry for Industry and Trade. It is expected that these incentives will help industries reduce taxes and get favourable loan conditions while installing new equipment for improved environmental performance and energy efficiency.

8.1.3. International co-operation

The Russian Federation is involved in a number of international BAT projects, notably in collaboration with EU countries. Examples include the large-scale project “Harmonisation of environmental standards” implemented over the period 2004-2009, which resulted in studies of the possible reduction of environmental impacts due to implementation of BAT in the Russian Federation, and the ongoing project “Climate friendly economic activities: implementing BAT in Russia”. Both projects were coordinated by the German development agency GIZ. There have also been Swedish-Russian projects, focused on the pulp and paper sector, and British-Russian projects in the ceramic industry sector, which were implemented at the beginning of the 2000s.

Furthermore, there is the project entitled “Strengthening of the UNECE’s Air Convention through integrated permits in Russia”, which is financed by the German Ministry for Environment, Nature Conservation and Nuclear Safety, and supervised by the German Environment Agency. As part of this project, experts provide advice on the management of selected Russian Large Combustion Plants and prepare recommendations on the (further) development of the procedure for granting of integrated environmental permits in the Russian Federation.

The UK has also been supporting BAT-related projects in the Russian Federation, with the requirement that the projects are aimed at improving the energy efficiency of industrial production. Over the period 2001-2012, such projects were implemented in sectors such as glass, ceramics, large combustion plants, etc. as part of these projects, several EU BREFs and UK Practical Guides were translated into Russian and discussed with industry and regulators. More recent projects which are supported by the UK focus on the food and drinks sector, chemical industry and metallurgy.

The Barents Environmental Hot Spot project of the Barents Euro-Arctic Council plays a significant role for the implementation of BAT in the Russian Barents region, including in Murmansk and Arkhangelsk regions, Republics of Komi and Karelia, and Nenets Autonomous Okrug. In 2003, 42 environmental Hot Spots, i.e. highly polluting industrial facilities, in this region were identified in collaboration with environmental authorities from Sweden, Finland and Norway along with the Nordic Environment Finance Corporation. The Hot Spots include, inter alia, facilities for pulp and paper, energy generation and municipal wastewater treatment. The Ministers of Environment of the four countries have committed to investing in measures to reduce industrial emissions from these facilities, in order to eventually eliminate them from the hot spots list. In 2018, the list was down to 33 whole and three half facilities. The progress of each of these can be consulted in the Barents Environmental Hot Spots Information System[3]. Progress is measured based on a traffic light system, where a green light reflects the ultimate step and thus exclusion from the Hot Spots list. Within the framework of the collaboration, BAT-related supporting activities are implemented in the Barents region by the European experts and the Russian BAT Bureau.

8.2. Policy evaluation

8.2.1. Governmental evaluation projects

As the Russian BAT policy entered into force in 2018 and the first integrated environmental permits will be issued starting from 2019, the Russian Government has not yet conducted an assessment of its effectiveness. However, since the 1990s, the Russian government annually issues a State Report on the State of the Environment, assessing the effectiveness of environmental policy and emission standards. Reports issued at the federal and regional levels assume that if emissions decrease and air and water quality improve, the policy measures currently in place are effective. Some of these reports contain emissions data that could be relevant for the evaluation of the effectiveness of the BAT policy (see Section 8.3.1 on emissions monitoring data). One of the recent assessments was made in 2016 and covered a time span of approximately 20 years. The results of this assessment can be found in the Report on the Environmental Development of the Russian Federation in the Interests of the Future Generations (Government of the Russian Federation, 2016[97]).

Assessment studies have been carried out for certain industrial sectors, such as by the aluminium company Rusal, which is the country's only company in the aluminium production sector. The company continually runs internal assessments as well as develops and implements Environmental Management Programmes. These programmes form a good basis for the Environmental Performance Improvement Programmes that installations will have to develop if they do not reach compliance with BAT-AELs once integrated environmental permitting is rolled out. Further, although there so far is no practical experience in granting integrated environmental permits in Russia, Rusal has conducted a comparative study of the environmental performance of each of its eight facilities. In addition, the company has prepared a company-wide study assessing whether the recently published BAT-AELs for the aluminium sector can be achieved, or not, for each of its facilities, determining environmental objective priorities. An associated training for Rusal's environmental managers and engineers was organised in March 2018, conducted by the Russian BAT Bureau and aluminium BAT experts, as the first corporate BAT-related training in Russia. This training was followed by a number of sector events in the exploration of hydrocarbons, oil and gas refining, energy generation, etc.

8.2.2. Stakeholder opinions

Considering that the first integrated environmental permits are issued in 2019, the Russian BAT Bureau and the Russian UNIDO Office believe it would be premature to assess the effectiveness of the BAT policy at this stage. However, they state that based on the evaluation of pilot projects and the adoption of draft legislative acts, there is a general expectation among many stakeholders that the BAT policy will foster 'environmental modernisation' of industry, improve resource and energy efficiency, and thereby reduce pollution. According to the BAT Bureau, the international BAT projects implemented in the Russian Federation with the support of EU countries, such as Germany, and the collaboration with Nordic countries through the Barents Environmental Hot Spots work, have also created positive expectations to the Russian BAT policy (see Section 8.1.3). Recent and upcoming BAT initiatives, such as the establishment of the society of BAT experts, the granting of permit authority to the regional units of the Federal Supervisory Natural Resources Management Service, and the integration of BAT work in the national project "Ecology" (or "Environment"), are also likely to have a positive influence on the outcome of the BAT policy.

Further, the Russian BAT Bureau expects that the use of BAT and integrated environmental permits will help to focus on larger polluters and to set more substantiated and stringent requirements, and that the BAT policy provides a more transparent procedure for permitting, motivating companies to better assess their own performance. The BAT Bureau also believes that the forming of the society of BAT experts will spur greater effectiveness of the BAT policy.

The BAT Bureau also points to the following challenges associated with the BAT policy:

i. identifying indicators and approaches for assessing the effects of BAT-based legislation and permitting;

ii. agreeing on an environmentally sound and economically feasible rationale for the revision of the first set of BREFs and BAT-AELs;

iii. developing BAT Conclusions similar to those in the EU, both as chapters in the BREFs and later as separate documents;

iv. supporting Category 1 installations seeking advice on developing Environmental Performance Improvement Programmes and Continuous Self-Monitoring Programmes;

v. providing adequate training to the staff of Category 1 installations, representatives of environmental authorities, universities, research bodies and consulting companies;

vi. ensuring that the competent authorities have the capacity to address permit applications from all 7000 Category 1 installations; and

vii. further developing best practice-based legislation, such as general binding rules for Category II installations and BAT and Best Environmental Practices (for example, for the environmental Hot Spots of the Barents region).

The Russian UNIDO office stresses that the effectiveness of the BAT policy depends on the quality of the 27 legal acts developed under the Federal Law No. 219 on amending the Federal Law on environmental protection (Government of the Russian Federation, 2014[91]), their interlinked impacts and their convergence with other regulations, strategic planning and environmental safety. The Russian UNIDO Office notes that the Russian Ministry for Natural Resources and Environment jointly with the Russian BAT Bureau runs a number of workshops, seminars and business games to facilitate the transition to a BAT-era for industry, and especially for Category 1 installations. As a result, industry is being equipped with adequate tools and algorithms, which partially eliminate existing methodological gaps as regards how to achieve compliance with BAT-AELs and permit conditions. Yet, removing all existing gaps is a long-term process and UNIDO Russia believes that engagement with companies on BAT-issues should be continued. Furthermore, the UNIDO office reports that a significant impact of the BAT policy can be expected following the implementation of the national project “Ecology”, which was launched in 2019 to attain national priorities, including those related to the development of a domestic environmental engineering sector based on BAT.

Moreover, UNIDO Russia states that many industry operators express concerns about the hotly debated introduction of a new environment-related tax, that may replace the existing environmental payments system and which would increase the tax burden on the private sector. Yet, Russian business associations express their confidence in the absolute need to preserve the current level of environmental taxes in order to ensure a stable and successful transition to BAT. UNIDO Russia points out that the adequate development of the tax and payment systems, together with compliance with the Sustainable Development Goals and improvement of industry’s environmental performance over time should play a key role in the implementation of BAT.

The Russian UNIDO Office recommends that an effectiveness evaluation of the Russian BAT policy could be conducted once permits have been issued to most of the Category 1 and new installations (i.e. after 2022), and that a multitude of stakeholders should be involved in this exercise, notably leading Russian energy companies which are amongst the 300 key polluters, the Russian Union for Industrialists and Entrepreneurs, WWF Russia’s Green Economy department, the Lomonosov Moscow State University and the Russian Higher School of Economics, as well as Global Compact Russia and others. Including a broad specter of stakeholders is likely to help creating synergies and connections between the BAT policy and other policy areas.

8.3. Available sources of data

8.3.1. Emissions monitoring data

The Russian Federation does not have a PRTR. However, Category 1 installations are mandated to start developing continuous (i.e. automatic and real-time) self-monitoring systems once they receive their permits, in addition to demonstrating their compliance with BAT-AELs or developing Environmental Performance Improvement Programmes. The installations will be given a four years’ period for implementation, i.e. to install equipment and start continuous measurements. The parameters to be monitored include emissions of stack gases such as dust, SO_X, NO_X, CO (for combustion and other processes), HF, HCl,

H_2S and ammonia above given thresholds, in addition to wastewater discharges, including flow, temperature, pH and BOD/COD. These requirements are to a large extent based on experience with emissions monitoring from Germany and other EU countries.

Category 1 installations already have self-monitoring systems in place, albeit not for continuous monitoring, and submit data on emissions and on the state of the environment to the environmental and statistical authorities. The data are made publicly available in the state statistical reports, and, in some cases, in the regional reports on the state of environment. Data provided by environmental authorities and the Russian Statistics Service have official status. Some types of data are mandatory for the industry to report, including data on emissions to air (in loads, not concentrations). There are no thresholds for reporting of such data. At the national level these data are aggregated, but at the regional level the reported data are supposed to be more detailed. Managers of all larger installations falling into Categories I and II, according to the new legislation, submit statistical forms including lists of pollutants being emitted in the environment. Regional offices of Rosprirodnadzor (The Regulation on the Federal Supervisory Natural Resources Management Service[4]) analyse these data in detail for enforcement purposes.

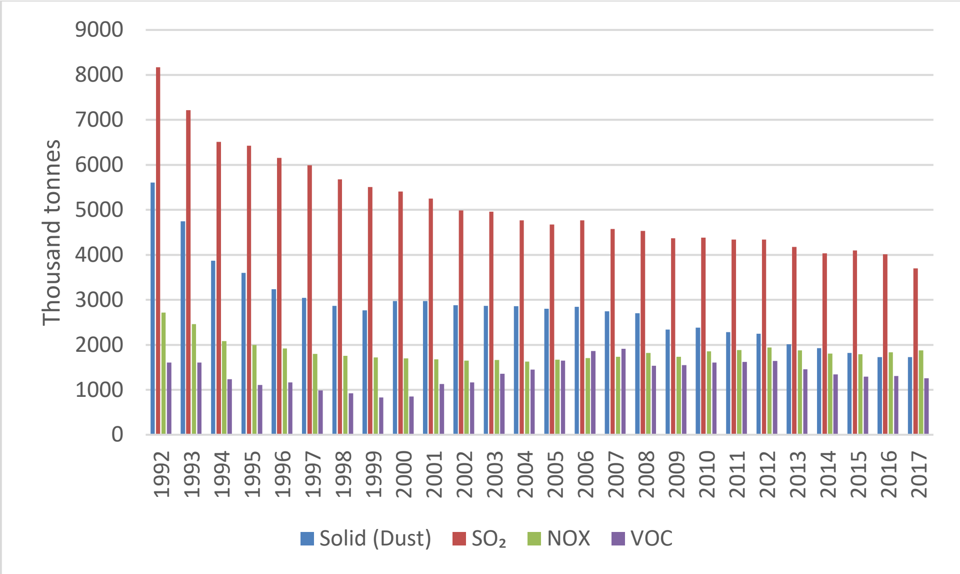
In addition to the mandatory reporting data, there are some types of data that companies can choose to report voluntarily. This includes e.g. plant and process descriptions, risk analysis in sustainability reports, interim results, monthly returns, etc.

Data reported by industries are sometimes collected and presented in accordance with the Global Reporting Initiative requirements and audited. Companies are free to follow the Initiative's standards, or any other recommendations, including internal ones. Some data on emissions can be accessed online through the website of the Russian Statistics Service[5].

Aggregated emissions data at the sector level at regional or national level are also presented in some of the State Reports on the State of Environment (Government of Russian Federation, 2018[98]). In addition, there are Regional Reports on the State of Environment, which sometimes contain data on emissions. For example, there is one that contains data on emissions of aluminium production facilities located in the Krasnoyarsk region (MoNRE of the Krasnoyarsk Region, 2016[99]).

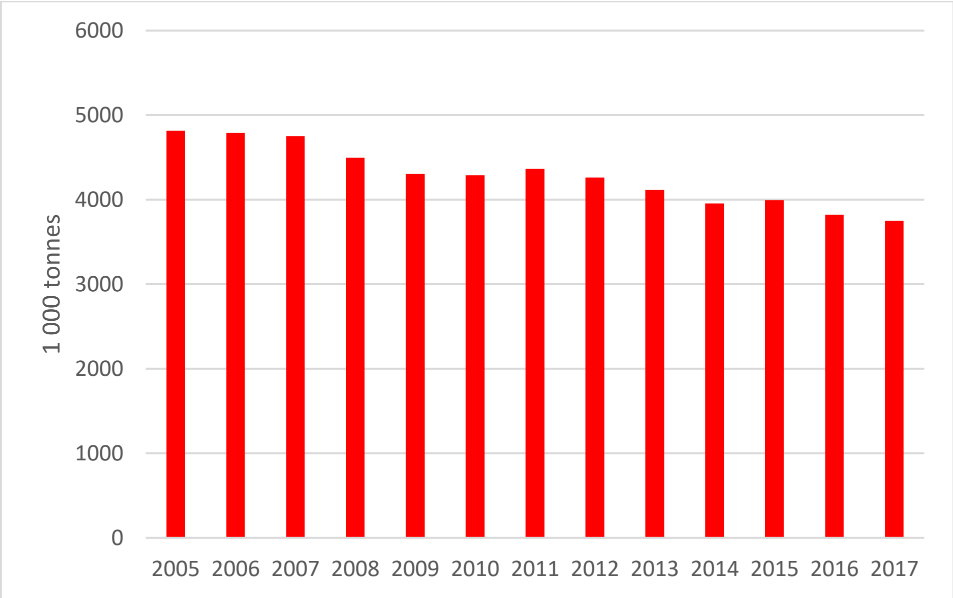
Data on air emissions from stationary sources, in total and categorised by economic activity, are made publicly available. Figure 8.2 presents available data on emissions on major air pollutants (dust, SO_2, NOx and VOCs) from all stationary sources. Figure 8.3 displays total reported emissions to the atmosphere of substances departing from stationary sources of the metallurgical production and manufacture of fabricated metal products. Based on the reporting requirements, we can assume that these emissions contain dust, black carbon, fluoride, SO2, NOx, CO, VOCs and hydrocarbons.

Figure 8.2. Emissions to the atmosphere of substances departing from stationary sources in the Russian Federation



Source: Developed by the authors based on data from the Russian BAT Bureau

Figure 8.3. Total air emissions reported by stationary sources of metallurgical production and manufacture of fabricated metal products (in thousand tonnes) in the Russian Federation



Source: (Rosstat, n.d.[100])

8.3.2. Activity data and other metrics

Activity data (yearly production rates for the years 2010-2016) are available from the Russian Statistics Service[6] for 15 different sectors and/or activities. For example, production data from basic fabricated metal products are available (see Table 8.2) in addition to data on the annual changes (2014-2016) in production in the aluminium sector compared to the previous year (in percentage), as presented in Table 8.3. Activity data for the aluminium sector are not available in absolute values in the ROSSTAT database. However, activity data are published by (Rusal, 2017[101]), which is the only aluminium company in the Russian Federation, consisting of eight plants.

Table 8.2. Manufacture of basic fabricated metal products (million tonnes)

	2010	2011	2012	2013	2014	2015	2016
Cast iron	48,0	48,0	50,5	49,9	51,5	52,4	51,9
Steel	66,8	68,1	70,4	68,9	70,5	69,4	69,8
Ferrous metal rolled products	55,0	56,5	60,0	59,2	61,2	60,4	60,5
Steel tubes	9,2	10,0	9,7	10,1	11,3	11,4	10,4

Table 8.3. Annual changes in total aluminium production in the Russian Federation in relation to the previous year

Year	Change in production compared to previous year
2014	4,6%
2015	1.4%
2016	-3.2%

8.4. Conclusion

All 7 000 Category 1 installations in the Russian Federation will have to apply for BAT-based integrated environmental permits by the end of 2024. Once they receive their permits, they will have maximum four years to install continuous self-monitoring equipment and up to seven years to implement their EPIPs. No comprehensive assessment of the effectiveness of the BAT policy has yet been conducted. The Russian Federation does not have a PRTR. The Russian emissions monitoring data, as presented in this chapter, are at aggregated levels and cannot be used for a quantitative analysis of the effectiveness of the BAT policy, as this requires emissions data reported at facility or installation level and corresponding activity data expressed in physical units (e.g. tonnes of production). Aggregated emissions reported at sector level are not useful for such an analysis as sectors are internally too heterogeneous.

International co-operation with EU countries helps facilitate the implementation of the Russian BAT policy, and has also created positive expectations to its outcome. The Russian BAT Bureau believes, however, that policy's successful implementation would depend on capacity building in permitting authorities, and training of industry operators to help them install continuous emissions monitoring and develop Environmental Performance Improvement Programmes. Furthermore, the Bureau believes it would be important to identify indicators and approaches for assessing the effects of BAT-based legislation and permitting, develop best practice-based legislation for Category II industries, and agree on a reasonable review cycle for BREFs.

Notes

[1] Starting from the 1980s, i.e. prior to turning to a BAT-oriented legislation, single-medium ELVs were set for all industrial installations in the Russian Federation. These ELVs were calculated based on the assumption that concentrations of pollutants at the boundaries of so called sanitary zones (in principle, in the nearest settling area; e.g. a zone of 1 000 meters in diameter for aluminium production) resulting from their dispersion should not exceed Maximum Permissible Concentrations of these pollutants, i.e. immission concentrations (MoJ, 2008[130]). In general, the Maximum Permissible Concentrations would apply country wide, while there might be regional variations. Gathering data on immission concentrations is difficult because of e.g. influence from other industries and transport as well as sensitivity issues, especially for existing plants.

[2] See www.burondt.ru/index/its-ndt.html.

[3] See https://www.barentsinfo.fi/hotspots/.

[4] See http://www.mnr.gov.ru/en/fsnrms.php.

[5] See http://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/environment/.

[6] See http://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/enterprise/industrial/.

Chapter 9. **India**

The Indian policy to control and prevent industrial pollution establishes national emission standards and guidance for a wide range of industrial sectors. This chapter includes three case studies, illustrating the effects of government policies to enhance effluent treatment through co-operative plants, to phase out mercury in the chlor-alkali industry based on a voluntary approach, and to reduce pollution from thermal power plants with stricter emission standards. India is currently implementing a comprehensive continuous emissions monitoring system for 17 highly polluting industries, which will help strengthen environmental performance. One stakeholder highlights that the effectiveness of India's current policy framework for industrial pollution prevention and control could be improved through strengthened enforcement and coordination across ministries, regular audits, increased involvement of the public and enhanced financial capacity for knowledge-sharing on techniques, such as through demonstrations.

9.1. BAT and environmental permitting in India

India's policy framework for preventing and controlling the emission of industrial pollutants is based on legally binding emission standards or discharge limit values specific to each industrial sector, such as the Minimal National Standards (MINAS), which are developed under the Pollution Control Law Series (CPCB, 2010[102]). The MINAS are not based on BAT. However, techniques for prevention and control of industrial emissions - sometimes termed Best Techno-Economically Available Techniques- are considered as part of the development of the MINAS, and sometimes presented in the accompanying Comprehensive Industry Documents Series (COINDS), which forms a set of sector-specific guidelines. The complete list of Indian MINAS and COINDS is available the OECD's report *Approaches to Establishing BAT Around the World* (OECD, 2018[36]) and online[1].

Under the Pollution Control Law Series, there is a requirement to obtain *consent* in order to run or establish any industrial operation or system for treatment or disposal that discharges effluent or emits pollutants into air, water or land. Additionally, operators of certain industries are required to seek *environmental clearance* under the Environmental Impact Assessment Notification (adopted in 2006). However, the development of a unified consent mechanism and compliance system is still in progress.

9.2. Policy evaluation

9.2.1. Governmental evaluation projects

The Ministry of Environment, Forests and Climate Change, the Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCBs), along with other agencies and in collaboration with leading technical institutions, carry out assessment of various environmental programmes from time to time, so as to develop and revise policies, guidelines and standards, such as the MINAS and the COINDS. These assessments may be based on peer reviews.

9.2.2. Stakeholder opinions

The Ministry of Environment, Forests and Climate Change

According to experts from the Ministry of Environment, Forests and Climate Change the Indian policy framework to prevent and control industrial pollution is effective, and impacts the environment, industries and human health in a positive way. Legislation, rules, regulations and standards have been adopted for many industrial sectors. One of the attributes of the current policy framework is that it is generic and spans across all sectors, although there is a difference in applicability and feasibility depending on the type of installation (e.g. large and medium scale versus small scale enterprises).

The experts from Ministry indicate that other policy instruments contribute to strengthening the impact of the emission standards, such as tax exemptions (e.g. custom duty exemption for pollution control equipment) and pollution control awards to industries that adopt good environmental practices. Eco-labelling has not yet been implemented in India.

Finally, the experts note that there is room for improvement of the current policy framework for industrial pollution prevention and control, and that different stakeholders have different perceptions of its effectiveness.

Other stakeholders

An expert from the Innovation Centre Denmark in Delhi points out that a weakness of the current policy framework for prevention and control of industrial pollution is that old technology still is used and implemented, e.g. because of counter-productive subsidies and revenues. According to this expert, the effectiveness of the policy could be improved by updating it, e.g. by paying more attention to green chemistry, strengthening enforcement, setting stricter standards for specific pollutants, respecting strict timelines, conducting regular audits, enhancing monitoring and involving the public as a stakeholder. A bottleneck to the implementation of pollution prevention and control techniques is the lack of financial capacity to share knowledge about the purpose and appropriate use of techniques, e.g. through demonstrations. Better coordination amongst the different ministries and sector organisations could also improve the impact of current policy.

9.3. Available sources of data

9.3.1. Emissions monitoring data at installation level

Continuous emissions monitoring system

India does not have a PRTR. However, with rapid industrialisation and minimal inspections of industrial facilities, the Indian Central Pollution Control Board (CPCB) decided to establish a Continuous Emission Monitoring System (CEMS) for real-time emissions monitoring and reporting. The CEMS is aimed at providing accurate and continuous information on particulate matter and gaseous emissions from industrials stacks, and to indicate whether facilities comply with legal emission standards or not. CEMS have multiple benefits, including fast response time, reasonable costs, process control and the fact that no sample conditioning is required. Further, with all industrial facilities submitting *real-time* data, one avoids the complexity of different technologies and data formats, facilitating the consolidation of data.

The Indian CEMS was adopted in 2014, and is currently under implementation. CEMS data are not yet publicly available. CEMS is required by all facilities that have been given consent to operate within 17 highly polluting industries/activities, including more than 20 000 installations. These industries and activities include pulp and paper, distillery, sugar, tanneries, power plants, iron and steel, cement, oil refineries, fertilizer, chloral alkali plants, dye and dye intermediate units, pesticides, zinc, copper, aluminium, petrochemicals and pharmaceuticals, in addition to common effluent treatment plants (CETP), sewage treatment plants, common bio medical waste and common hazardous waste incinerators (CPCB, 2017[103]). Other industries are encouraged to consider installation of CEMS as a tool of self-regulation. Grossly polluting industries, i.e. those generating 100 kg or more biochemical oxygen demand (BOD) per day and discharging into River Ganga, have also been mandated to install Continuous Effluent Quality Monitoring Systems.

The responsibility of data submission for CEMS lies with the individual industrial units, which will have to install the necessary equipment to determine the concentration of gaseous emissions and particulate matter, or emission rates using analytical measurements, as well as a computer programme to provide results in units of the applicable emission limits or standards. The data generated will be gathered either through analogue outputs to a recording system or sent directly to a Data Acquisition System for storage and onward transmission. Industrial facilities will have to submit details of the CEMS installed and operationalised as per CPCB’s Compliance Reporting Protocol for OCEMS (*online* CEMS).

Vendors and instrument suppliers will regularly cross check the data obtained from CEMS with that of samples collected manually, conduct analyses using approved laboratory techniques and revalidate the calibration factors essential for generating better quality data. Industrial facilities shall ensure that the monitoring systems are covered by a maintenance contract with the vendors as well as carry out the performance audit of OCEMS for routine calibration and OCEMS data verification. Further, industries will have to inform the CPCB, SPCBs and Pollution Control Committees of the date and time of visits of the laboratory engaged for the calibration, data verification, performance audit and other activities, through an online system. CPCB empanelled laboratories shall only be engaged as Third Party agency for all activities related to assessment of installation, calibration of CEMS, validation of data, etc.

The CPCB will ensure that the analysis procedures used are up to par with international standards, such as the performance specification of the United States Environmental Protection Agency or the quality assurance levels of the European Commission. Performance characteristics for the CEMS have been set following a field testing procedure assessing the performance of plant operators, vendors and testing laboratories.

The CPCB and the respective SPCBs will be receiving the real-time emissions monitoring data at the control room situated in their premises. SPCBs and PCCs will be in charge of conducting plausibility controls of the data received, and for verification, validation, accuracy and interpretation of the values indicated by the online devices as well as for interpolation of data on periodic basis.

If the concentration of pollutants from an industrial facility exceeds the relevant discharge/emission limit, the industry operator will receive an SMS alert from the CPCB/SPCBs. If the number of SMS's exceeds a given threshold, CPCB and SPCB will pay a visit to the concerned industrial facility for inspection of functions of emission control equipment and treatment facilities.

Comprehensive Environmental Pollution Index

CPCB launched the Comprehensive Environmental Pollution Index (CEPI) in 2009. The index, which was revised in 2016, is based on a nation-wide environmental assessment of industrial clusters, based on recorded emissions monitoring data, gathered from other monitoring mechanisms than CEMS. Three rounds of monitoring have been undertaken so far (in 2009, 2011 and 2013). CEPI assigns a number between 0 and 100 to all industrial clusters, characterising the environmental quality of their operations, i.e. their impact on air, water, land, health and ecology, and color-code them based on their score: red for facilities scoring between 60 and 100; orange for those scoring between 30 and 59; green for those scoring between 21 and 40; and white for those scoring under 21 (ENVIS, 2016[104]). CEPI is also aimed at assessing the progress achieved in the implementation of the action plans of each CEPI area. These action plans are monitored by the SPCBs and envisage road maps for improving the environmental status of industrial clusters by lowering their CEPI score. The plans take into account local factors affecting the industrial clusters and their environmental performance. If there are violations of the action plans, legal and penal action are taken.

Using CEPI, CPCB assessed the pollution levels in 88 industrial clusters and identified 43 critically polluted areas in 2010. These areas were banned for new industrial set-up or expansion until the respective SPCBs prepare a mitigation action plan for improvement of the environmental quality.

9.3.2. Activity data and other metrics

Under CEMS, there is an intention to make activity data available for all the 17 categories of polluting industries.

In addition to CEMS and CEPI, India has a National Air Quality Monitoring Programme and a National Water Monitoring Programme, which monitor ambient air and water quality at monitoring stations across the country.

Furthermore, the Ministry of Environment, Forest and Climate Change has recently published the National Clean Air Programme (NCAP) with the goal to meet the prescribed annual average ambient air quality standards at all locations in the country in a stipulated timeframe. The objective is to augment and evolve an effective and proficient ambient air quality monitoring network across the country in order to ensure a comprehensive and reliable database, efficient data dissemination and a public outreach mechanism for timely measures for prevention and mitigation of air pollution. In addition, the programme seeks to facilitate inclusive public participation at the planning and implementation stages of the government’s air pollution policies, and to develop feasible management plans for prevention, control and abatement of air pollution.

9.4. Case studies

9.4.1. The effects of new emission standards for thermal power plants

India's electricity sector is dominated by fossil fuels, and in particular coal, which in 2017-18 produced about two thirds of all electricity. Thermal power plants account for 64.8% of the country’s total production capacity (Kamyotra, 2018[105]). Air pollution from such plants is a major challenge, notably due to the high ash content in India's coal as well as its high silica and alumina content, which increases ash resistivity and thus reduces the ash collection efficiency of electrostatic precipitators (ESP). With coal-based capacity projected to increase to 250 GW in the next three-five years (from the current 186 GW), the impact on air quality and health would be seriously damaging unless stringent controls are put in place (Kamyotra, 2018[105]).

In order to address the pollution problem from thermal power plants, the central government has firmed up plans to shut down 11 000 MW of coal-based power generation capacity that are at least 25 years old and contributing a major share of pollution. In addition, the Ministry of Environment, Forest and Climate Change has mandated the use of beneficiated coal which ash content has been reduced to 34% (or lower) in all stand-alone power plants and captive thermal power plants that have an installed capacity of 100 MW or above and that are located 500 kilometres or more from pit head power plants or located in ecologically sensitive and other critically polluted areas (Kamyotra, 2018[105]).

In addition, the Ministry introduced new national standards for emissions of SO_2, NO_X, mercury and particulate matters from thermal power plants in 2015, representing the first revision of norms for this sector in close to two decades. Standards for for SO_2, NO_X and mercury emissions were introduced for the first time for thermal power plants. The emission standards were set for three different categories of installations, based on their year of installation (see Table 9.1). Other factors were also taken into account when determining the standards, such as potential for upgradation and retrofitting, existing regulations and environmental clearances (e.g. that these clearances after 2003 required large units to leave sufficient space to install pollution control equipment) (Kamyotra, 2018[105]).

Table 9.1. Indian emission standards for thermal power plants

	PM	SO_2	NO_x	Mercury
Original standard	150-350	None	None	None
New standards				
Units installed before 2004*	100	< 500 MW: 600>= 500 MW: 200	600	>= 500 MW: 0.03
Units installed between 2004–16*	50	< 500 MW: 600 >= 500 MW: 200	300	0.03
Units installed after December 2016	30	100	100	0.03

Note: (Kamyotra, 2018[105])

Over the next decade, the new standards are expected to cut total emissions loads from thermal power plants across the country by 65% for particulate matter, 85% for SO_2 and 70% for NO_X. This will in turn help bring about an improvement inambient air quality in and around thermal power plants. The technologies employed for the control of the proposed limit of SO_2 and NO_X will also help controlling mercury emissions (at a projected level of 70-90%) as a co-benefit. Limiting the use of water in thermal power plants, which is stated as a specific, separate requirement in the new notification, is projected to lead to water conservation of about 1.5 m^3/MWh, as thermal power plant is a water-intensive industry. This will also lead to a reduction in energy requirement for drawl of water (Kamyotra, 2018[105]).

There are a number of challenges related to reaching compliance with the new emission standards and the originally planned implementation period has been revised considering various bottlenecks such as space constraints and increase in power costs. Key challenges relate to the techniques that will have to be installed by the power plants, notably ESPs for control of suspended particulate matter emissions. Many plants have already installed ESPs, as they were designed to meet the new PM standards and may just need to undergo refurbishment or basic upgradation. However, older units may have been designed to meet lower standards or performance of their ESPs may have significantly deteriorated; these will have to consider major overhauls, e.g. by incorporating bag filters or increasing fields in existing ESPs (Kamyotra, 2018[105]).

Other control equipment is required to reduce SO_X and NO_X emissions, posing additional challenges to industry operators. Since regulations previously did not require SO_2 and NO_X abatement, very few plants have installed pollution control technology such as flue gas desulphurisation or selective catalytic reduction units to cut SO_X and NO_X emissions. Industry executives and regulators have limited knowledge about these technologies or experience of their operations. Moreover, in case of future coal based power plants, impetus should be on adoption of Super Critical & Circulating Fluidised Bed Combustion technology for achieving better combustion efficiency and reduced emissions (Kamyotra, 2018[105]).

It is estimated that operating coal fired power plants will need to invest between INR 5.0 and 12.5 million per MW capacity for installing pollution control equipment to comply with the new emission standards (Kamyotra, 2018[105]).

9.4.2. Reduction of mercury consumption in the Chlor-Alkali industry

India has been successful in significantly reducing mercury consumption based on a *voluntary approach*. The Ministry of Environment, Forest and Climate Change launched the Charter on Corporate Responsibility for Environmental Protection (CREP) (2003[106]) with the purpose of going beyond compliance with regulatory norms for prevention and control of pollution through various measures including waste minimisation, in-plant process control and adoption of clean technologies. CREP is not legally binding, but a voluntary, mutual agreement between regulatory bodies and industrial associations, incorporating voluntary initiatives by 17 identified categories of highly polluting industries (see Section 9.3.1), including the chlor-alkali sector, to ensure full compliance with pollution control norms. The voluntary approach was chosen because industry had shown reluctance to accept new legally binding command and control instruments.

The Charter is a a road map for progressive improvement of environmental management systems and has defined targets for the conservation of water and energy, recovery of chemicals, reduction in pollution, elimination of toxic pollutants, processing and management of residues that are required to be disposed of in an environmentally sound manner. The Charter listed action points for pollution control for various categories of highly polluting industries. An industry-specific task force has been constituted to monitor the progress of the implementation of the action points.

The measures to be taken by industry under CREP include modernisation and technological upgrade of production processes, transition to new technologies, waste minimisation through reduction in resource use as well as recycling of waste. Other steps include the installation of pollution control and monitoring equipment, improving housekeeping practices and furnishing bank guarantees by the defaulting industries until compliance is ensured.

As a result of the implementation of the Charter in the chlor-alkali sector in India, the consumption of mercury fell from 55.25 to 4.53 metric tonnes per annum over the last ten years. With a voluntary approach, India brought down the consumption of mercury by around 90% by 2012, demonstrating a successful public-private partnership.

9.4.3. Common Effluent Treatment Plants

Under the Indian Water Act (adopted in 1974), all industrial facilities have to ensure adequate treatment of its effluents before disposal. The effluent can be treated individually by each facility or jointly. While large scale industries are rich in financial, technical and human resources, lack of finances, manpower and technologies can often be a bottleneck for effluent treatment in small scale industrial units. Therefore, the Ministry of Environment, Forest and Climate Change implemented a scheme for Common Effluent Treatment Plants (CETPs) in 1991, to assist small scale industry in treating their effluent in a more techno-economic manner which ensures adequate environmental protection.

The CETP scheme sets out to reduce costs for individual small scale industrial units by treating effluent in cooperative wastewater installations. Joint CETPs for clusters of compatible small scale industrial units, or industrial estates, are to be set up and managed by the State Industrial Infrastructure Corporation or through an appropriate institution including a cooperative body of the concerned units, as may be decided by the State Governments and SPCBs concerned. Financial assistance is available from the central governments as well as from state governments, which will match industry operators' investment in the construction of CETP.

The CETP scheme seeks to reduce wastewater treatment and treatment costs, strengthen water conservation, share treatment technology costs, and protect the water environment to a maximum. In addition to ensuring savings for small scale industry, the scheme makes it easier for CPCB to monitor compliance with prescribed effluent standards.

The criteria for a CETP set up under the scheme include:

i. The CETP should have a conveyance system from the individual units to the CETP, compliant with outlet discharge norms.

ii. The project should be self-supporting for repayment of loans and meeting operation and maintenance costs.

iii. The project must formulate adequate institutional arrangements for cost sharing, proper management, recovery of dues and management and ensure observance of prescribed standards.

iv. The CETPs should have a sludge management plan.

v. An environmental management and monitoring plan should be in place.

vi. The cost recovery formula developed for the CETP project should be ratified by all members and be documented in the feasibility report of the CETP project.

The establishment of CETP has improved collection of waste besides ensuring the treated effluent conforms to the norms in industrial clusters such as textiles, tanneries and pharmaceuticals. To date, 193 CETPs have been installed serving 212 of the country's 2 900 industrial areas/estates. Their combined hydraulic capacity is 1 474 million litres per day. In the future, India may consider developing BAT for CETPs.

9.5. Conclusion

India does not have a PRTR, and the necessary information for a quantitative analysis of the Indian policy framework to prevent and control industrial pollution, i.e. installation or facility level emissions monitoring data, is not available. Although a nation-wide environmental assessment of industrial clusters is available via CEPI, no consolidated information exists on e.g. on the emissions/discharges of individual plants or on the implementation of BAT. The Indian government is however, currently addressing this by setting up a comprehensive system for continuous emissions monitoring in 17 highly polluting industries.

Although the government does not conduct regular assessments of its industrial emissions policy as a whole, its effects on selected sectors are illustrated through case studies. This chapter has demonstrated the impact of the government's efforts to phase out mercury consumption in the chlor-alkali sector, to set up joint effluent treatment plants for small scale industry operators, and to reduce pollution from thermal power plants based on more stringent emission standards.

One stakeholder highlights that the effectiveness of India's current policy framework for industrial pollution prevention and control could be strengthened through improved enforcement and coordination across ministries, regular audits, increased involvement of the public, enhanced financial capacity for knowledge-sharing on techniques, such as through demonstrations.

Note

[1] See http://cpcb.nic.in/publication-details.php?pid=Mw.

Chapter 10. People's Republic of China

The People's Republic of China has developed Guidelines on Available Technologies for Pollution Prevention and Control (GATPPCs) for a range of industrial sectors, in addition to national environmental quality and emission standards. The Government is currently implementing a system of integrated discharge permitting, to take full effect in 2020. However, stakeholders stress the lack of an effective link between BAT and emission limit values under the new permitting system. Furthermore, the Chinese Government has over the past decade introduced several new requirements for sharing of information, including emissions monitoring data. To date, such data are primarily available for selected state-owned enterprises. The Chinese Government has developed guidelines for the evaluation of environmental policies, but these have not yet been published, nor applied, due to the lack of necessary data. The effects of BAT implementation in China are illustrated in this chapter by two case studies on medical waste treatment and zinc smelting.

10.1. BAT in the People's Republic of China

10.1.1. Guidelines on Available Technologies of Pollution Prevention and Control

The People's Republic of China (hereafter 'China') has a set of non-binding Guidelines on Available Technologies of Pollution Prevention and Control (GATPPCs). The GATPPCs are developed under the Administration Regulations for Revisions of Environmental Protection Standards and the Draft Directives for Development of Guidelines of Pollution Prevention and Control Available Techniques. They include information on available techniques for prevention and control of industrial emissions and associated discharge or emission limit values. A complete list of the GATPPCs is available the OECD's report *Approaches to Establishing BAT Around the World* (OECD, 2018[36]).

When new GATPPCs are developed, the Ministry of Ecology and Environment (MEE) launches a call for comments on its website. In August 2018, this was the case for the glass manufacturing industry[1], the ceramics manufacturing industry[2], the sugar industry[3] and the coking chemical industry[4].

10.1.2. Standards for environmental quality and emissions

In addition to the GATPPCs, China has a series of legally binding environmental quality and emission standards, developed under various laws, including the Environmental Protection Law, the Solid Waste Pollution Prevention Law, the Water Pollution Prevention Law and the Air Pollution Prevention Law. Based on more than 40 years of development, China has formed a system of environmental protection standards at two levels of government - national and local. The standards are divided into five categories, including for environmental quality standards, pollutant emission standards, environmental monitoring standards, environmental management standards and environmental basic class standards. As of 2015, there were 1 697 national environmental protection standards (including 16 environmental quality standards, 161 pollutant discharge control standards, 1 001 environmental monitoring standards, 481 management standards, and 38 environmental basic standards) and 148 local environmental standards approved.[5]

The national standards for environment protection are established by the competent department of environmental protection administration under the State Council. The people's governments of provinces, autonomous regions and municipalities directly under the Central Government may establish local environment protection standards that are consistent with - or more stringent than - the national standards, or for items not specified in the national standards. Whenever new national environmental protection standards are approved, the corresponding local environmental protection standards shall be reviewed and, if necessary, revised. The formulation of local environmental protection standards shall be reported to the competent department of environmental protection administration under the State Council (usually the provincial people's government) for approval and reported to the MEE for filing.[6]

10.1.3. Environmental permits

China previously had a medium-specific environmental permit system, which was managed at the provincial level. By 2016, 240 000 permits had been issued by the provinces. However, to enhance management efficiency and enforcement, a plan for integrated permits was established in the 2013 Decision of the Central Committee of the

Communist Party of China on Several Major Issues Concerning Comprehensively Deepening Reform. Subsequently, the General Office of the State Council issued the Implementation Plan for the Permission System for Controlling the Discharge of Pollutants (No. 81) in 2016. The MEE (previously the Ministry of Environmental Protection) further elaborated the scope and structure of the new permitting system in the Directory of Classified Management on Pollutant Permits of Stationary Sources in 2017, and the Draft Measures for the Administration of Pollution Discharge Permits in 2018, together with the Environmental Protection Tax Law. The implementation of the permitting system started in 2017 and is expected to be fully rolled out by 2020. It will cover all stationary sources, including 32 sectors, 78 small and medium subsectors, and four general processes. Further, it will cover air and water pollutants, such as sulphur dioxide, nitrogen oxide, soot (dust), COD and ammonia-nitrogen. The system will be administered by the Office of Pollution Discharge Permit and Total Pollution Control, and will aim to achieve compliance with the national emission standards.

Leading up to 2020, MEE gradually publishes technical requirements for application and issuance of permits for each industrial sector. The Ministry issued requirements for coal power plants and the paper industry in 2016; for the steel, cement, petrochemical, glass, coking chemistry, electroplating, non-ferrous metal smelting, tanning, pesticide manufacturing, sugar, fertilizer, textile printing and dyeing industries in 2017; and for the starch, slaughter meat processing, boiler and ceramic tile industries in 2018. The requirements for each industrial sector can be consulted in Chinese on the Ministry's website[7]. MEE has also started registering the permits, in first instance for coal power plants, cement plants and smelting plants.

Permit applications can be submitted online and must include the application form, a self-monitoring plan, a commitment letter and a description of the standardisation of sewage outlets by the concerned pollutant discharge unit. Applicants are subsequently informed of whether their application is approved or rejected. Permits are granted to enterprises as a whole, and not to individual installations or facilities. Information about each enterprise's permit can be consulted on the MEE's website[8] and should include the permit holder's unit name, address, legal representative or principal responsible person, industry category, in addition to production information, pollutant information and pollution sources and prevention. For each permit holder, an implementation report should be published annually, containing basic information on the production of the installations that emit pollutants, installed pollution prevention facilities, self-monitoring and environmental management accounting records, the construction and operation of internal environmental management system of pollutant discharge units. However, these requirements are quite recent; some companies have not yet uploaded complete information to the website.

Non-compliance or undocumented compliance with permit conditions are addressed by the penalty system for environmental offences and may lead to severe punishment. Permit holders that fail to demonstrate compliance shall be investigated for criminal responsibility according to the law.

10.2. Policy evaluation

10.2.1. Governmental evaluation projects

China's official guidelines to assess the effectiveness of environmental policies, issued in 2016, set out to harmonise and evaluate the implementation of national emission standards, its environmental benefits and economic costs. Further, the guidelines seek to measure levels of compliance with the standards as well as continuously to improve the science behind, and the applicability of, the standards.

However, the guidelines have not yet been made publicly available, nor applied, as the data needed to perform the prescribed evaluation are currently not available.

10.2.2. Stakeholder opinions

Academia

The Beijing Advanced Science and Innovation Centre points to the following challenges of the current policy framework for control and prevention of industrial emissions in China:

i. The pollutant discharge permit system is not effectively linked to the improvement of environmental quality.

ii. The GATPPCs are considered guidance only, and the setting of emission standards is thus not systematically based on BAT.

iii. The development of standards takes precedence over the introduction of BAT guidelines.

iv. Excessively strict emission standards have made it difficult for industrial companies to achieve compliance.

v. The quantitative emission limits in the standards are affected by many factors (such as raw materials, working conditions, pollution control facility efficiency, etc.), and it is difficult to give them appropriate values.

The Beijing Advanced Science and Innovation Centre also suggests measures that can address the challenges listed above:

i. Establish a system where emission standards are based on one of three variations of BAT:

   a. Best practical control technology standards for existing industries, i.e. based on the best control technology that balances economic and environmental benefits;

   b. optimal control technology standards for new industries, i.e. based on a combination of control technologies that consider certain economic and environmental benefits; and

   c. most stringent control technology standards for areas where the environmental quality is inadequate, i.e. based on the technologies that provide the best environmental benefits regardless of economic costs.

ii. Use emission standards based on BAT as a basis for determining emission limit values in permits, i.e. make it mandatory to align the development of GATPPCs and emission standards as well as to base permit conditions on these documents.

iii. Establish a mechanism for updating BAT in order to promote the scientific development of emission standards.

10.3. Available sources of data

10.3.1. Emissions monitoring data

PRTR

In recent years, some regions and organisations in China have launched pilot work to establish PRTR systems (Jun et al., 2018[107]). In 2009, Tianjin’s Economic and Technology Development Area (TEDA) announced that it would disclose enterprise environmental information. In 2013, the TEDA Eco Center, which is TEDA’s Environmental Protection Bureau, co-implemented the “EU-China Environmental Governance Programme: Developing a Pilot Regional Pollutant Release and Transfer Register in Tianjin Binhai New Area, China” together with the Institute of Public & Environmental Affairs and Sweden’s International Institute for Industrial Environmental Economics at Lund University. The programme set out to draw on relevant experience and management expertise from the European Union in order to implement a PRTR system in TEDA (Jun et al., 2018[107]).

Emissions monitoring data at installation level

MEE publishes monitoring and discharge data for some state-owned pollution sources[9]. These pollution sources are selected by the provincial and municipal governments based on a comprehensive set of criteria determined by the Ministry, relating to the enterprises’ contribution to industrial emissions to water and air, and transfer of hazardous waste. In addition, some enterprises are selected based on their specific industrial activities. The monitoring information is gathered by the China National Environmental Monitoring Centre.

A monitoring report on the state-owned pollution sources for the first quarter of 2017 presented data for a total of 7 781 enterprises, including 2 800 state-owned wastewater companies, 2 634 homes and 2 347 emission-controlled state-owned enterprises, sewage treatment plants, urban sewage treatment plants and centralised industrial wastewater treatment facilities.

As for other pollution sources, the Government of China has over the past decade introduced several new rules, regulations and measures to expand the disclosure of environmental information. These measures primarily concern the disclosure of governmental environmental information, information made or obtained by environment authorities in the course of their environmental protection work, and the disclosure of company monitoring information on conventional pollutants, including real-time and manual emissions monitoring data, monitoring plans, and annual discharge reports. Facilities identified as key pollutant discharge units shall according to the Government of China (2013[108]) also disclose information on the following elements, inter alia:

i. sewage discharge, including the names of major and characteristic pollutants, the mode of discharge, the quantity and distribution of discharges, the concentration and total amount of discharges, standards exceeded, implemented pollutant discharge standards and the total amount of approved emissions;

ii. construction and operation of pollution prevention facilities;

iii. environmental impact assessment of construction projects and other environmental protection administrative licenses; and

iv. emergency plans for sudden environmental incidents.

In 2015, the State Council proposed for the first time the establishment of a unified information disclosure platform for industry (Government of China, n.d.[109]). Two years later the Council stipulated that MEE establish an integrated environmental information disclosure platform for enterprises and public institutions as well as required that key pollutant discharge entities install automatic monitoring equipment and convey real-time emissions monitoring data to the integrated MEE platform for disclosure (Government of China, 2017[110]). MEE shall develop unified criteria for the formulation of directories of key pollutant discharge entities. The unified disclosure platform for industry is yet to be established and the disclosure of factory-level information on hazardous chemicals is still very limited (Jun et al., 2018[107]).

However, several recent governmental publications encourage monitoring by industries. Amongst others, the Government of China (2008[111]) encourages enterprises to voluntarily publish data on pollutant type, quantity, concentration and transfer, as well as waste treatment and recycling. The document requires enterprises which pollution discharge exceeds national or local emission standards or total discharge control targets to openly publish the aforementioned environmental information, and accepts no excuses on the pretext of commercial secrets (Jun et al., 2018[107]).

Further, the Government of China (2013[112]) requires over 14 000 large industrial emitters to publish their real-time and manual emissions monitoring data, monitoring plans, as well as annual discharge reports to the public via the platforms of provincial or city-level environmental protection bureaus. This requirement has resulted in the public release of information on conventional pollution parameters such as chemical oxygen demand (COD), ammonia nitrogen (NH_3-N), sulphur dioxide (SO_2), nitrogen oxides (NO_X) and particulate matters (PM) (Jun et al., 2018[107]).

Finally, the new Environmental Protection Law, which entered into effect on 1 January 2015, states that key pollutant discharge entities shall truthfully disclose to the public the names of their key pollutants, manner of discharge, discharge concentration and total volume, status of whether emissions exceeded limits, as well as the construction and operation status of pollution prevention and control facilities, and accept societal supervision (Jun et al., 2018[107]).

10.3.2. Activity data and other metrics

Production capacities are to be included in the discharge permits and in the accompanying implementation reports, and will be made accessible online in future.

10.4. Case studies

10.4.1. Reduction of mercury emissions from the Chinese primary zinc smelting industry

Wang et al. (2010[113]) demonstrate the effects of China's environmental policies on the reduction of mercury (Hg) emissions to air in the primary zinc smelting industry. There are currently two emission standards available for this sector:

i. Emission standard of pollutants for lead and zinc industry (MEE, 2010[114])

ii. Technical specification for application and issuance of pollutant permit non-ferrous metal metallurgy Industry — lead and zinc smelting (MEE, 2017[115])

All emission limit values available for the lead and zinc industry, including for Hg, are listed in the table below (Table 10.1). As no GATPPC has yet been published for the zinc smelting industry, there is no official guidance as regards what techniques industrial operators could apply to reach compliance with the Hg emission limit values.

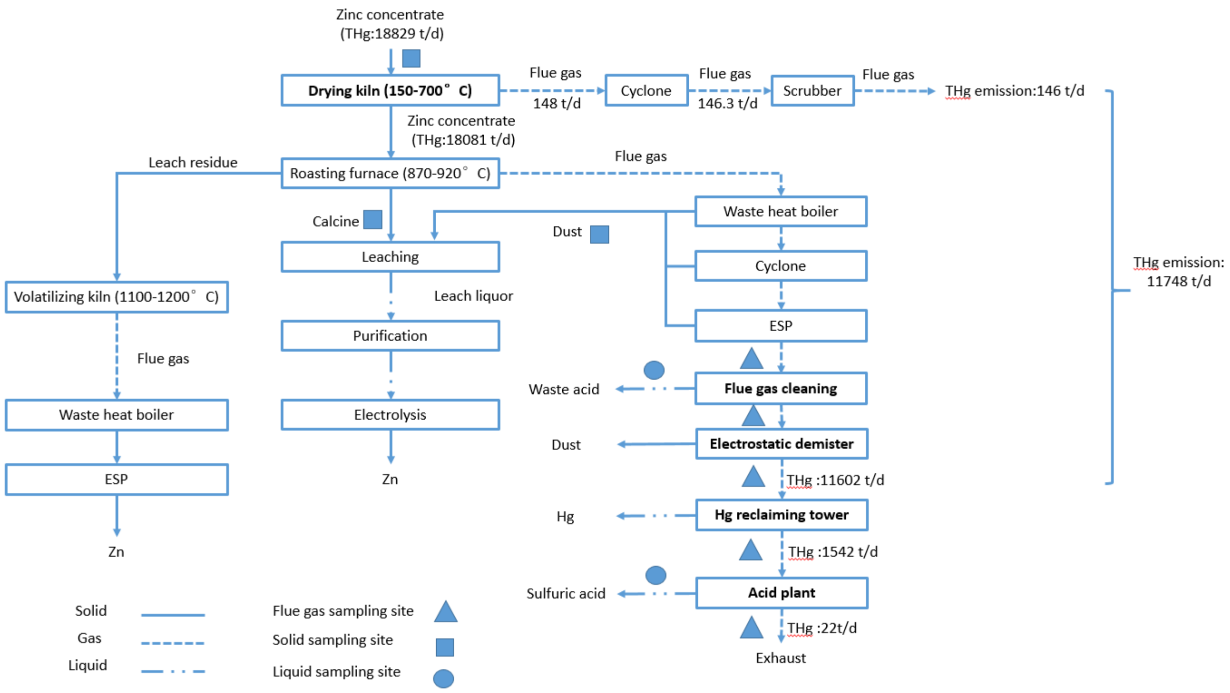
Table 10.1. Emission limit values for the Chinese lead and zinc industry

Pollutant	ELV (mg/m³)
PM	80
SO_2	400
Sulphuricacidmist	20 (Relievinghyperacidity)
Pb	8 (Smelting)
Hg	0.05 (Smelting)

Source: (MEE, 2010[114])

The primary zinc smelting plant in Shannxi has a capacity of 100 kilotonnes per year and uses a roasting leaching wet zinc smelting process. To reduce its Hg emissions to the environment, the plant has chosen to abate gaseous Hg emissions from exhaust roasting gas and Hg emissions to acid waste. Figure 10.1 provides more details on the plant's current and previous emission pathways, and on the emission reduction techniques installed. Together with Table 10.2, the figure also shows the inlet and outlet of air pollution control devices.

Figure 10.1. Production process and the sampling locations in the tested plant



Source: (Wang et al., 2010[113])

According to Figure 10.1 and Table 10.2, the Hg emission from the plant's outlet of electrostatic demister was 11 602 grams per day. This means that in the absence of the Hg reclaiming tower and the acid plant, the total Hg emissions from drying kiln, volatilizing kiln and outlet of the electrostatic demister to atmosphere would be 11 748 grams per day. In this case, the Hg emission factor would be 34 g t-1, which would be 68 times the Hg emission factor with Hg reclaiming tower and acid plant. The reduction of tail gas mercury concentration greatly reduced the atmospheric mercury concentration and exposure in the surrounding environment (Wang et al., 2010[113]).

Table 10.2. Stack tests at inlet/outlet of air pollution control devices

Sampling site	Dry gas flow (m^3 h^{-1})	Hg concentration (μg m^{-3}, dry gas)	Hg mass rate (g d^{-1})	Number of tests
Outlet of acid plant	80 446 ± 634	11 ± 2	22 ± 3	6
Inlet of acid plant	76 670 ± 1 391	473 ± 86	871 ± 166	6
Outlet of Hg reclaiming tower	73 287 ± 636	878 ± 167	1 542 ± 287	6
Inlet of Hg reclaiming tower	7 0495 ± 667	7 861 ± 1 327	13 307 ± 2 301	6
Outlet of electrostatic demister	70 780 ± 431	6 833 ± 827	11 602 ± 1 339	3
Inlet of electrostatic demister	60 291 ± 459	11 554 ± 430	16 721 ± 740	3
Outlet of flue gas cleaning	59 973 ± 415	7 876 ± 2 337	11 324 ± 3 285	2
Inlet of flue gas cleaning	57 706 ± 260	9 879 ± 2 769	13 691 ± 3 897	2

Source: (Wang et al., 2010[113])

The data in Table 10.2 allows calculating the Hg removal efficiencies of air pollution control devices. The results are shown in Table 10.3.

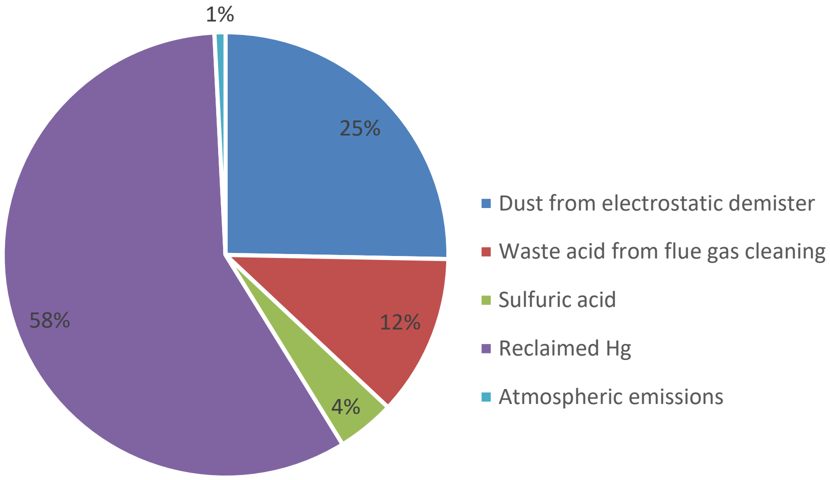
Table 10.3. Mercury removal efficiencies of air pollution control devices

Air pollution control device	Hg removal efficiency (%)			Number of tests
	Minimum	Maximum	Average ±Standard deviation	
Flue gas cleaning	17.0	17.7	17.4 ± 0.5	2
Electrostatic demister	21.0	42.2	30.3±10.9	3
Hg reclaiming tower	82.8	92.1	88.0±3.5	6
Acid plant	96.5	98.2	97.4±0.6	6

Source : (Wang et al., 2010[113])

According to tests carried out by Wang et al. (2010[113]), flue gas cleaning and electrostatic demister respectively captured 11.7% and 25.3% of the Hg output. The Hg reclaiming tower recycled 58.0% of the Hg output. Another 4.2% of the Hg output was captured by the acid plant. Only 0.8% of total Hg was emitted to the atmosphere. The fate of Hg is given in Figure 10.2.

Figure 10.2. Mercury fate in zinc smelting process



Source : (Wang et al., 2010[113])

In 2006, 474 kilotonnes of zinc, or 15% of the total zinc production in China, was produced in small scale zinc smelters, where neither Hg reclaiming towers nor acid plants were installed. Based on an emission factor of 34 g t^{-1}, Hg emission from these small scale zinc smelters would be 16 tonnes per year. If one shut down these small-scale smelters and built a new large scale zinc smelter with Hg a reclaiming tower and an acid plant, the Hg emissions would be reduced to as little as 0.2 tonnes per year (adopting the Hg emission factor of 0.5 g t^{-1}). This analysis suggests that integration of small scale zinc smelters and installation of Hg reclaiming towers and acid plants may effectively reduce 15.8 tonnes of atmospheric Hg emissions from zinc smelters in China annually. To further decrease the Hg emissions, measures should be taken to remove the Hg emitted from the drying kiln and the volatilizing kiln.

10.4.2. Application of BAT to medical wastes disposal and treatment in China

Due to its large population, China holds significant quantities of medical waste. Medical waste carries various pathogens which may endanger human health. The disposal of medical waste may result in emissions of dioxins, heavy metals and other pollutants (Jiang et al., 2012[116]). Before the SARS epidemic in 2003, the medical waste in China was managed and disposed of in a decentralised manner, by individual hospitals. The waste was often incinerated without essential air pollution control devices, mixed with municipal solid waste in landfills, or illegally reused and recycled (Jiang et al., 2016).

Following the SARS epidemic, the Chinese Government established the National Plan for Construction of Facilities for Disposal of Hazardous Waste and Medical Waste, committing to construct 332 dedicated medical waste disposal facilities, mainly using incineration disposal technology, across the country. By the end of 2010, 272 of these were already installed. 137 of these were incineration facilities, including seven rotary kilns and 130 pyrolysis incinerators. However, many of the facilities did not function optimally. With the ratification of the Stockholm Convention in 2004, more attention was paid to dioxin emissions from medical waste incineration, and non-incineration technology of medical waste disposal was developed: pyrolysis incineration, rotary kiln incineration, autoclave, chemistry disinfection, and microwave and combinations of these technologies.

Several technical guidelines, requirements and specifications for non-incineration techniques were published in China following the ratification of the Stockholm Convention and there has been an upward trend in the use of such technologies since 2006. Amongst the facilities installed by 2010, 120 were autoclave treatment facilities, ten were chemical disinfection facilities and five were microwave disinfection facilities. In addition, dry heat treatment technology has been applied in some facilities.

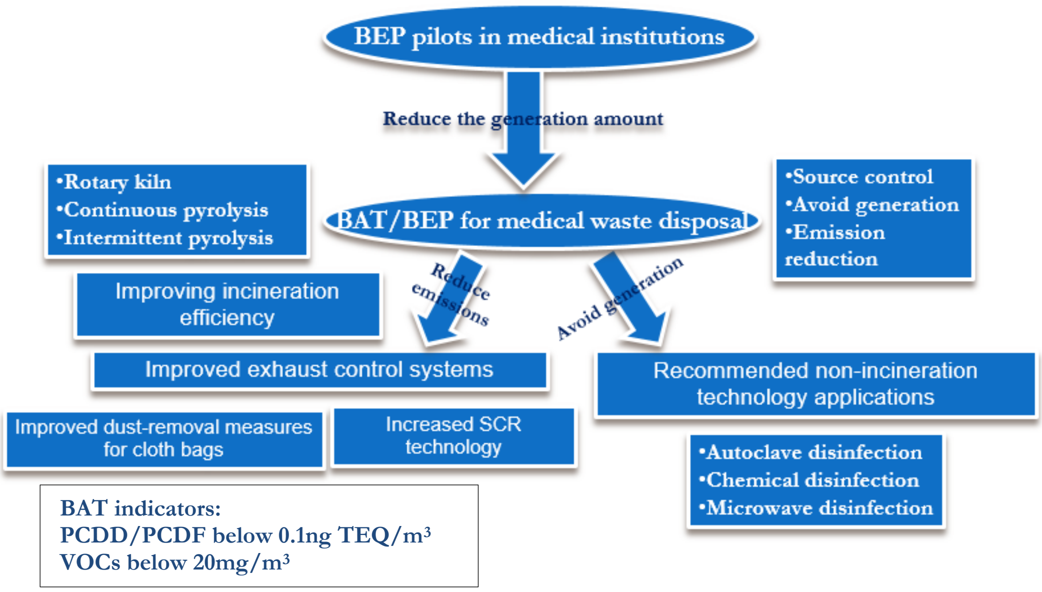
In 2012, the GATPPC for Medical Waste Treatment and Disposal was published, based on the United Nations Environmental Programme's Compendium of Technologies for Treatment/Destruction of Healthcare Waste (UNEP, 2012[117]). This compendium assists national and local governments, health organisations and other stakeholders in countries with developing and emerging economies in assessing and selecting appropriate technologies for the destruction of waste from healthcare activities.

On the basis of adoption of BAT, the dioxin release from medical waste treatment could be lowered to 0.1 ng TEQ/Nm^3 and the acid gas, heavy metals, and other pollutants could reach related pollution control requirements (Jiang et al., 2016).

Over the period 2007-2017, the Global Environment Facility funded a USD 45 million project on the environmentally sustainable management of medical waste in China. The project aimed to explore and establish a BAT/BEP system for the treatment and disposal of medical waste adapted to Chinese conditions, based on a life cycle approach. The project established a total of 15 BAT/BEP pilot projects, six of them in enterprises, including medical institutions, six at city level and three at the level of provinces.

All the pilot projects sought to set up a complete medical waste management system. For medical institutions, the BAT and BEP marked on Figure 10.3 were used. The techniques and practices were defined based on two "BAT indicators": keeping emissions of polychlorinated dibenzo-*p*-dioxins (PCDD) and dibenzofurans (PCDF) below 0.1 nanograms toxic equivalency per cubic meter, and emissions of volatile organic compounds (VOC) below 20 milligram per cubic meter.

Figure 10.3. BAT and BEP for medical waste treatment pilot projects in China



Source: Beijing Advanced Science and Innovation Centre

10.5. Conclusion

The Chinese government has taken important steps to encourage monitoring of industrial emissions and disclosure of emissions monitoring data, and pilot PRTRs have been established in certain regions. Nonetheless, currently available data do not enable a quantitative evaluation of the effectiveness of the Chinese policy framework for preventing and controlling industrial pollution, including environmental quality and emission standards, GATPPCs and the soon to be implemented integrated discharge permit system. The permitting system will facilitate increased transparency of industrial operations as well as likely reduce industrial emissions. However, one stakeholder point out that a key weakness of the new permitting system is that it does not align emission limit values in permits with the GATPPCs, but only with the national emission standards, which are not based on BAT. The case studies on medical waste treatment and zinc smelting illustrate how the introduction of improved control and prevention techniques can significantly reduce industrial emissions.

Notes

[1] See http://www.mee.gov.cn/gkml/sthjbgw/stbgth/201808/t20180820_452335.htm.

[2] See http://www.mee.gov.cn/gkml/sthjbgw/stbgth/201808/t20180828_454335.htm.

[3] See http://www.mee.gov.cn/gkml/sthjbgw/stbgth/201808/t20180828_454338.htm.

[4] See http://www.mee.gov.cn/gkml/sthjbgw/stbgth/201809/t20180905_548930.htm.

[5] See http://www.mee.gov.cn/gkml/hbb/bwj/201704/t20170414_411566.htm.

[6] See http://www.npc.gov.cn/wxzl/gongbao/1989-12/26/content_1481137.htm and http://www.mee.gov.cn/gkml/hbb/bwj/201404/t20140415_270560.htm.

[7] See http://permit.mep.gov.cn/permitExt/outside/Publicity?pageno=1.

[8] See http://permit.mee.gov.cn/permitExt/syssb/xxgk/xxgk!sqqlist.action

[9] See http://app.envsc.cn/ValidTransferRatePublicityPlatform/Module/Main/Main.html.

Chapter 11. Kazakhstan

Kazakhstan's environmental code from 2007 included a provision to introduce environmental permits based on BAT. However, no permits were issued under the code and the government is currently working on revising the environmental legislation in order to allow for, inter alia, enhanced BAT uptake and widespread issuance of integrated permits. Under the new code, the government will seek to involve stakeholders in developing BAT reference documents. No ex ante assessment has yet been conducted of the impact of the new environmental code. Kazakhstan is currently establishing a PRTR system, which possibly could feed into an evaluation of the BAT policy in the future.

11.1. BAT in Kazakhstan

11.1.1. BAT and environmental permitting in the environmental legislation

The Environmental Code of the Republic of Kazakhstan of 9 January 2007 (no. 212-III-EC) establishes provisions for BAT and integrated environmental permitting on a pilot basis, following benchmarks established by the EU's Industrial Emissions Directive (EU, 2010[23]):

i. The Code states that "BAT are used and planned industry technologies, machinery and equipment that provide organisational and management measures aimed to reduce the negative impact of economic activity on the environment in order to achieve environmental quality targets".

ii. Under the Code, a list of BAT for selected processes and industries was developed and approved (Order of the Ministry of Energy No. 155 of 28 November 2014 "On Approving the List of Best Available Techniques"). The Code defines the requirements for the transition to technical specific emission standards based on the introduction of BAT (Article 26) which are established in technical regulations and are the basis of integrated environmental permits.

iii. Integrated environmental permits are considered as one of the types of environmental permits (Article 68). Requirements for the issuance of integrated environmental permits and a list of types of industrial facilities have been developed and hence it would be possible to obtain integrated environmental permits instead of permits for emissions into the environment (Order of the Minister of Energy of the Republic of Kazakhstan of 23 January 2015, No. 37).

iv. The Code states that users of natural resources can choose to apply any of the techniques included in the EU BREFs.

While the 2007 Environmental Code introduced the possibility for adoption of BAT, as well as of integrated environmental permitting, in practice, neither BAT nor integrated environmental permitting was implemented. Early 2018, no application had been submitted for an integrated permit. At present, the basic instrument for pollution control for stationary sources in Kazakhstan is a system of environmental quality standards, expressed through Maximum Allowable Concentrations (MAC), which theoretically are the determinant factor in setting emission limit values (ELVs) in permits for individual installations (see Box 11.1 for more information). Environmentally related taxes are levied based on emissions within and above the ELV with three types of payments (taxes for authorised emissions, non-compliance penalties and monetary pollution damages) (OECD, n.d.[1]).

The government of Kazakhstan is currently revising the Environmental Code, with the objective to, inter alia, better integrate the BAT concept as well as enable implementation of integrated environmental permitting. Under the new environmental code, integrated environmental permitting will be mandatory for all facilities above a certain size. The new code will seek to more clearly define the responsibilities of the public versus the private sector, in order to more easily manage conflicts between industry and government. Further, the code will aim to include provisions regarding the involvement of stakeholders, the issuance of, and determination of emission limit values for, permits, and the response to noncompliance with permit conditions.

Box 11.1. Analysis and comparison of Kazakhstan's emission limit values and maximum allowable concentrations for industrial pollution

Maximum Allowable Concentrations

According to OECD (2017[118]), the Kazakh system of Maximum Allowable Concentrations (MAC) is overly ambitious and mandates in theory very low ambient concentrations of pollutants derived from the concept of zero risk to humans and the environment during the worst possible circumstances (e.g. worst-case meteorological conditions; most vulnerable part of population) (OECD, 2017[118]). Most of the MAC were established before 1990 and the lists of ambient quality parameters have not been revised or harmonised with international standards since then. The MAC values are set for 683 pollutants (UNECE, 2019[119]). Every pollutant has a defined hazard class (from 1 to 4, with class 1 being the most hazardous). Air quality standards are based on short term maximum and daily mean values. However, effective monitoring capacity, in both public authorities and industry, falls well short of the ambition that the MAC lists indicate. The number of parameters that are actually monitored is rather small (OECD, n.d.[1]).

The system of environmental quality standards and MAC, however ambitious the parameters might be, is not fully effective and does not provide a realistic evaluation of the air quality in the country. The comparison with, for example, EU standards gives a more understandable picture of the situation with respect to the levels of air pollution. Air quality measurement results (measured concentrations of air pollutants in the period 2010–2012) show that, in a number of stations, the annual mean and monthly mean values for PM_{10} and NO2 are exceeding EU standards by (in some cases) a factor of 2–3 (World Bank, 2013[120]). There is thus widespread recognition of the need to reform the MAC system (OECD, n.d.[1]).

Emission Limit Values

Under the 2007 Environmental Code, resource-users in Kazakhstan can legally emit pollutants into the environment as long as they hold an environmental permit. The objective of the permits, and the ELV contained within them, is to ensure that the quality of the environment at the surrounding residential area or at the boundary of the so-called 'sanitary zone' meets the hygienic requirements for air or water quality, taking into account the background pollution level. Permits are issued by competent authorities at the national and regional level depending on the size of the operation (OECD, n.d.[1]).

Theoretically, ELVs in environmental permits in Kazakhstan are set at levels to ensure that the aggregate amount of emissions from all sources of pollution in a given location together with the existing level of pollution do not cause pollution levels in that location to exceed the MAC. The calculation of ELVs for individual enterprises in a given region, or oblast, involves computer-based simulations of pollutants' dispersion in the space (OECD, n.d.[1]).

In practice, there are a number of problems with the manner in which ELV are determined during the permitting process (World Bank, 2013[120]) .

- The ELV in the permitting process are based on the level of historical pollution and background concentrations rather than emission limits that an industry could achieve when applying BAT.
- Kazakhstan's industrial facilities typically obtain ELVs based on the highest level of emissions measured during the maximum production output. This might

facilitate compliance as enterprises often operate at a lower capacity without investing in processes, technologies and techniques.

- Although the ELVs should only be set for the pollutants for which the establishment of ELVs is mandatory, many of the environmental permit applications include ELVs for all identified emissions regardless of their quantities and potential hazard because of a lack of information about the mandatory list of pollutants for emission limits. This results in redundant paperwork both for responsible environmental specialists at industrial facilities and environmental regulators, without providing environmental/health benefits for industrial facilities and environmental regulators. It also leads to insufficient focus on the pollutants which cause most health impacts (OECD, n.d.[1]).

Also, for the main industrial emitters such as the heat and power industry, which are following the Kazakhstan Technical Emission Standards, the ELVs significantly exceed European benchmarks:

- ELVs for SO2 (2 000-3 400 mg/m3 for existing plants and 700-1 800 mg/m3 for new plants in Kazakhstan) are also much higher than those in the EU (150–400 mg/m3 under the Industrial Emissions Directive (EU, 2010[23])).
- Similarly, NOx ELV (500-1 050 mg/m3 for existing plants and 300-640 mg/m3 for new plants) are higher than in the EU (150–300 mg/m3).
- The range of PM ELV for coal-fired power plants are 600-1,600 mg/m3 for existing plants and 100-500 mg/m3 for new ones. Both exceed by several times the level established by the EU of 10-20 mg/m3.

In 2017, the OECD underlined that there is an urgent need to optimise the present permitting, the compliance control requirements and reform the establishment of ELVs exclusively anchored in MAC (OECD, 2017[118]).

11.1.2. The Kazakh BAT Bureau: the International Green Technologies and Investments Centre

The International Green Technologies and Investments Centre (IGTIC), which is a governmental agency operating under the authority of the Ministry of Energy, will serve as the competent authority in charge of development of BREFs in Kazakhstan. IGTIC will facilitate the set-up and functioning of a multi-stakeholder platform for determination of BAT as well as assist the Ministry’s Committee for Environmental Regulations and Control in issuing integrated environmental permits and ensuring enforcement and monitoring of compliance with permit conditions. Furthermore, IGTIC plans to draw on its experiences from the transition to BAT to assist other countries in Central Asia in adopting BAT principles.

In December 2018, the IGTIC issued a draft concept note for Kazakhstan’s transition to a BAT-based policy (IGTIC, 2018[121]), including a five years plan for development of Kazakhstan’s first six BREFs and an extended plan (for the period up until 2030) for issuance of the country’s first integrated environmental permits and sanctioning of noncompliance with permit conditions. The concept note suggests an institutional set-up for the transition to BAT, consisting of, inter alia, technical working groups for the drawing up of BREFs. It remains to be determined for which industrial sectors the first BREFs will be developed. In elaborating its draft plan for BAT determination and implementation, the

IGTIC largely relied on the international BAT experience compiled by the (OECD, 2018[36]). In its recommendations to IGTIC, the OECD (n.d.[1]) notes that having wide inclusivity in the selection of industry experts involved in the development of BREFs would be of value, increasing the participation of services providers, small and medium sized enterprises and foreign companies, so as to ensure that techniques identified as BAT are indeed the *best available* techniques worldwide, developed on a scale to be implemented in the relevant sector, under economically and technically viable conditions.

Further, in preparation for the introduction of BAT, the IGTIC has conducted a study of the emissions from the Kazakh large combustion plants, concluding that current emission levels nearly are compliant with Russian BAT Associated Emission Levels (BAT-AELs), but far above the EU's BAT-AELs. The high emission levels in Kazakhstan are largely due to outdated equipment (with 70% of power plants being 30-60 years old) and the country's great reliance on coal.

11.2. Policy evaluation

11.2.1. Stakeholder opinions

IGTIC

According to the IGTIC, the reasons why BAT and integrated environmental permitting did not materialise under the 2007 Environmental Code include the following:

- Although some BAT documents were approved under the Code, the BAT concept and the criteria for assessing candidate BAT had not been clearly defined. Moreover, the documents merely provided specific technical regulations for four industrial processes (burning of fuel in boilers of thermal power plants, production of ferroalloys, production of aluminium by electrolysis and by the Bayer-sintering method), which were to be the basis for approved ELVs in permits. This was insufficient considering the variety of processes conducted by Kazakh industrial facilities. Further, the documents did not clearly specify emission levels for all basic pollutants.
- The emission limit values defined under the 2007 Code were based on historical emission levels and background concentrations rather than on a range of emission levels that an industrial facility could achieve by applying BAT.
- There was a no adequate mechanism or methodology for determining BAT. No non-governmental stakeholders were consulted in the process to establish the BAT documents under the 2007 Code.
- There was no single coordinating body for the management of the processes related to the transition to BAT principles, including for provision and coordination of relevant information.
- There was no regulatory framework for the creation of an open institution in charge of issuing integrated environmental permits involving the public and industry.
- There was a lack of incentive measures for BAT uptake.

The IGTIC is currently discussing *how* industry operators will be incentivised to adopt BAT during the period of transition to integrated environmental permitting, and for *how long* this period would last. In its recommendations to the IGTIC, the OECD has suggested that BAT should be seen as a prerequisite to run any industrial operation and thus that there should be no need to subsidise regular BAT uptake after the transition period, and that industry operators rather should be incentivised to go beyond BAT-based permit conditions.

In developing a procedure for determination of BAT, the IGTIC believes that it is important to ensure a transparent, multi-stakeholders process and to foster collaboration and acceptance for BAT and BAT-AELs across sectors, including industry. Such a process would also address the concerns of some nongovernmental stakeholders regarding corruption and lack of transparency in the public sector, as their involvement could help holding the government accountable when enforcing permit conditions.

Industry associations

Some industry associations fear that the implementation of BAT will impose significant costs on industry operators as well as have social and economic consequences for employees in facilities that might be shut down or otherwise sanctioned due to noncompliance with permit conditions. However, other industry associations believe that the introduction of BAT is necessary to make the Kazakh industry more internationally competitive as well as to improve environmental quality across the country.

11.3. Available sources of data

11.3.1. Emissions monitoring data

PRTR

Kazakhstan is in the process of forming a PRTR system. The list of substances reported to the PRTR were established by the rules for maintaining the state register of pollutant emissions, approved by the Ministry of Energy on 10 June 2016 (No. 241). The PRTR contains information on the volume of actual air emissions of pollutants for 60 substances, and water emissions for 62 substances. In 2017, PRTR reports were provided by 778 resource-users classified in Category 1, i.e. the most polluting industrial installations. The country’s 70 largest polluters have provided PRTR data for two consecutive years. The Informational Analytical Centre of Environmental Protection, underlying the Ministry of Energy, is the focal point for establishing the Kazakh PRTR (UNITAR, 2017[122]).

Kazakhstan has not yet ratified the PRTR Protocol to the Aarhus Convention – the UNECE Kyiv Protocol (UNECE, 2003[19]) - which imposes binding PRTR requirements on signatories, but is in the process of doing so.

The current PRTR system is a collection of scanned reports of different enterprises, which does not allow for real-time ranking of emissions by type (air, water, soil), by industry, and structurally is quite far from other PRTR systems such as the EU’s E-PRTR. There is not yet any consolidated information on all pollutants and all sectors of the national economy (OECD, n.d.[1]).

Furthermore, the ranking of emissions reports in the Kazakh PRTR system is not available; information is presented only by region. And some enterprises in some regions are not represented in the existing PRTR system at all. For example, the system does not issue any reports for Pavlodar and Turkestan. Pavlodar region is one of the leading regions according to air emissions. The existing PRTR system is thus not ready to provide full information of country emissions. Another reason for the system’s incapacity is to display a transparent picture of emissions, that is the functioning of this system in a pilot mode, which allows enterprises to report only on the emissions on which they wish to provide information (IGTIC, 2018[121]) (OECD, n.d.[1]).

11.4. Conclusion

Kazakhstan is currently in the process of introducing integrated environmental permitting based on BAT, and will be developing its own BREFs over the next few years. The country is also working on establishing a PRTR system. An ex post evaluation of the Kazakh BAT policy could only be conducted once integrated environmental permits have been issued to a significant share of companies and the transition period for reaching compliance with BAT-AELs has ended. However, Kazakhstan could benefit from conducting baseline or ex ante evaluations of the effects of BAT implementation for selected sectors at an earlier stage.

Chapter 12. New Zealand

The effects of New Zealand's Resource Management Act are evaluated regularly by the national Government, in its State of the Environment reports, as well as by local governments. A comprehensive assessment has also been conducted by a civil society organisation, stating that enhanced evaluation and a more effective strategy is needed to effectively protect the environment. Some emissions monitoring data are available in New Zealand, but at aggregated levels only, making it difficult to assess the impact of the Resource Management Act on industrial emission trends.

12.1. BAT in New Zealand

New Zealand has a performance-based environmental regulation at the national, state and local level under the framework of the Resource Management Act (RMA) since 1991. All new industrial facilities that may result in emissions to the environment must comply with the environment protection requirements of a local plan and with the conditions set by the local governmental authority. The Ministry for the Environment can impose rules through legally binding National Environmental Standards (NES) or specify objectives and policies through National Policy Statements, which local governments must comply with or give effect to. The NES are reviewed as appropriate.

The NES do not include specific requirements to assess or improve the technological potential of polluters, although the local governments may choose to apply Best Practical Options (BPO) as a means of compliance with the NES or where there are no applicable NES. There is no standard approach to determine BPO, but they are generally based on ‘good practice' or 'fit-for-purpose' techniques, rather than on BAT.

New Zealand also has a set of horizontal Good Practice Guides (e.g. for air quality management), developed by the Ministry for the Environment under the RMA, as well as five industry-specific guidelines. The complete list of guiding documents is available in the OECD’s report *Approaches to Establishing BAT Around the World* (OECD, 2018[36]).

12.2. Policy evaluation

12.2.1. Governmental evaluation projects

The New Zealand Environmental Defence Society released the report “Evaluating the environmental outcomes of the RMA” (Brown, Peart and Wright, 2016[123]) in 2016. The methodology used for the evaluation includes literature review, questionnaires and benchmarking, and was approved by relevant stakeholders. The report stresses that as the RMA interacts with a range of other regulations, observed impacts on the environment may be the result of a combination of measures. Further, the report concludes that, although the provisions in the RMA are adequate, the environmental outcomes of the Act do not meet expectations, due to poor implementation. The report suggests the following measures to enhance progress in achieving the objectives of the Act:

i. A clarification of the national direction on achieving environmental objectives;

ii. a more effective strategy and oversight (e.g. cumulative effects);

iii. developing a more integrated decision-making process, increasing the capacity and re-focusing the work of the government authorities involved in the implementation process; and

iv. enhanced evaluation (e.g. using economic tools) and monitoring.

The Ministry for the Environment regularly publishes reports on the State of the Environment, evaluating the impact of the RMA at a national level. The Parliamentary Commissioner for the Environment also releases reports of relevance for the assessment of the RMA. The effects of the Act are also assessed at the local level, by the local governments. For example, regional councils have primary responsibilities for air discharge management. District councils can employ a range of mechanisms to control where activities with air effects are located and how they operate. Other central government agencies, can significant support to achieve good outcomes for air quality (EDS, 2016[124]).

In general, improvements in air quality are considered achieved through a combination of regulatory changes (notably the NES for Air Quality) and technological improvements.

The effects of dust are often assessed and managed qualitatively. However, in cases where there may be adverse effects due to the scale of the activity and/or the sensitivity of the receiving environment, quantitative assessment and/or ambient monitoring are undertaken (MfE, 2016[125]). NES for Air Quality, national ambient air quality guidelines, and objectives and policies in some regional plans, are criteria used in a quantitative assessment.

12.3. Available sources of data

12.3.1. Emissions monitoring data

New Zealand does not have a PRTR nor any available activity data. However, aggregated monitoring data for emissions to air (e.g. PM_{10} and nitrogen oxides) are publicly available and can be found in the Good Practice Guides for Managing Air Quality[1], such as the Good Practice Guide for Assessing and Managing Dust (MfE, 2016[126]).

PM_{10} emissions monitoring data (averages and maxima at region levels) are available from all regional councils, either on their website or on request. Current air quality data can be found on the Land, Air, Water, Aotearoa website[2]. Information on complying with the PM_{10} standards is available in the following publications:

i. 2011 Users' Guide to the Revised National Environmental Standards for Air Quality: Updated 2014 (MfE, 2011[127])

ii. Clean Healthy Air for All New Zealanders: The National Air Quality Compliance Strategy to meet the PM_{10} standard (MfE, 2011[128]).

12.4. Conclusion

New Zealand does not have a PRTR and emissions monitoring data are only available at aggregated levels. No quantitative analysis of the effects of the RMA on industrial emission trends can thus be conducted. The impact of the RMA on environmental protection more broadly is assessed by the Ministry for the Environment and by local governments, and has also been evaluated by the civil society organisation New Zealand Environment Defence Society, which highlighted the need for a stronger overall strategy, enhanced evaluation and more adequate decision making processes.

Notes

[1] See http://www.mfe.govt.nz/air/improving-air-quality/good-practice-guides-councils.

[2] See https://www.lawa.org.nz/.

Chapter 13. **Conclusion**

This chapter provides concluding remarks based on the twelve previous chapters. It includes a table that summarises the key messages from the ten country chapters.

13.1. Why a report on the evaluation of BAT policies?

This report is the final output of Activity 3 of the OECD's BAT project. The report takes stock of the data and methodologies available for evaluating the effectiveness of policies that embody BAT or similar concepts to prevent and control industrial emissions in the EU, the US, Chile, Israel, Kazakhstan, Korea, the Russian Federation, India, China and New Zealand. The key findings from the ten country and region chapters are presented in Table 13.1. By presenting existing methodologies and projects for evaluation of the impact of industrial emissions policies, the report demonstrates governments' diverse approaches to such evaluations.

Evaluating BAT policies allows measuring the impact of past actions as well as strengthening future decisions. BAT policy evaluations benefit governments and the public alike by helping develop improved solutions, i.e. inform and facilitate the development of more effective and tailored BAT and emission limit values in permits. Impact assessments are also necessary in order to demonstrate and communicate the purpose and impact of BAT polices to relevant stakeholders, including industry, policy makers and the public.

Many of the policies considered for evaluation in this report have not yet taken full effect. For example, in Korea, the Russian Federation and China, integrated environmental permitting will only take full effect in a few years. In the EU, BAT Conclusions have not yet been published or fully implemented for all industrial sectors. In such cases, it would be premature to conduct an ex post evaluation of their impact on emission trends. Nonetheless – and exactly for that reason – the compilation of data and methodologies presented in the report may be useful for governments seeking to develop evaluation schemes or design the collection of data in a way that can enable the effective ex post assessment of policies in the future. If the necessary data are not gathered through the policy implementation period, it will not be possible to conduct an ex post evaluation.

13.2. Existing evaluation initiatives

The majority of the ten economies examined in the report evaluate the impact of their BAT policy (or the equivalent) in one way or another. Chile has an official, governmental methodology for the evaluation of environmental programmes, which currently is being used to assess the impact of national emission standards. China also has a governmental guidance document on the evaluation of environmental policies, but the guidance has not yet been made publicly available or applied in practice, as the necessary data are not available. The EU has a programme for effectiveness evaluation of all pieces of legislation, in addition to frequently conducting assessment studies of the Industrial Emissions Directive (IED) at the supra-national and national levels. Israel has published a report estimating the expected impact of BAT on emissions, and the US recently issued a report assessing the effect of federal and state regulations on emissions of pollutants to air. In the Russian Federation, the governmental State of the Environment reports take stock of industrial emission trends. In New Zealand, a major exercise to evaluate the Resource Management Act has been conducted by an environmental NGO.

In addition to evaluating the impact of their BAT policies overall, many governments assess whether the techniques defined as BAT are indeed the *best available* techniques, as part of regular reviews of BAT reference documents (BREFs). For example, the IED requires EU BREFs to be revised on a maximum eight years cycle, in order to reflect technical progress. Korea sets out to update BREFs every five years, based on information resulting from various evaluation exercises, such as of the applicability of existing BREFs. The US' Clean

Air Act requires that a risk and technology review be conducted eight years after setting technology-based standards for hazardous air pollutants.

13.3. Data requirements for evaluation of BAT-based policies

This report shows that many government currently do not collect and/or publish the most appropriate set of data needed for an ex post analysis of the impact of BAT policies on emission trends. Readily available data on key parameters, notably emissions, defined objectives and production or consumption volumes, are a prerequisite for effectiveness evaluations of BAT policies:

i. **Emissions monitoring data**, ideally at installation level and for a period *before and after* implementation of the BAT policy, are essential for the analysis of emission trends. The quality and availability of this type of data largely depend on the organisation of local data collection, the level of detail of reporting to competent authorities, and the user-friendliness of relevant databases. Data from PRTRs, i.e. facility level data, can be an option for the assessment of policy impacts on industrial emissions, in the absence of emissions monitoring data disaggregated at the level of each installation. Two major advantages of PRTRs are that data are publicly available and that reporting is periodic.

ii. **Information on BAT-associated emission levels and/or the emission limit values of individual facilities** is crucial in order to compare emissions monitoring data to objectives defined under the BAT policy. Governments can facilitate access to such data e.g. by making individual permit information publicly available.

iii. **Activity data** (e.g. production volumes or consumption data), preferably at the same level of aggregation as the monitoring or PRTR data, is necessary in order to analyse emission trends in the light of changes in economic activity. The activity data should be comparable across years. As disaggregated activity data can be hard to access, capacity data can be a useful indicator of production at the level of individual installations. In addition, some sector organisations and national research institutes release capacity and activity data for several countries, providing another valuable source of information.

iv. **Information on the emissions reduction techniques installed by operators** further facilitates the evaluation of the effectiveness of BAT policies. This information can be collected by governments and published in a publicly available database.

This report shows, however, that even where detailed quantitative data are available, it can be hard to determine whether observed emission trends, or changes in industrial technology, can be attributed only to the BAT policy. One way to draw a conclusion in this regard is to assess which external factors, such as other policies or changes to economic activity, could also affect emission trends.

The report contains an example analysis (see Chapter 2.), which explores how the effectiveness of policy instruments for industrial emissions reduction could be evaluated, based on activity and emissions monitoring data for the primary aluminium and copper production sectors in Chile, the EU and the US. The analysis shows, for example, that SO_2 emissions from copper plants in the EU decreased by 16% over the period 2008-2015, in spite of production increase of 5% over the same period. However, it also demonstrates that it can be hard to draw conclusions on the impact of BAT policies on emission trends, due to, inter alia, the lack of emissions data from the period before adoption of current industrial emission policies, the absence of readily available installation level data, and limited information on the characteristics and permit conditions of individual facilities. Furthermore, due to the recent or ongoing implementation of new regulations, such as of the EU BAT Conclusions for the non-ferrous metals industries, it is too early to conduct an ex-post evaluation of their impact at this stage.

As a complement to country-wide datasets, case studies can provide telling illustrations of the effects of BAT policies on emission trends. This report presents a series of case studies for various industrial sectors and pollutants. These cases show that some BAT policies tend to trigger the implementation of new, more effective techniques, and thus emissions reductions.

While the effectiveness evaluations considered in this report primarily concern the impact of BAT merely on emission trends, the report also makes reference to methodologies for a more detailed cost-benefit analysis of BAT policies. Assessing the benefits of a BAT policy to society as a whole requires additional data, such as on the damage costs of industrial pollution, e.g. its implications for human health, productivity and the environment. In a cost-benefit analysis, these benefits can be compared to the industry's cost of adopting BAT, provided that such data are available.

13.4. Strengths and limitations of existing BAT-based policies

Whilst an evaluation based on quantitative data is preferable, qualitative information, such as stakeholder opinions, can be an important complement to quantitative data. Such data may be shaped by the experiences and biases of the stakeholders. The stakeholders consulted for the development of this report include representatives from governmental agencies, industry associations, NGOs and academia. They highlight several benefits of existing BAT-based policies. For example, European industry representatives highlight that the EU IED creates a level playing field for industry, aligning environmental performance requirements for industrial installations. The Russian BAT Bureau stresses that their BAT policy will likely foster enhanced resource efficiency and an upgrade of industry. Representatives of the European Commission further note that the integrated approach to pollution prevention and control is an important advantage of the EU's BAT policy. Other stakeholders highlight that the participatory approach is gaining traction as a result of the BAT-based approach, as illustrated by projects in countries with emerging economies such as India and Pakistan.

Further, the stakeholders emphasise the potential for further improvement of current emissions reduction policies. For example, representatives of the European Commission highlight the need to consider value chain approaches to BAT determination, and European industry representatives underline the importance of developing more transparent and inclusive procedures for the determination of BAT and BAT-associated emission levels (BAT-AELs), and the translation of BAT into emission limit values. The European Environmental Bureau stresses the necessity of ensuring that the BAT-AELs reflect the performance achieved by the most effective techniques for the prevention or reduction of environmental impacts, and that the BAT determination process is fair, transparent, inclusive and governed by clear decision-making and conflict-of-interest rules. A Chilean industry representative notes the need to shorten the time spent by competent authorities on assessing permit applications from industry operators, and highlights the potential for the Chilean government to use PRTR data more widely in informing policy-making and research. The Russian BAT Bureau and the Korean National Institute for Environmental

Research address the need to enhance the capacity of competent authorities, and the Israeli Ministry of Environmental Protection observes the need to strengthen inspection routines.

Other suggested measures for strengthened policy performance include setting up more optimal monitoring systems and user-friendly databases allowing easy and timely gathering of information on performance and underlying drivers, for the purposes of benchmarking, compliance assessment, research, policy development, public awareness raising and engagement.

Furthermore, the (OECD, n.d.[1]) considers that having wider inclusivity in the selection of industry experts involved would further be of value, increasing the participation of service providers, small and medium sized enterprises and foreign companies, so as to ensure that techniques identified as BAT are indeed the *best available* techniques worldwide, developed on a scale to be implemented in the relevant sector, under economically and technically viable conditions.

13.5. The way forward

In order to improve existing and future BAT policies, further research as well as enhanced guidance to countries is needed. To that end, the OECD will continue its BAT project by developing guidelines on how to determine BAT, derive BAT-AELs from BAT as well as translate BAT-AELs into emission limit values in permits. Further, the OECD will conduct a study on value chain approaches to determining BAT for industrial installations, and cross-country comparisons of BAT and BAT-AELs for selected industrial sectors, in order to foster enhanced knowledge sharing.

Table 13.1. Key findings from the ten chapters in Part 2 of the report

	US	Chile	EU	Israel	Korea	Russian Federation	India	People's republic of China	Kazakhstan	New Zealand
Industrial emissions legislation	Clean Air Act (1970); Clean Water Act (1972); and Pollution Prevention Act (1990)	Supreme Decrees by the Ministry of Environment (No. 13/2011, No. 29/2013 and No. 28/2013)	Industrial Emissions Directive (IED) (2010)	Clean Air Law (2008); Prevention of Sea Pollution from Land-Based Sources Law (1988); and Water Regulations and Business Licensing Regulations	Act on the Integrated Control of Pollutant-Discharging Facilities (the 'IPPC Act') (2017)	Federal Law on Environmental Protection (2014) and related legislative acts	Pollution Control Law Series (2010)	The Administration Regulations for Revisions of Environmental Protection Standards (2017); the Directives for Development of Guidelines of Pollution Prevention and Control Available Techniques (2018); and Implementation Plan for Controlling Pollutant Discharge Permit System (2016)	Environmental Code (2007)	Resource Management Act (RMA) (1991)
Implementation mechanisms	A variety of legally binding technology-based performance standards; and medium-	Emission limit values in environmental permits; air emission and effluent standards; and Clean	Legally binding emission limit values in integrated environmental permits, based on BAT-AELs	Legally binding emission limit values in medium-specific environmental permits, based on BAT-AELs	Legally binding Maximum Discharge Levels in integrated environmental permits, based	Legally binding emission limit values in integrated environmental permits, based on BAT-AELs	Minimal National Standards (MINAS) and sector-specific guidelines or Comprehensive Industry	Legally binding emission limit values in integrated environmental permits (not based on BAT), environmental	BAT documents	National Environmental Standards (NES) and Best Practical Options (BPO)

	specific environmental permits	Production Agreements (CPA), sometimes based on BAT			on BAT-AELs		Documents Series (COINDS)	quality and emission standards; and Guidelines on Available Technologies of Pollution Prevention and Control (GATPPCs)		
Publicly available sources of emissions monitoring data	PRTR (Toxics Release Inventory (TRI)) for 692 substances; installation level emissions monitoring data in the National Emissions Inventory (NEI); the WebFIRE database	PRTR (El Registro de Emisiones y Transferenciade Contaminantes (RETC)) for 130 substances; Sistema Nacional de Información de Fiscalización Ambiental (Snifa)	PRTR (E-PRTR) for 92 substances; installation level emissions monitoring data collected by Member States' competent authorities, but not always publicly available	PRTR for 114 substances; installation level emissions monitoring data collected by MoEP and also publicly available	PRTR for 415 substances; facility inventory data, self-monitoring data, plant survey data and continuous air and water emissions monitoring data collected, but not publicly available	No PRTR; some emissions monitoring data available in State reports at national or regional level; continuous emissions monitoring under implementation	No PRTR; continuous emissions monitoring data for 17 highly polluting industries, not yet publicly available	No national PRTR, but some regions and organisations have launched PRTR pilots; some emissions monitoring data available online for state-owned pollution sources	PRTR data available for some sectors and companies.	No PRTR; some emissions monitoring data available in the Good Practice Guides for Managing Air Quality, aggregated
Available sources of activity data	No data available at facility level; production volumes at national level available in the US Geological Survey	Data on production capacities available	(i) Scarce data on production volume at facility level available via E-PRTR; (ii) Eurostat: data on production volume at sector level, in monetary units, difficult to correlate to	(i) Production capacities included in applications for air emission permits (publicly available); some production data available in permit holders' annual	Data on production volumes by sector unit is available	Available for some sectors	Will be available for 17 sectors under the continuous emissions monitoring system in the future	No data available	No data available	No data available

			IED activities; (iii) data on production capacity included in permits, sometimes accessible online	compliance reports						
Governmental evaluation projects	The impact of federal and state regulations on emissions of pollutants to air has been described in a 2018 report by the US EPA, but no plan for regular evaluations	Official methodological guide to evaluate the ex post effectiveness of environmental programmes and regulations – impact assessment of emission standards is ongoing, but no plan for regular evaluations	Continuous evaluation stipulated by the IED; the European Commission's Regulatory Fitness and Performance Programme; several studies conducted at EU and Member State level. Evaluations also carried out by environmental NGOs	One report has been published including quantitative assessment was published of the reductions in annual loads of air emissions expected in each industrial sector following the implementation of the BAT requirements, but no plan for regular evaluations	Ex post evaluation conducted by all permitted plants; quantitative and qualitative assessments of the field applicability of BREFs	Some assessment included in the State of the Environment reports, but no plan for regular evaluations. Sectoral ex ante assessment conducted for the aluminium sector	No methodology, ad hoc evaluations	Official guidelines to assess the effectiveness of environmental policies, but not yet used in practice due to data gaps	No methodology available.	The RMA is evaluated at the national and regional levels, but irregularly and without a fixed methodology. Evaluations also carried out by environmental NGOs
Suggested measures for strengthened policy performance	n.a.	Setting more stringent national emission standards and enhancing enforcement at the local level;	Developing more standardised and transparent procedures to determine Key Environmental	Introducing integrated environmental permitting; focusing more on prevention at source and efficiency	Strengthening the capacity of relevant authorities and other stakeholders, increasing industries'	Developing BAT Conclusions, providing training and support to industry operators;	Setting more stringent standards; strengthening enforcement (e.g. stricter timelines and better	Creating an effective link between permit conditions and BAT by making it mandatory to align the development of	Introducing integrated environmental permitting under the revised Environmental Code, based	Clarifying the national direction for achieving environmental objectives, developing a more effective

	shortening the time for assessment of permit applications in order to attract investors	Issues and BAT-AELs, including by ensuring a better balance of stakeholder interests; making emissions monitoring data more easily available; considering a value chain approach to BAT determination	measures; digitising emissions monitoring data	involvement, in particular for small size industry; improving emissions monitoring and ensuring access to monitoring data	building capacity in permitting authorities, developing best practice-based legislation for Category II industries; identifying indicators and approaches for effectiveness evaluation; agreeing on an adequate BREF review cycle	coordination amongst ministries); enhancing involvement of industry and the public; building financial capacity to fund demonstration projects	GATPPCs, emission standards and emission limit values in permits; developing an adequate mechanism for review of BAT	on legally binding emission limit values and BAT; and ensuring transparent, multi-stakeholder processes for establishing BAT and BAT-AELs	strategy and oversight and a more integrated decision-making process, increasing the capacity of, and re-focusing, the government authorities involved, improving evaluation and monitoring

References

Ahmadzai, H. (2018), *A Global Approach: Emissions – Releases and Cross-media Aspects in Assessments – BAT- BEP*, 73rd Meeting of the BEAC WGE Subgroup for Hotspots Exclusion, Skellefteå. [62]

AMEC Environment & Infrastructure UK Limited (2014), *Contribution of industry to pollutant emissions to air and water*, Publications Office of the European Union, http://dx.doi.org/10.2779/25422. [46]

AMEC Environment & Infrastructure UK Limited (2012), *Updated Impact Assessment of the Industrial Emissions Directive (IED)*, Defra, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/82614/industrial-emissions-amec-ia-120312.pdf. [49]

Aurubis (2018), *Environmental Protection in the Aurubis Group and Updated Aurubis AG Environmental Statement 2018 Hamburg and Lünen Sites*, https://www.aurubis.com/binaries/content/assets/aurubis-en/dateien/responsibility/20180815_aurubis_umwelterklaerung_2018_en_einzelseiten.pdf (accessed on 14 December 2018). [56]

BMU (2002), *Erste Allgemeine Verwaltungsvorschrift zum Bundes–Immissionsschutzgesetz (Technische Anleitung zur Reinhaltung der Luft – TA Luft) [Technical Instruction on Air Quality]*, https://www.bmu.de/fileadmin/Daten_BMU/Download_PDF/Luft/taluft.pdf (accessed on 14 December 2018). [57]

Boliden (2017), *Miljörapport 2017 – Boliden Rönnskärs och Rönnskärs hamn*. [59]

Brown, M., R. Peart and M. Wright (2016), *Evaluating the environmental outcomes of the RMA*, http://www.eds.org.nz/our-work/publications/reports/evaluating-the-RMA/ (accessed on 14 December 2018). [123]

Coglianese, C. (2012), *Measuring Regulatory Performance: Evaluating the Impact of Regulation and Regulatory Policy*, OECD, https://www.oecd.org/gov/regulatory-policy/1_coglianese%20web.pdf (accessed on 17 December 2018). [5]

CPCB (2017), *Guidelines for Continuous Emission Monitoring Systems*, http://cpcb.nic.in/cpcbold/Guidelines_on_CEMS_02.08.2017.pdf (accessed on 18 December 2018). [103]

CPCB (2010), *Pollution Control Acts, Rules and Notifications issued thereunder*, http://cpcb.nic.in/PollutionControlLaw.pdf. [102]

CPCB (2003), *Charter on Corporate Responsibility for Environmental Protection*, http://www.indiansugar.com/PDFS/CREP-2003-FullText.pdf (accessed on 14 December 2018). [106]

Dashti, A. (2018), "Chile sends SOS to WHO after massive intoxication in Valparaíso region", *The Santiago Times*, https://santiagotimes.cl/2018/09/02/chile-sends-sos-to-who-after-massive-intoxication-in-valparaiso-region. [87]

DeVito, S., C. Keenan and D. Lazarus (2015), "Can pollutant release and transfer registers (PRTRs) be used to assess implementation and effectiveness of green chemistry practices? A case study involving the Toxics Release Inventory (TRI) and pharmaceutical manufacturers", *Green Chemistry*, Vol. 17/5, pp. 2679-2692, http://dx.doi.org/10.1039/c5gc00056d. [74]

Dudley, S. (2017), "Retrospective evaluation of chemical regulations", *OECD Environment Working Papers*, No. 118, OECD Publishing, Paris, https://dx.doi.org/10.1787/368e41d7-en. [15]

Dudley, S., K. Wegrich and D. Wegrich (2015), *Achieving Regulatory Policy Objectives: An Overview and Comparison of U.S. and EU Procedures Achieving Regulatory Policy Objectives An Overview and Comparison of U.S. and EU Procedures*, The George Washington University, https://regulatorystudies.columbian.gwu.edu/sites/g/files/zaxdzs1866/f/downloads/Dudley-Wegrich_US-EU_RegOverview.pdf (accessed on 17 December 2018). [13]

EC (2018), *Application of IED Article 15(4) derogations*, Carried out by AMEC Environment & Infrastructure UK Limited for the European Commission, https://circabc.europa.eu/sd/a/9b59019b-df6c-4e6c-a5c2-1fb25cfe049c/IED%20Article%2015(4)%20Report.pdf. [43]

EC (2018), *EU industrial emissions rules in action: Leather sector eco-innovation*, https://publications.europa.eu/en/publication-detail/-/publication/a3bb443a-7822-11e8-ac6a-01aa75ed71a1/language-en. [63]

EC (2018), *Ex-post assessment of costs and benefits from implementing BAT under the Industrial Emissions Directive*, Carried out by Ricardo Energy & Environment for the European Commission, https://circabc.europa.eu/sd/a/28bb7d3c-cf70-4a80-a73a-9fb90bb4968f/Iron%20and%20Steel%20BATC%20ex-post%20CBA.pdf (accessed on 13 December 2018). [42]

EC (2018), *Industrial policy indicators*, http://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=14566 (accessed on 14 December 2018). [41]

EC (2018), *Summary of Directive 2010/75/EU on industrial emissions*, http://ec.europa.eu/environment/industry/stationary/ied/legislation.htm (accessed on 19 February 2019). [135]

EC (2018), *Summary on IED contribution to water policy*, Carried out by Ricardo Energy & Environment for the European Commission, https://circabc.europa.eu/sd/a/af2ff560-431b-4b61-b318-4543a9b176ff/Summary%20on%20IED%20contribution%20to%20water%20policy.pdf. [10]

EC (2017), *Report from the Commission to the Council and the European Parliament on implementation of Directive 2010/75/EU and final reports on its predecessor legislation*, http://www.ipex.eu/IPEXL-WEB/dossier/document/COM20170727.do. [40]

EC (2016), *Analysis and development of methodologies for estimating potential industrial emissions reductions and compliance costs of BAT conclusions adopted under the Industrial Emissions Directive*, Carried out by Ricardo Energy & Environment for the European Commission, https://circabc.europa.eu/sd/a/0a14b5db-bc53-4777-b2a0-8eee208d6068/1_FINAL%20REPORT.pdf. [44]

EC (2015), *Assessing the potential emission reductions delivered by BAT conclusions adopted under the directive on industrial emissions (IED)*, Carried out by AMEC Environment & Infrastructure UK Limited for the European Commission, https://circabc.europa.eu/sd/a/44aaf4c4-d716-4f02-91ab-a526b07ee6b7/Final%20report_20150501.pdf. [45]

EC (2013), *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Strengthening the foundations of Smart Regulation – improving evaluation*, http://ec.europa.eu/budget/biblio/documents/regulations/regulations_en.cfm (accessed on 17 December 2018). [3]

EC (2006), *Guidance Document for the implementation of the European PRTR*, http://ec.europa.eu/environment/industry/stationary/eper/pdf/en_prtr.pdf (accessed on 26 February 2019). [136]

EC (n.d.), *REFIT - Making EU law simpler and less costly*, https://ec.europa.eu/info/law/law-making-process/evaluating-and-improving-existing-laws/refit-making-eu-law-simpler-and-less-costly_en (accessed on 13 December 2018). [39]

EDS (2016), *Evaluating the environmental outcomes of the RMA*, http://www.eds.org.nz/our-work/publications/reports/evaluating-the-RMA/. [124]

EEA (2018), *Greening the power sector: benefits of an ambitious implementation of Europe's environment and climate policies*, https://www.eea.europa.eu/themes/industry/industrial-pollution-in-europe/benefits-of-an-ambitious-implementation. [47]

EEB (2017), *Burning: The Evidence*, https://eeb.org/publications/61/industrial-production/47539/burning-the-evidence.pdf (accessed on 13 December 2018). [51]

EIPCCB (2017), *Best Available Techniques (BAT) Reference Document for the Non-Ferrous Metals Industries*, http://eippcb.jrc.ec.europa.eu/reference/BREF/NFM/JRC107041_NFM_bref2017.pdf (accessed on 31 January 2019). [34]

EIPPCB (2007), *Reference Document on Best Available Techniques for the Manufacture of Large Volume Inorganic Chemicals - Ammonia, Acids and Fertilisers*, http://eippcb.jrc.ec.europa.eu/reference/BREF/lvic_aaf.pdf (accessed on 31 January 2019). [26]

EIPPCB (2006), *Integrated Pollution Prevention and Control: Reference Document on Economics and Cross-Media Effects*, http://eippcb.jrc.ec.europa.eu/reference/BREF/ecm_bref_0706.pdf (accessed on 13 December 2018). [88]

EIPPCB (2006), *Reference Document on Emissions from Storage*, http://eippcb.jrc.ec.europa.eu/reference/BREF/esb_bref_0706.pdf (accessed on 13 December 2018). [89]

Environment Agency (2017), *Regulating for people, the environment and growth*, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/663672/Regulating_for_people_the_environment_and_growth_2016_summary.pdf. [53]

ENVIS (2016), *Industrial Pollution - Comprehensive Environmental Pollution Index (CEPI)*, http://cpcbenvis.nic.in/industrial_pollution.html. [104]

EU (2017), *Commission Implementing Decision (EU) 2017/1442 of 31 July 2017 establishing best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for large combustion plants*, https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1503383091262&uri=CELEX:32017D1442 (accessed on 31 January 2019). [48]

EU (2016), *Commission Implementing Decision (EU) 2016/1032 of 13 June 2016 establishing best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for the non-ferrous metals industries*, https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1548941950414&uri=CELEX:32016D1032 (accessed on 31 January 2019). [25]

EU (2016), *Terms of Reference of a Study on Key Environmental Issues*, https://circabc.europa.eu/ui/group/06f33a94-9829-4eee-b187-21bb783a0fbf/library/5a427270-f380-47ca-96be-4804da6f1bff/details (accessed on 31 January 2019). [131]

EU (2016), *Treaty on the Functioning of the European Union*, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.C_.2016.202.01.0001.01.ENG&toc=OJ:C:2016:202:TOC#C_2016202EN.01004701. (accessed on 13 December 2018). [37]

EU (2012), *Commission Implementing Decision of 10 February 2012 laying down rules concerning guidance on the collection of data and on the drawing up of BAT reference documents and on their quality assurance referred to in Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions*, https://eur-lex.europa.eu/eli/dec_impl/2012/119/oj (accessed on 31 January 2019). [132]

EU (2012), *Directive 2012/18/EU of the European Parliament and of the Council of 4 July 2012 on the control of major-accident hazards involving dangerous substances, amending and subsequently repealing Council Directive 96/82/EC Text with EEA relevance*, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32012L0018. [54]

EU (2010), *Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control)*, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32010L0075&from=EN. [23]

EU (2006), *Regulation (EC) No 166/2006 of the European Parliament and of the Council of 18 January 2006 concerning the establishment of a European Pollutant Release and Transfer Register and amending Council Directives 91/689/EEC and 96/61/EC*, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32006R0166&from=EN. [52]

EU (2000), *Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy*, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32000L0060. [38]

EU (1996), *Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control*, http://COUNCIL DIRECTIVE 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control. [31]

EU (1984), *Council Directive 84/360/EEC of 28 June 1984 on the combating of air pollution from industrial plants*, https://publications.europa.eu/en/publication-detail/-/publication/528ec084-3b51-44d4-8511-d9c612d6b651/language-en. [35]

Gaona, S. (2018), "The Utility of the Toxic Release Inventory (TRI) in Tracking Implementation and Environmental Impact of Industrial Green Chemistry Practices in the United States", in *Green Chemistry*, InTech, http://dx.doi.org/10.5772/intechopen.70716. [73]

Gertler, P. et al. (2011), *Impact Evaluation in Practice*, The World Bank, http://siteresources.worldbank.org/EXTHDOFFICE/Resources/5485726-1295455628620/Impact_Evaluation_in_Practice.pdf (accessed on 17 December 2018). [7]

Government of Chile (2013), *National Green Growth Strategy*, http://www.hacienda.cl/documento/descargar/id/9185. [78]

Government of Chile (2012), *NAMA: Clean Production Agreements*, http://unfccc.int/files/cooperation_support/nama/application/pdf/nama_recognition_cap_chile_october_2012.pdf. [77]

Government of China (2017), *Measures on Environmental Information Disclosure for Enterprises and Public Institutions*, http://www.gov.cn/gongbao/content/2015/content_2838171.htm (accessed on 14 December 2018). [110]

Government of China (2013), *Measures on Self-Monitoring and Information Disclosure for Key State-Monitored Enterprises*, http://www.nmgepb.gov.cn/govcatalog/kjbz_2509/201309/P020130926366131480511.pdf (accessed on 14 December 2018). [112]

Government of China (2013), *Notice of the Ministry of Environmental Protection on Printing and Distributing the Measures for Self-monitoring and Information Disclosure of National Key Monitoring Enterprises (Trial) and the Measures for Supervision and Monitoring of Pollution Sources of State Key Monitoring Enterprises (Trial)*, http://www.gov.cn/gongbao/content/2013/content_2496407.htm (accessed on 14 December 2018). [108]

Government of China (2008), *Measures on Environmental Information Disclosure*, http://www.gov.cn/flfg/2007-04/20/content_589673.htm (accessed on 14 December 2018). [111]

Government of China (n.d.), *Several Opinions of the General Office of the State Council on Strengthening the Service for and Supervision of Market Subjects by Applying Big Data*, 2015, http://www.gov.cn/zhengce/content/2015-07/01/content_9994.htm (accessed on 14 December 2018). [109]

Government of Russian Federation (2018), *State report on the state and protection of the environment of the Russian Federation in 2016*, http://mnr.gov.ru/docs/o_sostoyanii_i_ob_okhrane_okruzhayushchey_sredy_rossiyskoy_federatsii/gosudarstvennyy_doklad_o_sostoyanii_i_ob_okhrane_okruzhayushchey_sredy_rossiyskoy_federatsii_v_2016_/. [98]

Government of the Russian Federation (2016), *Report on the ecological development of the russian federation in the interests of future generations*, http://ecoline.ru/wp-content/uploads/report-on-the-ecological-development-of-the-russian-federation-in-the-interests-of-future-generations-2016.pdf. [97]

Government of the Russian Federation (2015), *Federal Law No. 162-FZ "On standardization"*, https://www.ecolex.org/details/legislation/federal-law-no-162-fz-on-standardization-lex-faoc156879/. [94]

Government of the Russian Federation (2015), *Постановление от 28 сентября 2015 г. № 1029 об утверждении критериев отнесения объектов, оказывающих негативное воздействие на окружающую среду, к объектам I, II, III и IV категорий [Decree No 1029 of 28 September 2015 on Setting Criteria to Categories I, II, III and IV of Installations Causing Negative Environmental Impacts]*, http://static.government.ru/media/files/oHAMAREx1e9uyphc0U8Vq5ikOoyMOrAo.pdf (accessed on 14 December 2018). [96]

Government of the Russian Federation (2014), *Federal Law No. 219-FZ amending Federal Law No. 7-FZ on environmental protection*, https://www.ecolex.org/details/legislation/federal-law-no-219-fz-amending-federal-law-no-7-fz-on-environmental-protection-lex-faoc140704/. [91]

Government of the Russian Federation (2002), *Federal Law No. 7-FZ on environmental protection*, https://www.ecolex.org/details/legislation/federal-law-no-7-fz-on-environmental-protection-lex-faoc052751/ (accessed on 14 December 2018). [93]

Government of the Russian Federation (1999), *Federal Law No. 96-FZ on the protection of the atmospheric air*, https://www.ecolex.org/details/legislation/federal-law-no-96-fz-on-the-protection-of-the-atmospheric-air-lex-faoc052687/. [92]

Greenpeace European Unit (2015), *Smoke & Mirrors - How Europe's biggest polluters became their own regulators*, https://www.greenpeace.org/archive-eu-unit/en/Publications/2015/Smoke-and-Mirrors-How-Europes-biggest-polluters-became-their-own-regulators/ (accessed on 14 December 2018). [50]

HELCOM (2002), *Status of the hot spots in Denmark, Finland, Germany and Sweden*, http://www.helcom.fi/Lists/Publications/BSEP99.pdf (accessed on 14 December 2018). [58]

HELCOM (1992), *Convention on the Protection of the Marine Environment of the Baltic Sea Area (the Helsinki Convention)*, http://www.helcom.fi/documents/about%20us/convention%20and%20commitments/helsinki%20convention/1992_convention_1108.pdf. [61]

ICSG (2013), *Directory of copper mines and plants*. [32]

ICSG (2013), *DIRECTORY OF COPPER MINES AND PLANTS: Up to 2017*. [30]

IGTIC (2018), *Concept of transition of Kazakhstan to the principles of Best Available Technologies (BAT) for the period of 5 years (draft of January 2019)*. [121]

IGTIC (2018), *Concept of transition of Kazakhstan to the principles of Best Available Technologies (BAT) for the period of 5 years, draft of January 2019*. [133]

IIASA (2009), *GAINS Online: Tutorial for advanced users*, https://pingpdf.com/pdf-gains-online-tutorial-for-advanced-users-iiasa.html. [22]

Jiang, C. et al. (2012), "Application of Best Available Technologies on Medical Wastes Disposal/Treatment in China (with case study)", *Procedia Environmental Sciences*, Vol. 16, pp. 257-265, http://dx.doi.org/10.1016/j.proenv.2012.10.036. [116]

Jun, M. et al. (2018), *Establishing a PRTR Disclosure System in China*, Institute of Public and Environmental Affairs and IPEN, https://ipen.org/sites/default/files/documents/IPE%20IPEN%20PRTR%20report_EN_5.9.pdf (accessed on 18 December 2018). [107]

Kamyotra, J. (2018), *Environmental Compliance by Thermal Power Plants in India*. [105]

Legal Information Institute (n.d.), *Emission Standards for New and Existing Affected Sources*, https://www.law.cornell.edu/cfr/text/40/appendix-Table_1_to_subpart_RRR_of_part_63 (accessed on 14 December 2018). [71]

Madden, B. (2016), *Value Creation Thinking*, Learning What Works, http://www.valuecreationthinking.com/ (accessed on 17 December 2018). [4]

MEE (2017), *Technical specification for application and issuance of pollutant permit non-ferrous metal metallurgy Industry — lead and zinc smelting (HJ 863.1—2017 2017-09-29 implementation)*, http://kjs.mee.gov.cn/hjbhbz/bzwb/other/hjbhgc/201710/W020171010328581745201.pdf (accessed on 14 December 2018). [115]

MEE (2010), *Emission standard of pollutants for lead and zinc industry (GB 25466 - 2010, 2010-10-01)*, http://www.cesp.com.cn (accessed on 14 December 2018). [114]

MfE (2016), *Good practice guide for assessing and managing dust*, http://www.mfe.govt.nz/publications/air/good-practice-guide-assessing-and-managing-dust. [125]

MfE (2016), *Good practice guide for assessing and managing dust*, http://www.mfe.govt.nz/publications/air/good-practice-guide-assessing-and-managing-dust (accessed on 14 December 2018). [126]

MfE (2011), *2011 users' guide to the revised National Environmental Standards for Air Quality: Updated 2014*, http://www.mfe.govt.nz/publications/rma-air/2011-users-guide-revised-national-environmental-standards-air-quality-updated (accessed on 14 December 2018). [127]

MfE (2011), *Clean healthy air for all New Zealanders: The National Air Quality Compliance Strategy to meet the PM10 standard*, http://www.mfe.govt.nz/publications/air/clean-healthy-air-all-new-zealanders-national-air-quality-compliance-strategy-meet (accessed on 14 December 2018). [128]

Ministry of Public Works (1988), *Ley General de Servicios Sanitarios*, https://www.leychile.cl/Navegar/?idNorma=5545 (accessed on 13 December 2018). [82]

MMA (2017), *Guía Metodológica para Evaluación ex post de programas y normativa ambiental*, http://catalogador.mma.gob.cl:8080/geonetwork/srv/spa/resources.get?uuid=571fd106-d186-455c-addb-9105fab1062c&fname=Gu%C3%ADa%20metodol%C3%B3gica%20para%20Evaluaci%C3%B3n%20ex%20post.pdf&access=public (accessed on 13 December 2018). [129]

MMA (2017), *Registro de Emissiones y Transferencia de Contiminantes 2005-2014*, http://www.retc.cl/wp-content/uploads/2017/12/MEDIOAMBIENTE.compressed.pdf (accessed on 13 December 2018). [86]

MMA (2013), *Aprueba Reglamento del Sistema de Evaluacion de Impacto Ambiental [Approves Regulation of the System of Evaluation of Environmental Impact] (Decree 40)*, https://www.leychile.cl/Navegar?idNorma=1053563 (accessed on 6 March 2019). [84]

MMA (2013), *Establece Norma de Emisión Para Fundiciones de Cobre y fuentes Emisoras de Arsénico [Establishes Emission Standard for Copper Smelters and Arsenic Emission Sources]*, https://www.leychile.cl/Navegar?idNorma=1057059 (accessed on 18 December 2018). [28]

MMA (2013), *Establece Norma de Emision para Incineration, Coincineration y Coprocesamiento [Establishes Emission Standard for Incineration, Coincineration and Coprocessing]*, https://www.leychile.cl/Navegar?idNorma=1054148 (accessed on 6 March 2019). [80]

MMA (2011), *Establece Norma de Emisión para Centrales Termoeléctricas [Establishes Emission Standard for Thermoelectric Power Plants]*, https://www.leychile.cl/Navegar?idNorma=1026808 (accessed on 6 March 2019). [79]

MMA (2007), *Decree 156 of 2007 establishing the rules for the management, protection, restoration, use, conservation and promotion of Forest, Protected Areas and Wildlife resources*, https://digitalrepository.unm.edu/la_energy_policies/154/. [75]

MMA (1994), *Aprueba ley Sobre Bases Generales del Medio Ambiente [Approves law on General Bases of the Environment] (Law 19300)*, https://www.leychile.cl/Navegar?idNorma=30667 (accessed on 6 March 2019). [83]

MoEP (2018), *2017 Emissions and Transfers*, http://www.sviva.gov.il/English/env_topics/IndustryAndBusinessLicensing/PRTR/annual-prtr-reports-israel/Pages/2017-PRTR-data.aspx (accessed on 13 December 2018). [90]

MoJ (2008), *The Decision of the Chief Sanitary Officer of the Russian Federation of September 25, 2007 on issuing the new edition of the Sanitary and Epidemiological Regulations SanPiN 2.2.1/2.1.1.1200-03 "Sanitary zones and sanitary classification of enterprises, constructions and other installations"*, https://rg.ru/2008/02/09/sanitar-dok.html (accessed on 18 December 2018). [130]

MoNRE (2018), *On approving the list of installations causing negative environmental impact, categorised as Catogory I installations and contributing not less than 60 per cent towards total emissions of pollutants into the environment in the Russian Federation*, https://rg.ru/2018/07/03/minprirody-prikaz-154-site-dok.html (accessed on 18 December 2018). [95]

MoNRE of the Krasnoyarsk Region (2016), *Государственный доклад О состоянии и охране окружающей среды в Красноярском крае в 2016 году [State report on the state and protection of the environment in the Krasnoyarsk Region in 2016]*, http://www.mpr.krskstate.ru/dat/bin/art_attach/8804_2017.10.11_doklad_2016_gotovij_variant.pdf. [99]

Newcomer, K., H. Hatry and J. Wholey (2015), *Handbook of Practical Program Evaluation*, Wiley. [2]

OECD (2018), *Cost-Benefit Analysis and the Environment: Further Developments and Policy Use*, OECD Publishing, Paris, https://dx.doi.org/10.1787/9789264085169-en. [14]

OECD (2018), *Recommendation of the Council on Establishing and Implementing Pollutant Release and Transfer Registers (PRTRs)*, https://legalinstruments.oecd.org/en/instruments/OECD-LEGAL-0440 (accessed on 12 December 2018). [18]

OECD (2018), *Report on OECD Project on best available techniques for preventing and controlling industrial chemical pollution - Activity II: Approaches to establishing best available techniques (BAT) around the world*, http://www.oecd.org/chemicalsafety/risk-management/approaches-to-establishing-best-available-techniques-around-the-world.pdf. [36]

OECD (2017), *Multi-dimensional Review of Kazakhstan - Volume 2. In-depth Analysis and Recommendations*, OECD Publishing, https://www.oecd-ilibrary.org/development/multi-dimensional-review-of-kazakhstan_9789264269200-en (accessed on 19 February 2019). [118]

OECD (2017), *Multi-dimensional Review of Kazakhstan: Volume 2. In-depth Analysis and Recommendations, OECD Development Pathways*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264269200-en. [134]

OECD (2016), *Environmental Performance Reviews Chile*, http://www.oecd.org/env/oecd-environmental-performance-reviews-chile-2016-9789264252615-en.htm. [76]

OECD (2016), *The Economic Consequences of Outdoor Air Pollution*, OECD Publishing, Paris, https://dx.doi.org/10.1787/9789264257474-en. [8]

OECD (2014), *Global PRTR: Proposal For A Harmonised List Of Pollutants*, OECD, http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=env/jm/mono(2014)32&doclanguage=en (accessed on 12 December 2018). [20]

OECD (2013), *Global PRTR: Proposals for a Harmonised List or Reporting Sectors*, http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=env/jm/mono(2013)5&doclanguage=en (accessed on 12 December 2018). [21]

OECD (2013), *Revised OECD Core Set of Environmental Indicators*. [16]

OECD (2008), *Introductory Handbook for Undertaking Regulatory Impact Analysis (RIA)*, https://www.oecd.org/gov/regulatory-policy/44789472.pdf (accessed on 17 December 2018). [12]

OECD (2005), *Analytical Framework for Evaluating the Costs and Benefits of Extended Producer Responsibility Programmes*, http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?doclanguage=en&cote=env/epoc/wgwpr(2005)6/final (accessed on 17 December 2018). [6]

OECD (2004), *OECD Trade and Environment Working Paper No. 2004-05 - Identifying Complementary Measures to Ensure the Maximum Realisation of Benefits from the Liberalisation of Trade in Environmental Goods and Services - Case Study: Chile*, https://www.oecd.org/tad/envtrade/37439790.pdf. [81]

OECD (1996), *Recommendation of the Council on Implementing Pollutant Release and Transfer Registers (PRTRs)*, https://legalinstruments.oecd.org/en/instruments/44 (accessed on 12 December 2018). [17]

OECD (n.d.), *Addressing Industrial Air Pollution in Kazakhstan: Reforming Environmental Payments? (forthcoming)*. [1]

OECD (n.d.), *OECD.Stat*, http://dotstat.oecd.org/Index.aspx?DataSetCode=AIR_EMISSIONS (accessed on 5 February 2019). [9]

OSPAR (1998), *OSPAR Recommendation 98/1 concerning Best Available Techniques and Best Environmental Practice for the Primary Non-Ferrous Metal Industry*, https://www.ospar.org/documents?d=32570 (accessed on 18 February 2019). [60]

Rosstat (n.d.), *Air emissions of pollutants from stationary sources, by type of economic activity*, http://www.gks.ru/free_doc/new_site/oxrana/tabl/tab_oxr3.htm (accessed on 18 February 2019). [100]

Rusal (2017), *Sustainability Report 2017: Allow for a Better Future*, https://rusal.ru/upload/iblock/b93/LTN201807271059.pdf (accessed on 14 December 2018). [101]

Schröder, W. et al. (2017), *Impacts of Heavy Metal Emission on Air Quality and Ecosystems across Germany. Sources, Transport, Deposition and potential Hazards*, German Environment Agency. [55]

State of Utah (2014), *Approval Order: Modification of Smelter AO to Change PM10 Stack Testing Requirements (Approval order number:DAQE-AN103460054-14).* [33]

UNECE (2019), *Environmental Performance Reviews: Kazakhstan, Third Review*. [119]

UNECE (2003), *Kyiv Protocol on Pollutant Release and Transfer Registers*, http://www.unece.org/fileadmin/DAM/env/pp/prtr/Protocol%20texts/PRTR_Protocol_e.pdf (accessed on 12 December 2018). [19]

UNEP (2012), *Compendium of Technologies for Treatment/Destruction of Healthcare Waste*, https://www.healthcare-waste.org/fileadmin/user_upload/resources/Compendium_Technologies_for_Treatment_Destruction_of_Healthcare_Waste_2012.pdf. [117]

UNITAR (2017), *Inception Workshop on Phase 2 Project on POPs Monitoring, Reporting& Information Dissemination Using Pollutant Release and Transfer Register (PRTR)*, http://cwm.unitar.org/cwmplatformscms/site/assets/files/1271/kazakhstasn_national_prtr_inception_workshop_report.pdf (accessed on 18 February 2019). [122]

Urrutia, J. and S. Avilés (2015), “Environmental law and practice in Chile: overview”, *Thomson Reuters Practical Law*, https://uk.practicallaw.thomsonreuters.com/1-503-4725?transitionType=Default&contextData=(sc.Default)&firstPage=true&comp=pluk&bhcp=1. [85]

US EPA (2018), *Our Nation’s Air: Air Quality Improves as America Grows*, https://gispub.epa.gov/air/trendsreport/2018/documentation/AirTrends_Flyer.pdf. [68]

US EPA (2018), *Our Nation’s Air: Status and Trends Through 2017*, https://gispub.epa.gov/air/trendsreport/2018/ (accessed on 12 December 2018). [67]

US EPA (2015), *Memorandum Regarding Technology Review for the Secondary Aluminum Production Source Category – Final Rule*, https://www.regulations.gov/document?D=EPA-HQ-OAR-2010-0544-0327 (accessed on 12 December 2018). [72]

US EPA (2015), *Primary Aluminum Reduction Industry - National Emission Standards for Hazardous Air Pollutants (NESHAP)*, https://www.epa.gov/stationary-sources-air-pollution/primary-aluminum-reduction-industry-national-emission-standards. [140]

US EPA (2011), *Summary of the Technology Review for the Secondary Lead Smelting Source Category*, https://www.regulations.gov/document?D=EPA-HQ-OAR-2011-0344-0154 (accessed on 12 December 2018). [70]

US EPA (2002), *Federal Water Pollution Control Act*, https://www.epa.gov/sites/production/files/2017-08/documents/federal-water-pollution-control-act-508full.pdf. [65]

US EPA (2002), *Primary Copper Smelting: National Emissions Standards for Hazardous Air Pollutants (NESHAP)*, https://www.epa.gov/stationary-sources-air-pollution/primary-copper-smelting-national-emissions-standards-hazardous-air. [138]

US EPA (1997), *Primary Aluminum Reduction Plants: New Source Performance Standards*, https://www.epa.gov/stationary-sources-air-pollution/primary-aluminum-reduction-plants-new-source-performance-standards. [139]

US EPA (1976), *Primary Copper Smelting: New Source Performance Standards*, https://www.epa.gov/stationary-sources-air-pollution/primary-copper-smelting-new-source-performance-standards#rule-summary. [137]

US EPA (n.d.), *Basic Information of Air Emissions Factors and Quantification*, https://www.epa.gov/air-emissions-factors-and-quantification/basic-information-air-emissions-factors-and-quantification (accessed on 14 December 2018). [24]

US EPA (n.d.), *Overview of the Clean Air Act and Air Pollution*, https://www.epa.gov/clean-air-act-overview (accessed on 26 February 2019). [11]

US EPA (n.d.), *Summary of the Clean Air Act*, https://www.epa.gov/laws-regulations/summary-clean-air-act. [64]

US EPA (n.d.), *Summary of the Pollution Prevention Act*, https://www.epa.gov/laws-regulations/summary-pollution-prevention-act (accessed on 26 February 2019). [66]

US EPA (n.d.), *Table of Historical Sulfur Dioxide National Ambient Air Quality Standards (NAAQS)*, https://www.epa.gov/so2-pollution/table-historical-sulfur-dioxide-national-ambient-air-quality-standards-naaqs. [27]

US EPA (n.d.), *TRI-Listed Chemicals*, https://www.epa.gov/toxics-release-inventory-tri-program/tri-listed-chemicals (accessed on 14 December 2018). [69]

US Geological Survey (2018), *Mineral commodity summaries 2018*, US Geological Survey, http://dx.doi.org/10.3133/70194932. [29]

Wang, S. et al. (2010), “Estimating mercury emissions from a zinc smelter in relation to China’s mercury control policies”, *Environmental Pollution*, Vol. 158/10, pp. 3347-3353, http://dx.doi.org/10.1016/j.envpol.2010.07.032. [113]

World Bank (2013), *Joint Economic Research Program (JERP), Towards Cleaner Industry and Improved Air Quality Monitoring in Kazakhstan*, http://documents.worldbank.org/curated/en/132151468047791898/pdf/839150WP0P133300Box0382116B00OUO090.pdf. [120]

Industrial pollution prevention and control policies can achieve significant environmental, financial and human health gains. A growing number of countries use Best Available Techniques (BAT) to set industrial emission levels that are rooted in evidence and based on multi-stakeholder dialogue. Evaluating the effectiveness of BAT-based policies is essential to enhance their impact and strengthen future policy design. However, many countries lack the most appropriate datasets for an adequate effectiveness analysis of their BAT-based policies.

This report provides an assessment of how governments can measure the effectiveness of their BAT-based policies to mitigate industrial pollution while generating benefits to society, such as improved air quality, and fostering efficient industrial operations. It presents the first comprehensive cross-country analysis of existing approaches to evaluating the impact of industrial emissions policies, and demonstrates the diverse approaches to such evaluations in the European Union, the United States, Chile, Israel, Korea, the Russian Federation, India, the People's Republic of China, Kazakhstan and New Zealand.

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

Visit our website: oe.cd/bat