European Union Network for the Implementation and Enforcement of Environmental Law

Integrating circular economy principles within IED permits

Assisting regulators in aligning IED permits with circular economy principles and measuring performance

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Introduction to IMPEL

The European Union Network for the Implementation and Enforcement of Environmental Law (IMPEL) is an international non-profit association of the environmental authorities of the European Union (EU) Member States, and of other European authorities, namely from acceding and candidate countries of the EU and European Economic Area (EEA). The association is registered in Belgium and its legal seat is in Brussels, Belgium.

IMPEL was set up in 1992 as an informal Network of European regulators and authorities concerned with the implementation and enforcement of environmental law. The Network's objective is to create the necessary impetus in the European Community to make progress on ensuring a more effective application of environmental legislation. The core of the IMPEL activities concerns awareness raising, capacity building and exchange of information and experiences on implementation, enforcement and international enforcement collaboration as well as promoting and supporting the practicability and enforceability of European environmental legislation.

During the previous years IMPEL has developed into a considerable, widely known organisation, being mentioned in a number of EU legislative and policy documents, e.g. the 8th Environment Action Programme that guide European environmental policy until 2030, the EU Action Plan: "Towards a Zero Pollution for Air, Water and Soil" on Flagship 5 and the Recommendation on Minimum Criteria for Environmental Inspections.

The expertise and experience of the participants within IMPEL make the network uniquely qualified to work on both technical and regulatory aspects of EU environmental legislation.

Information on the IMPEL Network is also available through its website at: www.impel.eu

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Executive Summary

Implementing the principles of a circular economy within an IED installation.

Many factors significantly influence the performance of IED installations such as the design and operation of the plant, compliance with permit conditions and implementation of management systems. To adhere to circular economy principles the full range of these factors should be addressed in permitting processes.

Implementing the IED with respect to the circular economy requires operators and regulators to consider increasingly complex information. This poses a challenge for competent authorities, especially those with limited capacity.

This guidance aims to assist regulators in aligning IED with circular economy principles and measuring performance in this area. It outlines what an IED application should include regarding the circular economy and what regulators need to prescribe to enhance circularity.

The guidance can help regulators incorporate provisions for self-monitoring plans and reports in the "new IED circular permits." These reports should contain the necessary information to monitor the circularity of installations using various tools, such as a circularity index. The document can serve as a basis for decision-making, setting conditions, and enabling operators to achieve required targets related to circularity.

Additionally, a Circularity Index and a Circular Plan are developed as part of the IED application.

Disclaimer

This report is the result of a project within the IMPEL network. The content does not necessarily represent the view of the national administrations or the Commission.

Quotation

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1. Introduction

1.1 Purpose and objectives of the guidance

Implementing the principles of a circular economy within an Industrial Emissions Directive (IED)[1] installation.

Many factors significantly influence the performance of IED installations such as the design and operation of the plant, compliance with permit conditions and implementation of management systems. To adhere to circular economy principles the full range of these factors should be addressed in permitting processes.

Implementing the IED with respect to the circular economy requires operators and regulators to consider increasingly complex information. This poses a challenge for competent authorities, especially those with limited capacity.

This Guidance aims at helping regulators at adjusting IED to fit with circular economy principles and to measure performance on this field: it indicates what an IED application should contain with reference to circular economy and what regulators have to prescribe to boost circularity.

The guide can help regulators to include in the "new IED circular permits" provisions to provide self-monitoring plan and reports containing pieces of information needed to monitor the circularity of the installations by using different tools such as a circularity index. The document could be used as a basis for decision making, setting conditions and enabling operators to achieve any required targets in relation to circularity.

Chapter 2 provides an overview of the strategies and regulatory drivers for circular economy principles within the EU. This provides the links for the reader to understand key principles and goals.

Chapter 3 considers the specific "hooks" between the strategies and the IED framework. By understanding the legislative links within IED requests for information or clauses within permits can be justified. The chapter takes account of some of the changes brought in by IED2.0.

Chapter 4 provides more details on how circular economy principles can be adopted in practice. This chapter looks at what information is needed in an application, what the permit writer should consider when reviewing and application and what should be in a permit.

Chapter 5 looks at the role of an installation Environmental Management System (EMS) and highlights the areas of most relevance to implementing the principles Circular Economy.

[1] Industrial and Livestock Rearing Emissions Directive (IED 2.0) - European Commission

Chapter 6 introduces a methodology for assessing circular economy performance, specifically a circular index that can be used to quantify performance within an installation.

Chapter 7 considers the role of an inspector when reviewing the implementation of circular economy principles. Some key enforcement practices are highlighted.

Chapter 8 takes a wider perspective with some recommendations for policy makers, regulators and industrial stakeholders. Recognising delivery of a true circular economy goes beyond the specific confines of an installation permit boundary.

Chapter 9 provides some case studies and best practice examples where circular economy and principles have been developed.

Annex I. provides an outline of what a permit application should have as part of its circular plan. This is broken down into describing the activities, highlighting the key areas that contribute to a circular economy – such as product design and materials selection use and disposal. Consideration of the product end use, waste, decommissioning and reporting are also described.

Annex II. describes the Circularity Index methodology in detail. It covers the principles, KPI, evidence collection, data evaluation, interpretation and presentation or results. The index provides a mechanism for benchmarking the circular economy of an installation.

1.2 Who is this Guidance for

This guidance is aimed at regulators, permit writers, installation inspections. Local policy makers will gain from reviewing this document as it provides a step-by-step review of the implementation questions that regulators and industry need to consider.

2. Regulatory background

Improving how industry uses materials is crucial for Europe's circular economy. The main regulation, the Industrial Emissions Directive (IED), helps but has its limits. The EU's Circular Economy strategy, Circular Economy Action Plan (CEAP) and the Green Deal highlight the importance of industry in achieving a clean and circular economy, especially in resource-intensive sectors. While regulations can drive some changes, other actions are also needed.

The IED, which regulates many large industrial activities in Europe, aims to improve resource efficiency but doesn't specifically mention circular material use. Resource efficiency is important but not enough on its own. Circularity involves using secondary materials and creating by-products that can be reused instead of disposed of.

In April 2022, the Commission proposed revising the IED to include new requirements for environmental management systems and transformation plans for industrial installations. These plans would outline how installations will contribute to a sustainable, circular, and climate-neutral economy by 2050. This approach requires support from regulators and a broader understanding of the environmental and economic context.

While improvements to the IED are needed, regulators and industry must also look beyond it. Collaboration with other sectors and exploring the wider materials economy are essential for achieving a European circular economy.

2.1 European Commission Climate change strategy

The European Commission's climate change strategy[2], launched in 2020, is focused on a promise to make Europe a net-zero emitter of greenhouse gases by 2050 and to demonstrate that economies will develop without increasing resource usage. However, the Green Deal has measures to ensure that nations that are already reliant on fossil fuels are not left behind in the transition to renewable energy. The green transition is a top priority for Europe.

The European Green Deal[3], approved in 2020, is a set of policy initiatives by the European Commission with the overarching aim of making the European Union (EU) climate neutral in 2050. The plan is to review each existing law on its climate merits, and also introduce new legislation on the circular economy, building renovation, biodiversity, farming and innovation.

[2] Climate strategies & targets - European Commission

[3] The European Green Deal - European Commission

The reasons pushing for the plan's creation are based upon the environmental issues such as climate change, a loss of biodiversity, ozone depletion, water pollution, urban stress, waste production and more.

Figure 1 The European Green Deal

In particular, the European Green Deal advocates for the implementation of a circular economy, where resources are used more efficiently, and waste is reduced. It proposes reforms in sectors such as textiles, construction, and electronics to make products more durable, repairable, and recyclable. The deal also aims to foster innovation and the adoption of new sustainable technologies, as well as to strengthen the EU's environmental and climate legislation. Together, these measures are not only intended to mitigate climate change but also to promote sustainable economic growth and improve the quality of life for European citizens.

The legal initiatives related to the integration practices of the circular economy for greener performance of European industries are considered in this chapter. Some of these are under the umbrella of the European Green Deal.

2.2. Circular Economy Action Plan

The Circular Economy Action Plan (CEAP)[4] is a fundamental part of the European Green Deal, with its main objective being to transform how the European Union's economy handles resources by promoting sustainability and efficiency. This plan focuses on reducing waste and encouraging the recycling and reuse of products in various key sectors, including electronics, plastics, textiles, and construction. By promoting a more efficient use of resources, the plan aims to minimize environmental impact and reduce dependency on non-renewable raw materials, which is crucial for achieving sustainability and climate neutrality by 2050.

One of the key strategies of the Action Plan is sustainable product design, which focuses on making goods more durable, repairable, and recyclable from their conception. This includes introducing regulations that require manufacturers to provide clear information on the reparability and lifespan of products, as well as facilitating their disassembly and recycling. In the electronics sector, for example, the goal is to reduce waste and promote reuse by extending the lifespan of devices and improving energy efficiency.

Additionally, the plan addresses waste management with the goal of turning what is traditionally considered waste into valuable new resources. Practices such as advanced plastic recycling, the reuse of construction materials, and textile recovery are encouraged. The plan also includes measures to improve waste collection and treatment, as well as to develop markets for high-quality secondary raw materials. This not only helps to reduce pressure on natural resources but also can create new economic and employment opportunities in the EU, aligning environmental sustainability with economic growth.

2.3. The New Industrial Strategy

The EU's "New Industrial Strategy"[5] [i]is an initiative designed to revitalize and strengthen the European industrial sector by promoting innovation, sustainability, and competitiveness in a digitized world. It was first introduced in March 2020 by the European Commission as part of its efforts to drive economic growth, innovation, and competitiveness in Europe.

The primary objective of this strategy is to ensure that the European industry is prepared to face the challenges of the 21st century, such as the transition to a greener and more digital economy, and to capitalize on emerging opportunities in areas such as artificial intelligence, robotics, cybersecurity, and clean technologies.

The relationship with circular economy strategies lies in that both share sustainability and efficiency goals. The circular economy aims to close the resources loops, by minimize waste and maximize the reuse, recycling, and

[4] EUR-Lex - 52020DC0098 - EN - EUR-Lex

[5] European industrial strategy - European Commission

to increase the value, or sustainable use, of resources as opposed to the linear "take-make-dispose" model. In this sense, the "New Industrial Strategy" can contribute to the circular economy by promoting the adoption of practices and technologies that reduce resource consumption, waste generation, and carbon emissions.

EU's "New Industrial Strategy" and circular economy strategies are closely related in their focus on sustainability and resource efficiency. Both aim to transform industrial models towards more sustainable and resilient practices, thus promoting a more balanced and environmentally responsible economic development.

2.4 The Zero Pollution Action Plan.

The "Zero Pollution Action Plan," [6] an initiative designed by the EU to address pollution in all its forms and protect human health and the environment, was presented by the European Commission in May 2021 as part of the European Green Deal and is framed within the EU's Biodiversity Strategy for 2030[7]. Its main objectives align perfectly with circular economy strategies by focusing on significantly reducing air, water, and soil pollution across the EU and minimizing exposure to toxic chemicals. To achieve this, the plan establishes a series of specific measures and objectives in key areas such as air quality, waste management, water pollution, and biodiversity protection.

Some of the priority areas and actions included in the Zero Pollution Action Plan are:

- Improve air quality: Reduce emissions of key air pollutants, promote sustainable mobility and transition to clean energy, and ensure compliance with EU air quality standards.
- Protect water and soil: Reduce water and soil pollution caused by agriculture, industry, and urban activities by promoting sustainable agricultural practices, proper waste management, and safe disposal of hazardous chemicals.
- Address chemical pollution: Regulate and control the use of hazardous chemicals in the EU, improve the assessment and management of chemical risks, and promote safer and more sustainable alternatives.
- Protect biodiversity and ecosystems: Strengthen the protection of biodiversity and ecosystems against the impacts of pollution, ensuring sustainable management of natural resources and restoration of degraded habitats.

The relationship with circular economy strategies lies in their shared goals of sustainability and resource efficiency. The circular economy aims to minimize waste and maximize resource reuse, recycling, and assign value, as opposed to the linear "take-make-dispose" model.

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[6] Zero Pollution Action Plan - European Commission

[7] Biodiversity strategy for 2030 - European Commission

The actions included in this policy should drive the circular economy by promoting the adoption of practices and technologies that reduce pollution, improve resource management, and regulate and control the use of hazardous chemicals, thus fostering circularity in the supply chain.

2.5. Secondary raw material in the Waste Framework Directive (WFD).

The legal framework for waste management in the EU has been defined by the Waste Framework Directive (WFD)[8] with the clear objective of protecting the environment and human health by promoting waste reduction, reuse, recycling, and recovery. Within the WFD, specific reference is made to "secondary raw materials," which are recycled or recovered materials that can be used as raw materials in the manufacturing of new products. Policies related to "secondary raw materials" focus on promoting their use and maximizing their value within the circular economy.

These policies include measures to encourage waste separation and selective collection, as well as the establishment of quality standards for recycled materials, including promoting economic and financial incentives to stimulate demand for products made from recycled materials.

Thus, policies on "secondary raw materials" in the WFD aim to promote the transition to a circular economy by facilitating the recovery and recycling of materials and encouraging their use as raw materials in the manufacturing of new products, to the detriment of extractive consumption of new raw materials.

2.6. Ecodesign.

Ecodesign policies[9] within the framework of the European Union (EU) are measures designed to integrate environmental considerations into product design, with the aim of reducing their environmental impact throughout their life cycle. These policies are closely related to the circular economy, which seeks to minimize waste and maximize the efficient use of resources.

The relationship between ecodesign policies and the circular economy is based on several aspects:

- Design for durability and repairability: They encourage the creation of durable and easily repairable products, which helps to extend their lifespan and reduce the amount of waste generated. These objectives align with the principles of the circular economy.

[8] EUR-Lex - 02008L0098-20180705 - EN - EUR-Lex

[9] Ecodesign for Sustainable Products Regulation - European Commission

- Minimization of materials and resources: It involves reducing the use of materials and resources in the manufacturing of products, as well as selecting more sustainable materials. This reduces the scale of extracted resources and associated waste generation.
- Facilitation of recycling and material recovery: They promote the design of products that facilitate disassembly and component separation at the end of their lifespan, which facilitates recycling and material recovery, feeding into the circular flow of materials in the economy.
- Innovation and technology: They encourage innovation in the development of more sustainable products and processes. Technological advancement towards more efficient and environmentally friendly solutions is promoted.
- The principles of the circular economy are closely aligned with ecodesign policies by promoting resource efficiency, extending product lifespan, reducing waste, and fostering innovation towards more sustainable solutions.

2.7. Industrial Symbiosis.

Industrial symbiosis is a system which connects facilities where by-product from one facility is a valuable input resource in the other facility. Key aspects of industrial symbiosis include:

- Collaboration: Industrial symbiosis thrives on collaboration among different entities. Companies and facilities work together to identify opportunities for resource sharing and mutual benefit.
- Material Exchange: The physical exchange of materials, energy, water, and by-products is a fundamental aspect. This can involve the reuse of waste or by-products from one facility as inputs for another, reducing overall waste generation.
- Synergies: The concept relies on identifying and exploiting synergies between industries. By working together, entities can create a system where the combined output is greater than the sum of individual contributions.
- Geographic Proximity: Physical closeness between facilities is often crucial. Proximity reduces transportation costs and logistical challenges, making the exchange of resources more feasible.
- Circular Economy Principles: Industrial symbiosis aligns with the principles of a circular economy, aiming to minimize waste, promote recycling, and optimize the use of resources throughout the production and consumption cycle.
- Environmental Sustainability: The overarching goal is often to enhance environmental sustainability by reducing the environmental impact of industrial activities through efficient resource use and waste reduction.
- Economic Benefits: Companies involved in industrial symbiosis can experience economic advantages through cost savings, improved resource efficiency, and shared infrastructure.

These aspects collectively contribute to the effectiveness of industrial symbiosis as a strategy for sustainable industrial development. The larger the amount of materials the more complex and time it will take for it to be a success.

The European Union places Industrial Symbiosis at the core of resource efficiency strategies and the transition to Circular Economy, as stated in the Circular Economy Action Plan (2020), which proposes facilitating and enabling industrial symbiosis as a means of transforming consumption and production patterns for greater circularity in Industry. The CE Action Plan 2020 addresses Industrial Symbiosis and recommends: *facilitating industrial symbiosis by developing an industry-led reporting and certification system and enabling the implementation of industrial symbiosis.*

2.8. Critical Raw Material Act (CRMA).

In March 2024, the Council adopted European Critical Raw material act (CRMA)10 as availability of rare earths and specific minerals is expected to decrease in the future. This Act is a pivotal legislative initiative within the European Union aimed at bolstering the sustainable management and availability of (at this moment 34) critical raw materials (CRMs) crucial for advancing the principles of the circular economy. These CRMs, most of them essential for various high-tech and renewable energy sectors, face supply chain vulnerabilities due to heavy dependence on imports. The CRMA addresses this by identifying and prioritizing CRMs vital for economic and technological competitiveness, such as rare earth elements, lithium, copper and cobalt.

Central to the CRMA is the promotion of sustainable sourcing, recycling, and innovation to enhance CRM supply chain resilience. By fostering domestic production capabilities and encouraging responsible mining and recycling practices, the act seeks to reduce environmental impact and dependency on single suppliers. Furthermore, the CRMA emphasizes the development of secondary raw material markets, facilitating the reutilization of CRMs from end-of-life products back into the production cycle. This approach not only conserves resources but also supports the EU's transition towards a more circular economy, where materials are used more efficiently and waste is minimised.

In addition to domestic strategies, the CRMA advocates for strategic reserves and international cooperation to diversify supply sources and mitigate supply risks. It promotes collaboration with resource-rich countries and strengthens trade policies to ensure stable and sustainable CRM supply routes. By aligning resource security with circular economy principles, the CRMA aims to safeguard Europe's economic resilience, technological leadership, and environmental sustainability in the face of global supply challenges.

The EU green transition will require the build-up of local production of batteries, solar panels, permanent magnets and other clean tech so it will be a great access to a range of raw materials needed to address the corresponding demands.

[10] Regulation - EU - 2024/1252 - EN - EUR-Lex

2.9 Corporate Sustainability Reporting Directive (CSRD):

The CSRD[11] came into force on January 5, 2023. It expands the reporting requirements to include more large companies, listed SMEs, and some non-EU companies with significant EU market activity. The directive aims to provide investors and stakeholders with better information on companies' social and environmental impacts and financial risks related to sustainability. Companies must start applying these rules in the 2024 financial year, with reports published in 2025. Reporting must follow the European Sustainability Reporting Standards (ESRS), developed by EFRAG. The CSRD requires assurance on reported sustainability information and introduces a digital taxonomy for this data. The European Commission is working to ensure the rules are implemented proportionately and is encouraging Member States to minimize the reporting burden on companies. These changes aim to harmonize sustainability reporting, making it easier for companies and more useful for stakeholders.

2.10 Legal framework summary

- Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: A new Circular Economy Action Plan For a cleaner and more competitive Europe, COM/2020/98 final.
- Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee, and the Committee of the Regions: "A new Industrial Strategy for Europe" (COM/2020/102 final).
- Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: "EU Action Plan Towards a Zero Pollution Ambition for air, water and soil" (COM/2021/560 final).
- Regulation (EU) 2019/1020 of the European Parliament and of the Council of 20 June 2019 on market surveillance of products and amending Regulation (EC) No 765/2008 and Directive 2004/42/EC, and repealing Directive 2006/43/EC and Regulation (EU) No 305/2011.
- Waste Framework Directive (WFD): Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain directives.
- Directive on Waste Electrical and Electronic Equipment (WEEE): Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment (WEEE).
- Directive on Packaging Waste: Directive 94/62/EC of the European Parliament and of the Council of 20 December 1994 on packaging and packaging waste.
- Directive on End-of-Life Vehicles (ELV): Directive 2000/53/EC of the European Parliament and of the Council of 18 September 2000 on end-of life vehicles.

[11] Corporate sustainability reporting - European Commission

- Regulation on Market Surveillance of Products (Market Surveillance Regulation): Regulation (EU) 2019/1020 of the European Parliament and of the Council of 20 June 2019 on market surveillance of products and amending Regulation (EC) No 765/2008 and Directive 2004/42/EC and repealing Directive 2006/43/EC and Regulation (EU) No 305/2011Directive 2009/125/EC of the European Parliament and of the Council, of October 21, 2009, establishing a framework for setting ecodesign requirements applicable to energy-related products (also known as the Ecodesign Directive). This directive establishes a framework for setting ecodesign requirements for energy-consuming products with the aim of improving their energy efficiency and reducing their environmental impact throughout their life cycle.
- Regulation (EU) 2019/1020 of the European Parliament and of the Council, of June 20, 2019, on market surveillance of products and amending Regulation (EC) No 765/2008 and Directive 2004/42/EC and repealing Directive 2006/43/EC and Regulation (EU) No 305/2011 (also known as the Market Surveillance Regulation). This regulation establishes provisions for market surveillance of products, including those subject to ecodesign requirements, to ensure compliance with the standards and requirements set out in EU legislation.

3. Overview of the Industrial Emission Directive: hooks to circular economy and gaps

The Industrial Emissions Directive (IED) is a cornerstone of the European Union's environmental legislation, aiming to reduce pollution from large industrial installations.

The IED explicitly requires that installations use resources efficiently which is also at the heart of the EU Circular Economy Action Plan (CEAP). It might be assumed that resource efficiency is a pre-requisite for circularity; overall, in contributing to the circular economy, IED installations should become more efficient in their material inputs and outputs and the material inputs and outputs should be as circular as possible.

As reported in the "*Wider environmental impacts of industry decarbonisation" Final Report12, "using less material as an input and producing less waste as an output are both examples of efficiency in material use. Using secondary materials instead of primary materials as an input and producing outputs that are either directly by-products or waste that others can convert to secondary materials are examples of circularity in material use*".

The following figure presents a simplified view of efficiency and circularity in material flows for IED installations:

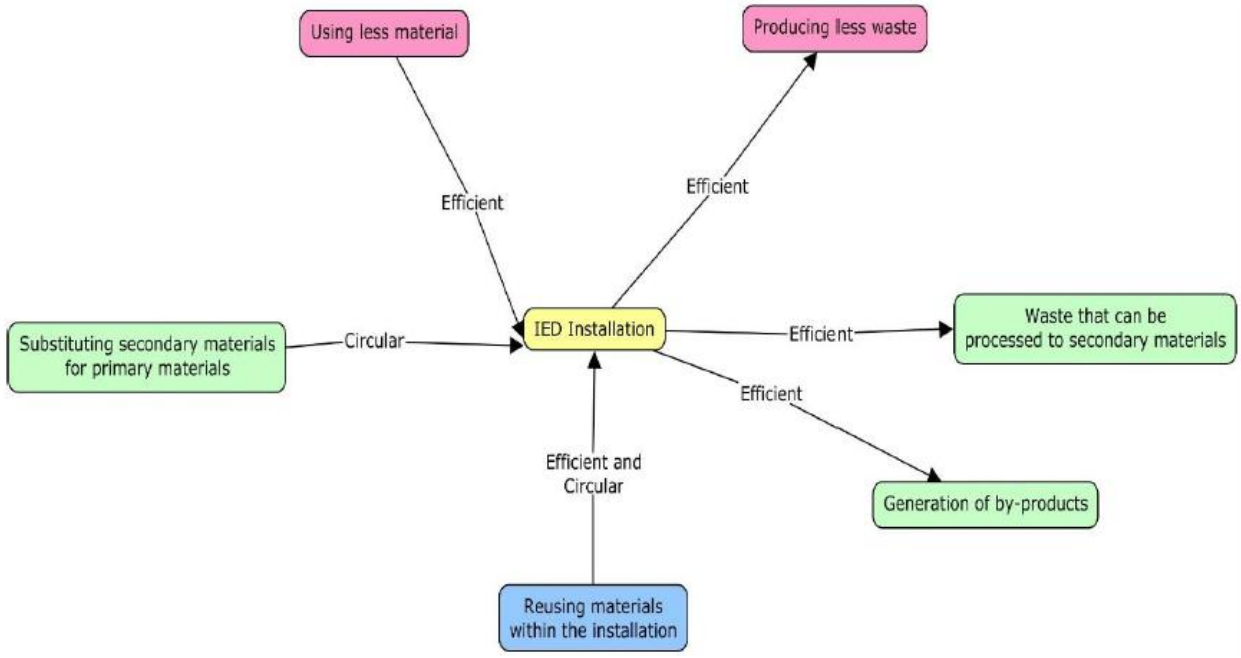

Figure 2 Simplified view of efficiency and circularity in material flows

[12] Wood, IEEP, Deloitte February 2021 - Report for European Commission DG Environment

The above-mentioned Report states that there is in the IED no "*hard evidence of the IED driving circularity as opposed to resource efficiency."*

HAZBREF (2020) stated *"The traditional scope of the IED and BREFs is the installation (gate to gate thinking), whereas CE needs to apply a life cycle thinking and a better connection of upstream and downstream processes. This requires better implementation of value chain thinking"*.

The study from Ricardo and Vito (IED Contribution to the circular economy[13]) provided an understanding of the extent of the IED's contribution to meeting circular economy objectives. This was achieved by gathering and analysing available information on the following topics in relation to IED activities:

- Use of energy, its reduction and where possible evolution over time;
- Use of materials, its reduction and where possible evolution over time;
- Generation of waste, its prevention or reduction; such as through recycling and reuse of materials
- Reduction of use of hazardous chemicals and chemical substances of high concern and their substitution with safer ones;
- Industrial symbiosis.

The IMPEL Guidance "Making the Circular Economy work"[14] contains a detailed overview of provisions of the IED relevant to circular innovations. The following topics relevant to circular innovations have been addressed in more detail:

[13] Service Request 13 under Framework Contract ENV.C.4/FRA/2015/0042 - Final report for European Commission - DG Environment (2019)

[14] https://www.impel.eu/en/guidance/guidance-making-the-circular-economy-work/guidance-making-the-circular-economy-work

ITEM	TOPIC	RELEVANCE
1	Definition of installation	Sets a framework for Industrial symbiosis
2	IED categories of activities	Determining what regime is applicable to waste recovery process
3	Requirement to apply Best available techniques (BAT) and BREFs (BAT reference documents), in particular the BAT Conclusions in BREF's	Sets a framework for assessing innovative, more circular production and waste recovery processes
4	Stimulating the use of Emerging Techniques (ETs) and allowing for temporary derogations from the requirements on emissions for the testing and use of emerging techniques	Can encourage and facilitate carrying through innovative, more circular production and waste treatment processes
5	Requirement to use resources efficiently	Can trigger and encourage circular innovations at production/waste treatment facilities aimed at using less resources and substituting primary resources by secondary resources
6	Requirement to prevent waste and to properly manage waste	Can trigger and encourage circular innovations at production/waste treatment facilities aimed at preventing waste from processes and/or producing secondary materials from waste streams.
7	Requirement to have an environmental management system (EMS)	Can facilitate a dialogue between regulator and operator on opportunities for circular innovations

With the IED revision in 2024, circular economy has become an explicit goal of the Directive, the BREF standards and the BAT definition.

Article 1 of the revised IED states that one of the aims of the Directive is to "continuously reduce emissions, to improve resource efficiency, and to promote circular economy, and decarbonisation, in order to achieve a high level of protection of human health and the environment taken as a whole".

The revised IED will support the industrial transformation towards a cleaner, carbon neutral, more circular, and competitive economy. It will spur innovation, reward frontrunners, help level the playing field on the EU market, and guide optimal investments.

In the context of circularity, which focuses on resource efficiency, waste reduction, and the continual use of resources, the revised IED incorporates both direct and indirect measures to promote a circular economy. The more significant recitals and provisions are detailed below.

3.1. Direct Measures: Recitals and Provisions

a) Alignment with Broader EU Strategies

- European Green Deal & Circular Economy Action Plan: The IED revision aligns with the European Green Deal, Zero Pollution Action Plan, Circular Economy Action Plan, and Farm to Fork Strategy. These frameworks collectively aim to enhance resource efficiency, promote reuse, and reduce pollutant emissions, extending the scope beyond what was previously covered under Directive 2010/75/EU.

b) Strategic Importance of the Extractive Industry

- Role of Metals: The directive recognizes the strategic importance of the extractive industry, particularly metals, in supporting the digital and green transitions, energy transformation, and enhancing EU economic resilience and autonomy.

c) Environmental Management Systems (EMS)

- Implementation and Transparency: Operators must establish and implement an EMS that focuses on improving environmental performance, preventing waste, optimizing resource and water use, and managing hazardous substances.
  Key aspects include:
- Public Access and Confidentiality: Relevant parts of the EMS should be publicly accessible, with provisions to redact confidential business information as necessary. Requirements of the Corporate Sustainability Reporting Directive (CSRD) may be needed.
- Risk Management and Substitution: EMS must cover risk management related to hazardous substances and explore the substitution of these substances with safer alternatives.
- Auditing and Compliance: EMS should be regularly reviewed by operators and audited by accredited external auditors to ensure compliance with the directive and relevant Best Available Techniques (BAT) conclusions.
- EMS has to include a chemicals inventory of the hazardous substances present in or emitted from the installation, as well as measures to prevent the generation of waste and optimise resource and energy use and water reuse.

d) Content of the permit

- the permit should include suitable monitoring requirements for the consumption and **reuse** of resources such as energy, water and raw materials

e) Best Available Techniques (BAT)

- BAT conclusions: BAT-conclusion should include indicative environmental performance values associated with emerging techniques, for individual processes that have similar characteristics (e.g. energy carriers, raw materials, production units and final products) and a high degree of homogeneity across the EU.
- The BAT conclusions should also include indicative benchmarks for other cases to be included by operators in their environmental management systems, where environmental performance is highly dependent on specific circumstances of the processes. These benchmarks guide operators in their EMS and ensure alignment with circular economy goals.

f) Emerging Techniques

- Support for Innovation: The directive encourages the adoption of emerging techniques with improved environmental performance, facilitating innovation through cooperation with research projects and establishing a dedicated innovation centre INCITE[15]. It is the new innovation centre for industrial transformation and emissions which shall collect and analyse information on innovative techniques, including emerging and transformative techniques, which contribute inter alia to minimisation of pollution, decarbonisation, resource efficiency, a circular economy using fewer or safer chemicals.
- Article 27b "Testing of emerging techniques" allows the competent authority to grant temporary derogations for the testing of emerging techniques for a total period of time not exceeding 30 months. Therefore, frontrunners can apply for permits under special conditions, enabling them to implement experimental or unproven methods that show promise in achieving sustainability objectives, such as reducing emissions, increasing resource efficiency, or enhancing circularity.

g) Resource efficiency

- The directive emphasizes updating BAT reference documents (BREFs) to include benchmarks and practices for improving resource efficiency.
- The BAT conclusions should now include binding environmental performance levels (incl. resource efficiency levels) associated with BAT (BAT-Associated Environmental Performance Levels or BAT-AEPLs), indicative environmental performance values associated with emerging techniques, and indicative benchmarks (for other cases) to be included in the EMS.
- Operators must monitor and report on their resource use and efficiency, ensuring transparency and accountability. These reports are evaluated by regulatory authorities to assess progress and identify areas for improvement.

[15] European Innovation Centre for Industrial Transformation and Emissions (INCITE) launch event - European Commission

- The directive promotes industrial symbiosis, where waste or by-products from one process serve as raw materials for another.

h) Transformation Plans
   - Industrial Transformation: Operators of energy-intensive installations, except of those related to landfill activity, are required to develop transformation plans as part of their EMS. These plans include information on how the installation will be transformed by the operator during the 2030-2050 period to contribute to the development of a sustainable, clean, circular, resource-efficient and climate-neutral economy by 2050.
   - Public Reporting and Auditing: Transformation plans must be audited for compliance with minimum information standards set by the European Commission and made publicly available.

i) Standardised Methodologies and Implementation Powers
   - Commission's Role: The European Commission is empowered to establish standardised methodologies for assessing cost-disproportionality, compliance with emission limits, the minimum information which should be in transformation plans, and other key aspects. This ensures uniform implementation across the EU.

j) New definitions
   - Changed and new definitions in order to ensure circular economy in IED installations: environmental performance limit value, deep industrial transformation, BAT conclusions, operating rules, environmental performance and sustainable resource efficiency, benchmarks and emerging techniques.

3.2 Indirect Measures: Contextual Integration

While the directive provides explicit provisions, it also fosters circularity indirectly through its alignment with broader EU policies and strategic objectives such as:

Integration with EU Policies: By aligning with the European Green Deal and other strategic frameworks, the IED promotes circularity also indirectly by ensuring that industrial emissions controls contribute to overarching goals like reduction of greenhouse gas emissions, resource efficiency and waste minimization.

Digitalisation: Digital tools such as digitalized management systems might help to quantitatively and qualitatively assess, manage pollution-related risks and help operators in the transformation of their installations

Cooperation with institutions:

- Establishment of INCITE and strengthening of ECHA[16] within revision and creation of new BREFs indirectly encourage the development and deployment of circular economy solutions within the industrial sector.
- Sustainable Agricultural Practices: Inclusion of agro-industrial activities within the directive's scope promotes sustainable practices that have multiple environmental and climate benefits, contributing to the circular economy.

Summary

- Comprehensive Framework: The updated IED provides a robust framework that directly mandates environmental management practices conducive to circularity while indirectly supporting broader EU circular economy objectives.
- Economic Resilience and Autonomy: Enhancing the circular economy supports economic resilience by reducing dependency on raw material imports and fostering local resource utilization.
- Emphasis on Innovation and Flexibility: By encouraging the adoption of emerging techniques and allowing for transformation plans, the directive ensures that industries can adapt and innovate towards more sustainable and circular practices.
- Transparency and Accountability: Public access to EMS and transformation plans, coupled with stringent auditing requirements, ensures transparency and accountability, essential for driving circularity.
- Standardisation for Uniformity: The directive's provision for the development of standardised methodologies ensures that circularity measures are implemented uniformly across the EU, facilitating a cohesive approach to industrial emissions and resource management.

The Industrial Emissions Directive integrates circularity into its regulatory framework through a combination of direct provisions and indirect contextual support. By mandating comprehensive environmental management systems, promoting best and emerging techniques, and aligning with broader EU strategies, the IED plays a pivotal role in advancing the EU's circular economy ambitions. This dual approach ensures that industrial activities not only reduce emissions but also enhance resource efficiency, fostering a sustainable and resilient economic landscape.

[16] Homepage - ECHA

4. Integrating Circular Economy principles within IED permits

The founding principle of Best Available Techniques it to identify the best techniques that can achieve a high general level of protection of the environment as a whole. These techniques include the way technology is used and the way the installation is designed, built, maintained, operated and decommissioned.

Application of a circular economy in permits may support operators in developing alternative methods, change inputs and process designs which improve material or energy efficiency, reduce operating costs and improve sustainability of processes and output to help secure future investment in installations.

Circular economy principles can sit within the wider goals of Net zero. Operators should consider ways in which to demonstrate net zero ambitions in the most effective and efficient manner. For example, requiring less energy to make a product would put less demand on power stations and help the environment as a whole.

Basic questions like “is this product needed?” should drive operators to consider all aspects of design and manufacturing at a very early stage. Application of circular economy principles at the design stage of a process can also avoid (or mitigate) less efficient ways of achieving net zero. For example, considering product design first, incorporating ways to repair rather than replace products before looking at materials or waste hierarchy will give better Circular outcomes. Only after this review process and when moving to production, should the net zero hierarchy be considered.

Circular economy (benefits)
- ↓ Better product design
- ↓ Repair rather than replace
- ↓ Use recovered materials rather than virgin
- ↓ Apply waste Hierarchy.

Net Zero (Benefits)
- ↓ Energy efficiency
- ↓ Resource efficiency
- ↓ Electrification
- ↓ Fuel switching
- ↓ Carbon Capture
- ↓ Offsetting

4.1 A Circular plan as part of the IED application

A circular plan shall be presented as part of the IED application (please see the contents of the Plan, Annex 1).

Pre-Permit application.

At the application stage it is important that the operator has demonstrated a full assessment of all the design options with a view to preventing pollution and achieving the high level of protection as a whole.

The regulator can influence the process design choices in a number of ways:

- Clear sectorial guidance on BAT for a sector and an understanding of emerging techniques.
- Application forms asking specific questions on the technique selection
- Questions on the life cycle of the products and the wastes being produced (now and in the near future)
- Options of use of recovered raw material rather than virgin
- Options for industrial symbiosis
- Promoting example of best practice to trade associations to encourage better applications.
- Require a circular economy plan

4.2 Resource efficiency

Material efficiency and the circular economy are activities that complement each other. Material savings can be achieved from good product design. Consideration is needed on the selection of the main manufacturing material, the product's components, fastening, processing, packaging or transport. Optimising the size of production facilities and utilisation of sharing economy solutions bring material savings at least indirectly.

Industry should promote material efficiency because it reduces costs, improves competitiveness and reduces environmental impacts. In case resource efficiency is not presented as part of the IED application, the applicant shall be asked to provide additional information. The operators themselves are in the best position to evaluate how to monitor material and resource efficiency in their plants. It depends on the sector.

Availability and costs of resources will also determine the urgency to become more resource efficient or to choose other, secondary (or renewable) materials.

4.3 Secondary raw materials

Secondary raw materials are recycled materials that can be used in industrial processes. The use of secondary raw materials is also recognised in the recent BAT reference documents (BREFs) for industry. The regulatory background (WFD) is described in the chapter above.

4.4 Use of Chemicals

The EU is taking action to promote clean material cycles and reduce the use of hazardous chemicals throughout a product's life cycle. The European chemicals legislation places obligations but also provides incentives for industry to replace hazardous substances with less hazardous ones. Producing cleaner materials without hazardous chemicals makes recycling easier, preserves our environment and is key to making a circular economy work. Companies innovating and investing in safer alternatives also contribute to the competitiveness of European industry on the global market. Information on where dangerous chemicals end up is key to circularity.

4.5 Waste prevention and recycle

At an installation, several key issues need to be considered for effective waste prevention and recycling within a circular economy framework:

- Material Selection: Choose materials that are durable, recyclable, and non-toxic. This helps in reducing waste and ensuring that materials can be reused or recycled at the end of their life.
- Design for Disassembly: Design products and components in a way that they can be easily disassembled. This facilitates repair, refurbishment, and recycling.
- Efficient Waste Management Systems: Implement efficient systems for collecting, sorting, and processing waste. This includes having dedicated bins for different types of waste and ensuring that recycling facilities are available and accessible.
- Employee Training and Engagement: Educate and engage employees on the importance of waste prevention and recycling. This can include training programs, awareness campaigns, and incentives for sustainable practices.
- Monitoring and Reporting: Regularly monitor and report on waste generation and recycling rates. This helps in identifying areas for improvement and tracking progress towards circular economy goals.
- Collaboration with Suppliers and Partners: Work closely with suppliers and partners to ensure that materials and products are sourced sustainably and that there are systems in place for returning and recycling materials.
- Policy and Compliance: Ensure compliance with local and international regulations related to waste management and recycling. This includes staying updated on new policies and adapting practices accordingly.

4.6 Product life cycle

Products that are designed with longevity, repairability, and disassembly in mind need to ensure that they can be easily maintained, upgraded, or recycled at the end of their life. Product Life Cycle Analysis is a method used to assess the environmental impacts of a product throughout its entire life cycle, from raw material extraction to disposal. Steps to consider include:

- Raw Material Extraction: Assess the environmental impact of extracting raw materials. This includes energy consumption, emissions, and resource depletion.
- Manufacturing: Evaluate the processes involved in manufacturing the product. Consider energy use, waste generation, and emissions.
- Distribution: Analyse the transportation and logistics involved in getting the product to market. This includes fuel consumption and emissions.
- Usage: Examine the environmental impact during the product's use phase. This can include energy consumption, maintenance, and potential emissions.

- End-of-Life: Assess the disposal or recycling of the product. Consider the potential for recycling, waste generation, and environmental impact of disposal methods.

The scale of any life cycle analysis undertaken within an application would be proportionate to the complexity of the activity.

4.7 Supply chain

Work closely with suppliers, manufacturers, and customers to create a closed-loop system where materials are continuously cycled back into the supply chain. This collaboration can help in developing new business models and improving resource efficiency

4.8 Application receipt and review.

When an application is received the regulator should recognise that this is a significant opportunity to gain the best outcome for the environment as a whole. Once the installation is permitted and operational, it becomes increasingly difficult to change designs or alter techniques, at that stage regulation moves to minimisation and abatement which is less efficient than prevention.

To align with the key principles of Circular Economy which include designing out waste and pollution, keeping products and materials in use at their highest value, and supporting regeneration of natural systems, BAT is to implement a Circular Economy Plan (CEP).

A circular economy plan should include all the following features.

a. Maximise resource efficiency (raw materials, energy and water)
b. Implement a resource hierarchy to reduce the use of virgin raw materials in favour of recovered and recycled materials.
c. Minimise waste from processes and products and ensure all wastes are treated at highest available point in the waste hierarchy.
d. Minimise hazardous chemicals in processes and product design.
e. Consider emerging techniques when commercially available.
f. Enhances supply and distribution chain resilience and industrial symbiosis.
g. Monitors and reports progress against targets identified in the CEP

The integrated approach of the Industrial Emissions Directive requires an understanding of the industrial process in order to minimise waste and increase resource efficiency. The features of a Circular economy plan as outlined above are touched upon in other BATC, features f. to g. but by bringing these into a single Circular Economy Plan CEP it allows the installation to identify links between site activities and makes opportunities for external improvements more viable.

Note: Applying the principles described in ISO 59004:2024 [17] Framework for implementing the principles of the circular economy in organizations – Guide, is an example of a standard consistent with this BAT.

Applicability

The level of detail and the degree of formalisation of the CEP will generally be related to the nature, scale and complexity of the installation and the range of environmental impacts it may have.

4.9 Considerations for Permit writers

IED permits must consider the whole environmental performance of the plant.The permit conditions, set by national authorities, must incorporate circular economy principles and practices.

Industrial emissions permit writers play a crucial role in advancing the circular economy by ensuring that environmental regulations and permits include specific conditions to encourage or require the implementation of circular economy.

Incorporating Circular Economy principles in permit

Setting emissions limits that encourage efficiency:

- By setting strict emissions limits, permit writers can push industries to implement processes that minimize waste generation and adopt more efficient and less polluting technologies. This often leads to innovations that not only reduce emissions but also minimize waste and make better use of resources.

Promoting waste and by-products to resource initiatives:

- Permits can encourage industries to view waste as a resource, by stipulating the use of recycled materials within the production process, implementing process to recover valuable material from end-of-life products, and the recovery and use of by-products.

Product design and innovations:

- By setting conditions to promote sustainable product designs, that extend the lifespan of products, make them easier to repair and reuse and including components that can be easily replaced or upgraded.

Facilitating innovation and technology adoption:

[17] ISO 59004:2024(en), Circular economy — Vocabulary, principles and guidance for implementation

- Permits can include conditions to industries adopt innovative technologies and research initiatives that support circular economy goals. Permit writers can promote collaboration with industry stakeholders, research institutions, and technology providers in research and development initiatives aimed to find new ways to reduce emissions and waste, improve resource efficiency, develop and identify sustainable materials and processes.

Implementing Lifecycle Assessment Requirements:

- Requiring companies to conduct lifecycle assessments of products and materials as part of their permitting process to evaluate environmental impact throughout their lifecycle and identify opportunities for circularity.

Promoting energy and resource efficiency:

- Permit writers can include conditions to drive companies to adopt practices to promote energy recovery, the use of renewable energy sources, and efficient use of resources.

Fostering industrial symbiosis:

- Permit writers can facilitate collaboration between different industries and help to create industrial symbiosis where the waste or by-products of one industry become the raw materials for another. This can be encouraged through permits that support shared infrastructure or resource exchanges.

Monitoring and reporting requirements:

- Strict monitoring and reporting requirements can ensure that companies follow circular economy principles. Regular reporting can help to assess trends, identify areas for improvement, evaluate the effectiveness of regulatory measures and ensure transparency and accountability.

Implementation of Best Available Techniques (BAT):

- Permit writers must include conditions based on the best available techniques and practices within the sector to identify the most effective techniques for preventing or minimizing emissions and impacts in the environment.

By integrating these elements into industrial emissions permits, permit writers can significantly influence the shift towards a circular economy, promoting sustainability, reducing environmental impact, and fostering economic growth through more efficient use of resources.

5. The role of the Environmental Management System

The circular economy is a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. In this way, the life cycle of products is extended.

To understand the role of the EMS in the circular economy, the following were considered:

1) the requirements of the ISO 14001 standard of EMS

2) **BAT 1** which is present in all BRefs for the application of an EMS and the related requirements (note the changes brought in by IED 2.0.)

From this comparison, overlapping requirements are evident and among these requirements some are particularly effective for applying the principles of Circular Economy.

5.1 Requirements ISO 14001 standard

ISO 14001:2015 requirements are broadly separated into 10 sections (called ISO 14001 clauses), with clauses one through three describing the standard and clauses four through 10 containing the requirements for an EMS.

Clauses 1 through 3 include no requirements, but instead deal with the scope of the standard, normative references to understand the standard better, and terms and definitions used.

ISO 14001 Requirements (clauses 4-10):

4) Context of the organization
5) Leadership
6) Planning
7) Support
8) Operation
9) Performance evaluation
10) Improvement

4. Context of the organization

This section deals with general requirements for an EMS including understanding organizational context, the needs and expectations of interested parties for an EMS, and documentation of the scope of the Environmental Management System.

5. Leadership

This section identifies the requirement for Top Management to demonstrate leadership and commitment to the EMS and identify the organizational roles, responsibilities, and authorities that will be present in the EMS. Leadership also includes the definition of the Environmental Policy that will act as the overall goal of the EMS. This policy must include a commitment to prevent pollution and to comply with all legal requirements to which the company is subject.

6. Planning

The section on planning emphasizes the need to identify and plan to address risks and opportunities of the EMS, and how the processes of the organization interact with the environment, as well as how the company will keep up to date with legal requirements. The requirements also address the setting of objectives and planning to achieve them within the EMS.

7. Support

This largest section addresses requirements on resources in the EMS, including the assessment of competence, training, and EMS awareness. Included in these requirements are how to control documented information for the EMS as well as internal and external communication that is relevant to an EMS.

8. Operation

While this is a small section, it is very important, as it sets the requirements on how to plan for the control of operations and how to prepare and respond to emergency environmental situations.

> *8.3.6 Design and development changes, including the results of the review and the authorisation of the changes and necessary actions*

9. Performance evaluation

This second-largest section deals with how to monitor, measure, analyse, and evaluate EMS processes, including how to evaluate compliance with legal requirements. A system of internal audits is mandated to identify problems and apply corrections for these problems. Finally, there are requirements on how management will review the EMS to ensure it is working and improving. Part of the review is to make sure adequate resources are applied to the EMS so that it can function properly.

10. Improvement

The last section deals with requirements for how to address nonconformity in an EMS process, corrective actions needed for these nonconformities, and continual improvement activities for early identification of a problem before it occurs or seek to make your processes better with respect to your environmental impact.

5.2 Some Difficulties in Implementation of an EMS

The greatest difficulty of implementing ISO 14001 is to ensure that the resulting collection of policies, procedures, processes, and records meet the needs of the company while still allowing improvement of the system. Improvement of the system is one of the main reasons for implementing an EMS, as it benefits the company in the long run.

Implementation steps include:

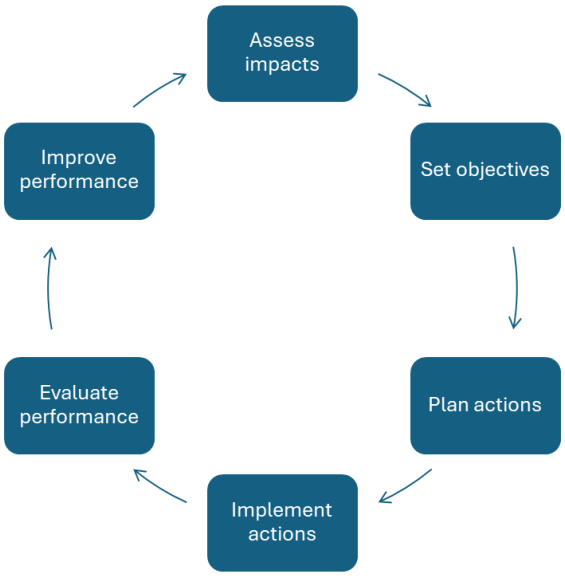

Figure 3 EMS process flow

1 Assess environmental aspects

The first step is to identify and evaluate environmental aspects, which are the elements of activities, products, or services that interact with the environment. For example, environmental aspects may include the materials used, the energy consumed, the waste generated, or the emissions released. By assessing environmental aspects, their significance, risks, and opportunities for improvement can be determined. Tools such as life cycle assessment, material flow analysis, or environmental audits can be used.

2 Set environmental objectives

The next step is to set environmental objectives, which are the specific and measurable goals to improve your environmental performance. Environmental objectives should be aligned with business strategy, stakeholder expectations, and legal requirements. They should also reflect circular economy vision and principles, such as reducing resource consumption, extending product lifespan, or designing for reuse and recycling.

Tools such as SWOT analysis, or benchmarking to define environmental objectives can be used.

3 Plan environmental actions

The third step is to plan environmental actions, which are the activities to achieve environmental objectives. Environmental actions should be based on the best available techniques, practices, and standards for waste reduction and circular economy. They should also be prioritized, resourced, and scheduled according to environmental aspects and objectives.

4 Implement environmental actions

The fourth step is to implement environmental actions, which means putting plans into practice. To implement environmental actions effectively, it is required to ensure that the necessary resources, competencies, and communication channels are in place.

Operational controls, documentation, and records to monitor and document environmental actions will need to be established.

5 Evaluate environmental performance

The fifth step is to evaluate environmental performance, which means measuring and analysing the results and impacts of environmental actions. To evaluate environmental performance accurately, relevant indicators, methods, and data sources are needed. Regular reviews, audits, and evaluations to verify compliance, effectiveness, and efficiency. Tools such as KPIs, or ISO 14031 guidelines can be utilised to evaluate environmental performance.

6 Improve environmental performance

The final step is to improve the environmental performance, which means identifying and implementing opportunities for continual improvement. To improve environmental performance continuously, use feedback, learning, and innovation processes.

Environmental aspects, objectives, and actions according to evaluation results and changing conditions need to be updated. Tools such as root cause analysis, corrective actions, or ISO 14004 principles to improve environmental performance.

5.3 EMS in BREF

BAT 1- Environmental management systems - Standard text used in BREFs

In order to improve the overall environmental performance, BAT is to elaborate and implement an environmental management system (EMS) that incorporates all of the following features:

- commitment, leadership, and accountability of the management, including senior management, for the implementation of an effective EMS;
- an analysis that includes the determination of the organisation's context, the identification of the needs and expectations of interested parties, the identification of characteristics of the installation that are associated

with possible risks for the environment as well as of the applicable legal requirements relating to the environment:

i. development of an environmental policy that includes the continuous improvement of the environmental performance of the installation;
ii. establishing objectives and performance indicators in relation to significant environmental aspects, including safeguarding compliance with applicable legal requirements;
iii. planning and implementing the necessary procedures and actions (including corrective and preventive actions where needed), to achieve the environmental objectives and avoid environmental risks;
iv. determination of structures, roles and responsibilities in relation to environmental aspects and objectives and provision of the financial and human resources needed;
v. ensuring the necessary competence and awareness of staff whose work may affect the environmental performance of the installation (e.g. by providing information and training);
vi. internal and external communication;
vii. fostering employee involvement in good environmental management practices;
viii. establishing and maintaining a management manual and written procedures to control activities with significant environmental impact as well as relevant records;
ix. effective operational planning and process control;
x. implementation of appropriate maintenance programmes;
xi. emergency preparedness and response protocols, including the prevention and/or mitigation of the adverse (environmental) impacts of emergency situations;
xii. when (re)designing a (new) installation or a part, consideration of its environmental impacts throughout its life, which includes construction, maintenance, operation and decommissioning;
xiii. implementation of a monitoring and measurement programme; if necessary, information can be found in the Reference Report on Monitoring of Emissions to Air and Water from IED Installations;
xiv. application of sectoral benchmarking on a regular basis;
xv. xvii. periodic independent internal auditing and periodic independent external auditing in order to assess the environmental performance and to determine whether or not the EMS conforms to planned arrangements and has been properly implemented and maintained;
xvi. evaluation of causes of nonconformities, implementation of corrective actions in response to nonconformities, review of the effectiveness of corrective actions, and determination of whether similar nonconformities exist or could potentially occur;
xvii. periodic review, by senior management, of the EMS and its continuing suitability, adequacy and effectiveness;
xviii. following and taking into account the development of cleaner techniques.

Specifically for the industry sector in question, it is also important to consider the following potential features of the EMS: include other appropriate features e.g.

- energy management plan
- waste management plan

- noise management plan
- odour management plan
- inventories of water, energy and raw material consumption and waste water and waste gas streams.

Regulation of eco-management and audit scheme (EMAS), which is an example of an EMS consistent with this BAT.

Applicability

The level of detail and the degree of formalisation of the EMS will generally be related to the nature, scale and complexity of the installation, and the range of environmental impacts it may have.

Monitoring

BAT is to monitor emissions with at least the frequency given below and in accordance with EN standards. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.

Substance/Parameter Standard(s) Minimum monitoring, frequency, Monitoring associated with [e.g. NOX] [e.g. EN XXXX] [e.g. continuous, once every month]

5.4 Items to achieve the circular economy goals

- Limiting the use of primary raw materials. Increasing the use of ingredients from sustainable primary
- production (e.g., organic or integrated production) and supporting activities to conserve biodiversity
- Increasing resource efficiency
- Reduction of the EU material and consumption
- Closing the material and energy loops
- Improving the well-being of internal and external stakeholders
- Activities for the rational management of water, including its reuse
- Recovery of bio-waste and the use of by-products

5.5 Some themes to consider within Environmental Management System.

Better design

- Design with no toxic input, clean additives in production processes
- Design with and use recycling material in products
- Design for easy disassembly in components
- Design with low impact inputs

- Design with for durability and quality

Material efficiency

- Reduce material consumption
- Produce and process with renewable energy
- Reduce production waste,
- Reduce transport volume
- Remanufacture existing products
- Reuse and sell components and materials from discarded products

Marketing

- Offer products and services
- Incentivise users to maintain/repair products
- Extended warranty
- Organize maintenance and repair services

Industrial cooperation

- Engage in industrial symbiosis
- Localise supply where appropriate
- Market circular products, components via online platforms

Conclusion

1. It is important to highlight that a good EMS will already incorporate many of the key features needed for delivery of circular economy principles and may minimise the work needed by operators to demonstrate compliance.
2. ISO 14001:2015 requirements are compatible with expectations of the circular economy
3. European authorities should better support using of certification and other tools, supporting environmental innovations
4. Some ISO 14000 requirements need to be strengthened to obtain better circular Economy results.

6. Assessing Circular Economy performance within the framework of IED: a circular index for IED installations

It has been previously mentioned that the current version of the IED directive is not focused on measuring the performance of installations in relation to circular economy principles. Therefore, there is a need for a tool that allows operators and regulators to make the circularity performance of installations transparent and quantifiable. This would enable a shared improvement pathway, either voluntary or mandatory, depending on the decisions of the competent authorities.

For this purpose, leveraging the references provided by the international standard ISO 5902018 and the Italian technical specification UNI/TS 1182019, a system has been developed to measure and evaluate the circular performance of an IED installation.

Beside the two above mentioned standards, to measure the degree of circularity, there are currently other two different standards to refer to, all of which can be integrated with the system management approach described by UNI EN ISO 14001:

BS 800120 (Great Britain): It aims to reconcile the ambitions of the circular economy with business processes. It serves as a guide that provides advice and recommendations, along with a series of definitions and clarifications.

AFNOR XP X30 – 901 21(France): It aims to be a reference point for the implementation of a circular system within organizations that want to adopt circular solutions in their production systems.

The **UNI/TS 11820** is an Italian technical specification that provides a methodological approach for assessing and measuring circularity in industrial processes and organizations. It is designed to help organizations evaluate their transition to a circular economy through a set of standardized indicators and metrics.

Both ISO 59020 and the derived Italian standard UNI/TS 11820, set requirements and guidance for organizations to measure and assess their circularity performance and aim to standardize the process by which organizations collect and calculate data using mandatory and optional circularity indicators, ensuring consistent and verifiable results.

Operators are offered a way to quantify progress and demonstrate commitment to sustainable practices, enhancing transparency, accountability, and stakeholder trust.

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[18] ISO 59020:2024 - Circular economy — Measuring and assessing circularity performance

[19] UNI/TS 11820:2022: measuring and evaluating circularity - RINA.org

[20] Introducing the BS 8001 Circular Economy standard - BBIA

[21] Standard XP X30-901

This system assesses the effectiveness of its circularity strategy through a set of indicators.

The system does not establish a minimum threshold for circularity but enables the evaluation of the level achieved by the installation in relation to the maximum attainable value. This approach allows for monitoring improvements in circularity over time. Comparisons should therefore be made between organizations within the same sector and for the same organization as it evolves over time.

Therefore, a **Circular Economy (CE) Index** based on UNI/TS 11820 provides a standardized framework for evaluating circularity in industrial processes, offering standardized indicators for resource efficiency, waste minimization, and material circularity. By aligning with these standards, the CE Index ensures consistency, reliability, and comparability of data within specific installation categories.

Operators can use the CE Index to measure their installation's circularity performance over time, identify trends, and demonstrate improvements; the index highlights inefficiencies in resource use or waste management, guiding operators toward innovative solutions tailored to their category's challenges.

Similarly, regulators can integrate the CE Index into reporting requirements for installations, ensuring a consistent framework for evaluating circular economy contributions within each category.

Policymakers can use the aggregated data from CE Index assessments to design incentives, subsidies, or penalties to drive CE adoption. Furthermore, the index provides a common language for stakeholders to discuss circularity goals, challenges, and achievements.

In consideration that IED and EIA permitting processes are ofthen integrated, the CE Index can complement traditional EIAs by offering a focused analysis of circular resource management.

Authorities and industry bodies can use the index to define category-specific targets for circularity, aligning with the broader goals of the IED and CE principles; by comparing installations within the same category, the CE Index facilitates the identification of leaders and laggards, promoting the adoption of best practices across the sector.

It is crucial to note that the Circularity Index is not suitable for direct comparison across different types of installations due to variations in processes, scales, and resource requirements. Instead, it is most effective when applied within the same category of installations.

In addition to being a tool for guiding evaluations in permitting processes, the circularity index must also be calculated and included in the self-monitoring yearly Report to assess the trend in the circularity performance of the installation.

6.1 Effective use of a Circular Economy Index.

The following features should be considered when using a circular economy index:

1. **Category-Specific Assessment**:
   By focusing on installations within the same category, the CE Index ensures fair and meaningful comparisons.

2. **Quantifying Circularity**:
   The CE Index translates abstract principles of circularity into measurable indicators, enabling a clear assessment of how well industrial processes align with CE goals.

3. **Enhancing IED Compliance**:
   The CE Index complements the IED's goals by assessing how well installations integrate circular economy practices.

4. **Driving Continuous Improvement**:
   Regulators and operators can use the CE Index to identify inefficiencies and prioritize areas for improvement, fostering more sustainable practices, encouraging innovation and investment in circular practices.

5. **Monitoring and Benchmarking**:
   The CE Index provides a baseline and enables monitoring of performance over time as well as benchmarking within a category, encouraging competition and collaboration to achieve higher circularity standards.

For permit writers and inspectors working under the Industrial Emissions Directive (IED), this index serves as a valuable tool to integrate circular economy principles into environmental governance and to drive industrial installations toward greater sustainability and circularity.

6.2 Applications for IED Permit Writers

1. **Evaluation of Permit Applications**:
   - The CE Index can help assess whether proposed installations or process modifications align with CE principles.
   - Permit writers can use the index to identify specific circular economy targets for inclusion as permit conditions.

2. **Defining CE Performance Metrics**:
   - Permit writers can require operators to track and report CE metrics, ensuring ongoing compliance with CE objectives set in the EMS.

3. **Customizing Requirements by Sector**:
   - The CE Index can be tailored to specific industrial sectors, helping permit writers set realistic and sector-appropriate benchmarks.

4. **Supporting the Transition to Circularity**:

- Permits can mandate progressive improvements in circularity over time, using the CE Index as a baseline for tracking compliance with evolving CE standards.

6.3 Applications for IED Inspectors

1. **Monitoring and Verification**:
    - Inspectors can use the CE Index to verify compliance with permit conditions, ensuring installations are meeting agreed-upon CE targets.
    - The index facilitates consistent monitoring of circularity performance, such as material reuse rates or waste-to-resource conversion.
2. **Identifying Non-Compliance**:
    - CE index metrics provide clear criteria to detect deviations from CE requirements, enabling inspectors to pinpoint inefficiencies or failures.
3. **Guiding Corrective Actions**:
    - Inspectors can use the index to recommend specific improvements, such as optimizing material flows, enhancing waste recovery systems, or reducing reliance on virgin resources.
4. **Promoting Best Practices**:
    - By benchmarking CE performance within installation categories, inspectors can identify leaders and share successful strategies across operators.

6.4 Advantages of Using the CE Index

- Consistency: Ensures a uniform approach to measuring circularity across installations and sectors.
- Data-Driven Decisions: Provides measurable indicators to support objective permit and inspection decisions.
- Progress Tracking: Allows for the evaluation of long-term improvements in circularity.
- Integration with IED Goals: Aligns with the IED's emphasis on resource efficiency, waste minimization, and environmental protection.

A structure for the Circularity Index has been proposed in Annex II. For the determination of the index, strict reference can be made to the aforementioned ISO and UNI standards, but in this document, a simplified version has been offered to facilitate easier implementation by the competent authorities in both permitting and inspection processes.

It is reccommended to gather feedback from stakeholders, including businesses, experts, and policymakers, on the usefulness and relevance of the index. This feedback will be used to refine the index methodology, update weights, or adjust Key Performance Indicators as necessary.

Therefore, the process must be periodically iterated to ensure the index remains relevant and reflective of current circular economy practices.

7. IED implementation: Inspectors

7.1 Inspectors

Environmental inspectors play a pivotal role in integrating circular economy principles within the framework of Industrial Emissions Directive (IED) permits. Inspectors are tasked with assessing raw materials, evaluating transformation plans, verifying adherence to circular economy principles, and leveraging Environmental Management Systems (EMS) data.

While the process of integrating circular economy principles into IED permits begins with legislative changes to the directive, effective enforcement practices are essential to ensure compliance with these regulations and promote the adoption of sustainable practices by industrial installations. Both aspects are integral to achieving the goals of environmental protection and resource efficiency within the industrial sector.

Their work supports the shift toward sustainable industrial practices leading the industry towards eco-friendly practices, public health, and environmental protection. Several reasons why environmental inspectors are key factors in the enforcement of circular economy principles are:

7.2 Enforcement Practices:

Routine and Targeted Inspections:

- Prioritising inspections based on the environmental risk posed by activities.

Comprehensive review of specific permit conditions:

- Reviewing permit documentation and waste management plans to ensure compliance.

On-Site Checks:

- Inspecting processes and conformity to permitted infrastructure to confirm proper implementation of circular economy measures e.g., storage, shared steam network and energy recovery devices.

Collaboration and Stakeholder Engagement:

- Coordinating with stakeholders to share insights and improve practices.

Data Analysis:

- Inspectors analyse data trends or indicators to identify non-compliance and inform enforcement strategies, e.g., understanding drops in performance relevant to Circular economy aspects.

Collaboration and Education:

- Providing guidance to industries on best practices and compliance.
- Raising public and industrial awareness about circular economy benefits.
- Facilitating dialogues between stakeholders to foster transparency and improvement.

Environmental inspectors play a crucial role in the following areas:

Inspection of Raw Materials. Inspectors ensure that raw materials meet sustainability standards and are sourced ethically. This involves:

- Reviewing certifications and supplier practices to confirm eco-friendly sourcing.
- Testing material samples for hazardous substances to meet safety standards.
- Monitoring supply chain transparency to ensure accountability.

Reviewing Transformation Plans. Inspectors evaluate how raw materials are converted into final products. This includes:

- Assessing energy and water usage for efficiency.
- Identifying cleaner technologies that reduce emissions.

- Ensuring compliance with industry guidelines.

Assessing Circularity Plans. Inspectors examine whether operations adhere to circular economy principles by:

- Checking design plans for recyclability and reuse potential.
- Verifying waste minimization efforts and multi-use materials.
- Reviewing feedback loops for take-back or remanufacturing processes.

Verification of Permits. Inspectors ensure compliance with legal requirements by:

- Ensuring adherence to permit conditions and reporting requirements.

Utilizing EMS Data. Inspectors use EMS to enhance their oversight by:

- Accessing data on emissions and waste outputs.
- Tracking compliance trends to spot improvement opportunities.
- Guiding corrective measures to promote sustainability.

Effective enforcement is key to compliance:

- Issuing citations and fines for non-compliance.
- Working with regulatory bodies to uphold environmental laws.
- Encouraging innovative solutions and research in sustainable technologies.

Inspectors are integral to maintaining sustainable industrial operations through their comprehensive inspection processes, use of EMS data, and enforcement of environmental standards. Their role in ensuring adherence to circular economy principles helps industries minimises their ecological footprint and promotes long-term environmental health.

Overall, environmental inspectors play a critical role in safeguarding the environment and public health by ensuring that businesses and industries comply with environmental regulations and take proactive measures to achieve a more sustainable circular economy.

8. Recommendations for policymakers, regulatory authorities and industrial stakeholders

A circular economy is a change of the economic system, reducing the total amount of resource use within the carrying capacity of the earth. Our present economic and political system will need a widely supported effort to turn from a linear to a circular system in a transition period of many years. A large number of stakeholders is involved in this transition. It will need a co-operative effort from policy makers, regulatory authorities and industrial stakeholders to get to a (more) circular system. This chapter focuses on the different stakeholder involvement in increasing sustainable resources efficiency in the whole chain. The focus is mainly on resources, not on waste.

8.1 Importance of involvement of governments and regulatory authorities in promoting Circular Economy practices within IED compliance

Defining national circular policies

A strong co-operative effort is required to be successful. The main incentives for working on the circular transition will be the availability and prices of resources, future perspectives on industrial developments and a save and liveable environment. The co-operative effort should include co-operation between governmental organisations, regulatory authority, industrial organisations and also with NGO's. This co-operation shall not take place automatically and there will have to be organized and where necessary formalized.

In many European countries, National circular economy programs have been set up. These programs will include governmental co-operation meetings of state and decentral governments and environmental regulators on effective implementation of regulations. Companies, knowledge institutes, financial organizations, trade unions and NGOs are involved to discuss, develop and implement their circular transition agendas for the different sectors in industry. Known examples are in the sectors of plastics production, the building industry, and the metal and machine building industry. In these transition agendas the stakeholders work together on pathways to the circular economy. The pathways include the design of processes and products, sustainable and safe (use of) raw materials, reuse and repair of products and new business models[22].

A standard thinking about circular economy is that 'something has to be done with waste'. The regulations named above show also the perspective of the 'focus on the front side'. The limited worldwide (physical and geopolitical) availability resources require a policy reducing the amount of primary raw materials and promoting the use of secondary raw materials and products in a sustainable way.

[22] Source NL: Dutch National Program on Circular Economy 2023 - 2030 en Circular production industry

Material chains are worldwide. It requires insights in the material flows in Europe and the world to influence and regulate the material flows in a sustainable way. A more coherent development of European chains of materials will make the dependence on worldwide chains smaller and the risk of geopolitical influences on resource supplies smaller. This requires a quick implementation of the critical raw materials act and a shared European perspective on the use of secondary materials as a resource. This may include changing taxation systems, supporting European resources transports and planning the development of mineral refining industries.

Use of secondary raw materials and products often requires an upcycle step in the process. This type of upcycling is a different type of refinery industry, requiring investments and physical space in industrial estates. The development has to be planned and programs, preferably at a European level to ensure an efficient use of scarce space and resources.

Circular Economy Labs[23] in different European countries may promote circular economy innovation by expertise exchange and creating networking opportunities for innovative players, such as startups, smaller and larger companies, knowledge institutes and technical transfer centres.

New EU regulations

The European green deal formulates the EU ambitions on climate neutrality and resource use for 2050, with a large number of regulations and directives. There are some specific regulations within the green deal that may have an impact on the daily work of the implementing regulators, in addition to the new circular aspects of the IED. These new directives require from businesses insights in their processes, in present and future resource use and in their sensitivity to changes in resource use. Different directives have different regulatory aspects (see below). However, regulation organisation can play an important factor in becoming a more circular company. For instance, asking about their future resource use, the repair and maintenance aspects of their products or about the ethical aspects of their production in the whole chain, may contribute to a more circular operation.

Table circular options within new EU regulation

Name directive	Main focus	Possible regulation aspects
CSRD (directive)	Sustainability reporting obligation on 12 ESG theme's incl. CE	Reporting obligation for (larger) businesses, and the businesses in the value chain about impacts. To be used to have insights in materials in the chain, sustainability in the chain and governance responsibility.
CSDDD (directive)	Obligation to take action on known	Actions required by business. It can lead to agreements

[23] Circular Economy Lab | European Circular Economy Stakeholder Platform

	impact on human rights and environment in the value chain	between authority and business on action to limit environmental impact in the chain. The agreements can be open for enforcement.
CRM act	Strengthening material chains and develop European resources	
EoW (End of Waste regulation)	Using waste as a resource	Advise on using waste as a resource in products or in a new application.
Circular laws	Making Circular economy part of the legal system	Legislation to allow chain approaches, promote sustainable resource use and improve resource efficiency.
Product and materials (regulation)	F.i.: Plastic Products directive	Requirements for using (% amount of) secondary resources in new products.

See: Circular Strategies: Putting the circular economy into motion (ICC/EY)

Recommendations for policymakers, governments and environmental authorities

An overview of possible measures is given as recommendations to policymakers, governmental organisations and environmental authorities on the roles they can take in businesses going from a linear (optimized) economy to a circular (not yet optimized) economy. These recommendations go from regulatory and stimulation measures to a geopolitical approach.

Regulation

- Implementation of the new directives in national legislation should focus on closing the materials loops and on sustainable resource use, within the resource capacity our earth;
- Life Cycle Assessment to raw material approach (scarcity and impacts of extraction)
- Inventories of resource use should be required in permits, with elaborated resource mass balances and future (efficient) resource use. The inventory should show the use of the critical raw materials, the energy use and closing the materials cycles;
- The available data in sustainability reports should be analysed on their focus on circularity and future resource us. The data can be used in the contacts between the governmental organization and the business to make adjustments to their process;
- Governmental environmental organisations should co-operate with, amongst others, certifying organisations, water quality bodies, waste management bodies and soil protection organisations to ensure an integrated approach to the circular economy aspects of business;
- Improving circular economy aspects should not lead to adverse effect on for instance energy use or environmental effects;
- Integrate emission reductions of waste and circular economy policy in the report on measures against climate change.

Stimulation

- Start a debate with the (advisors of) businesses on availability and costs of resources in the (near) future. In the application for a new permit, a chapter on future availability and costs could be required to considered. This debate will increase insight and possibly contributes to the development of a more circular business, especially when it concerns critical raw materials.
- In sustainability reporting the business already will have to open their data on ESG, also available for environmental authorities. These authorities
- In permit introduction debates, the relation between the possible measures for stimulation of circular economy and measures for energy efficiency, energy transition and climate adaptation can be used to enhance/promote business investments
- Set up circular help desks. In a help desk businesses can drop their questions on perceived limitations of regulation for their businesses. The regulatory authorities are asked to find solutions to their problems, bring business together (for instance for identifying shared resource use) and in identifying gaps in regulation or policy

Geopolitical approaches

- The European commission did discuss earlier the strategy towards the use of critical raw materials24. The main issue with this materials is that available resources are mainly outside Europe and that there are becoming more and more scarce. These resources are crucial to Europe's economy. It is therefore important to keep the materials in their respective cycles, to have these resources available in the right amounts in the right qualities, and to be able to produce them in the right quality in Europe.
- The European Commission has created a list of critical raw materials (CRMs) for the EU. These materials will have additional requirements to keep them available in Europe by recovering from waste and landfill, refining from industry waste and from mining tailings, and to establish new refining industries. It should focus on efficient use and recycling of critical raw materials.
- Cooperation in Europe is essential to be able to develop the circular ambitions within the European countries. The mineral and materials refinery industry development should be an European responsibility, not a country responsibility. This strengthened and renewed refinery industry in all European countries may lead to a more optimized production of secondary raw materials in the whole of Europe.
- Strengthening industry should include the existing regional strong holds. For instance, biomass processing in Amsterdam, minerals refinery in Rotterdam, tree and lithium processing in Sweden and

[24] Critical raw materials - European Commission

Serbia, etc. Strengthening these industrial sectors should not lead to detrimental environmental effects at a local or world wild level.

8.2 Strategies for fostering collaboration between industrial operators, regulatory authorities, and other stakeholders

Fostering collaboration among industrial operators, regulatory authorities, and other stakeholders is essential for advancing a circular economy, achieving sustainability goals, and addressing regulatory and environmental challenges. It is based on the Ellen Macarthur foundation document: Delivering the circular economy. It is a toolkit for local and regional policymakers, with some practical strategies based on knowledge sharing and building. In public-private collaborations and regulation the following strategies are available for the policymakers and operators to follow through at the regional level.

1. **Establishing cross-sector working groups**

Forming multi-stakeholder working groups with representatives from industry, government, NGOs, and the community to tackle shared challenges and develop policy solutions. Having regular meetings and workshops can help these groups identify common goals, build trust, and promote transparency in decision-making processes. Creating a trust base is essential for going forward but also give insight in the mechanics of the competent authority and the companies.

2. **Promote industrial symbiosis programs**

Facilitating industrial symbiosis where by-products or waste from one company serve as raw materials for another, creating a resource-efficient system. By acting as a kind of “matchmaker,” a competent authority helps to create closed loops of resources and energy. Local government supports business in identifying compatible industries and set up networks for resource sharing.

3. **Develop public-private partnerships (ppps)**

Governmental organisations can encourage public-private partnerships to co-develop infrastructure, resource-sharing programs, and technological solutions for a circular economy. This can later transform into private companies. These PPP’s can drive investment and innovation, pooling resources to tackle large-scale issues such as waste management, pollution control, and clean energy initiatives.

4. **Set up knowledge-sharing platforms**

The creating of online platforms or annual conferences for stakeholders can be used to share best practices, success stories, research, and resources. These platforms can also host webinars, training sessions, and case studies to foster learning and inspire collaborative projects. The implementing of digital tools like data-sharing portals, environmental dashboards, and communication apps to provide stakeholders with up-to-date information supports the sharing of knowledge. This would create transparency that helps build trust and ensures that all parties are informed about regulations, compliance status, and performance metrics.

5. **Align regulatory incentives with industry goals**

The alignment of regulatory incentives with sustainability goals of businesses will create mutually beneficial outcomes. These outcomes, for example, can be the introduction of tax incentives, subsidies, or grants for companies investing in green technologies, waste reduction, or energy efficiency, all within environmental regulations. Examples include simplified regulatory requirements or the provision of clear guidance to support compliance, the reduction of administrative burden and the promotion of proactive engagement from industrial operators. An example is the creation of standards for certification of secondary materials.

6. **Implement pilot programs with stakeholder collaboration**

Pilot programs can be run to test innovative circular economy initiatives with collaborative stakeholder involvement. These programs can serve as proof of concept, generate data on economic and environmental impact, and help build stakeholder confidence in new models.

7. **Facilitate open dialogue and conflict resolution mechanisms**

It is important to have established structured communication channels and conflict resolution processes to address any disputes or challenges that arise during collaborative projects. This approach ensures that issues are resolved constructively, maintaining a positive atmosphere for future collaboration.

8. **Encourage joint funding of research and development (R&D)**

Resources should be pooled to fund research into innovative technologies and practices, such as pollution control, recycling, or renewable energy. Governments can co-sponsor research grants with industry to lower costs and risks, accelerating the development of sustainable solutions.

9. **Offer training and capacity-building programs**

Programs will have to be developed that enhances stakeholders' knowledge on circular economy practices, regulatory changes, and new technologies. It should include offering joint training sessions for regulators, industry and other stakeholders to improve mutual understanding and foster a collaborative approach to compliance and innovation. Examples are workshops on basic circular economy principles to help stakeholders understand key concepts such as resource efficiency, sustainable resource use, waste reduction, closed-loop systems and industrial symbiosis.

Integrating case studies relevant to various industries (e.g., manufacturing, construction, and logistics) into those workshops will illustrate how circular economy practices can be applied in different sectors. Providing regular sessions by the competent authority or a third party on the latest regulatory developments and compliance requirements, ensuring all stakeholders are aware of changes impacting the circular economy.

10. **Embed collaboration in policy frameworks**

Ensure that collaboration is not only encouraged but institutionalized within policy frameworks. This can be done by designing policies that explicitly support collaborative efforts, such as requirements for stakeholder consultation in new projects or incentives for partnerships in sustainability initiatives. By employing these strategies, industrial operators, regulatory authorities, and other stakeholders can create effective partnerships

that drive forward sustainability, innovation, and shared economic benefits. We are aware not every IED-authority has the skills, the means or the mandate to develop such policies. In the ten eleven strategies above there is wide choice available to actively operate as a lead or as a stakeholder in the promotion of circular Economy practices within IED compliance

9. Case studies and best practices

Examples of successful integration of Circular Economy practices in various industrial sectors

9.1 Reuse of concrete in steel and cement production in UK

Researchers at the University of Cambridge have developed a scalable method to produce very low-emission concrete, which could significantly aid the transition to net zero. This innovative approach utilizes electrically powered arc furnaces, typically used for steel recycling, to simultaneously recycle cement, the carbon-intensive component of concrete.

Concrete, the second-most-used material globally after water, accounts for about 7.5% of total anthropogenic CO_2 emissions. Finding a scalable and cost-effective way to reduce these emissions while meeting global demand is a major decarbonization challenge.

The Cambridge team discovered that used cement can effectively replace lime flux in steel recycling, which is used to remove impurities and usually becomes waste known as slag. By substituting lime with used cement, the process yields recycled cement that can be used to produce new concrete.

This cement recycling method, reported in the journal Nature in March 2024, does not significantly increase the costs of concrete or steel production and substantially reduces emissions from both industries due to the decreased need for lime flux.

Recent tests by the Materials Processing Institute, a project partner, demonstrated that recycled cement can be produced at scale in an electric arc furnace (EAF) for the first time. If powered by renewable energy, this method could eventually lead to zero-emission cement production.

9.2 Forbo Flooring in Krommenie

Forbo Flooring, based in Krommenie, is a manufacturer of several types of flooring. Vinyl and linoleum are its main products. The IED installation in Krommenie produces linoleum flooring, a product made from natural materials. It primarily consists of a mixture of linseed oil, cork dust, wood flour, pine resin, and mineral fillers like ground limestone. Forbo has a sustainability strategy with a target to recycle more than 95% of internal and external product waste, including linoleum cutting residues. They also have a 'Take Back Service', where installation remnants and end-of-life floors are collected and recycled.

New Recycling Method for Cut-Off Waste

Since July 2014, Forbo Flooring has implemented a recycling method for processing clean linoleum cut-off waste. This method involves several steps:

1. Forbo began the structured collection of clean linoleum cut-off waste through the Take Back Service, where installation waste from customers is retrieved.

2. The collected cut-off waste is ground into fine scrap powder in the recycling department.

3. The scrap powder is then integrated into the production process of new linoleum, maintaining the quality standards and environmental benefits.

Take-Back of Cut-Off Waste

While Forbo precisely calculates the amount of flooring required for new buildings, cutting inevitably leaves on average percentage of 7-10% of remnants. These cut-offs are collected and sorted in large bags or containers at the project site and returned to the factory.

Recycling Process

A separate waste management company collects, inspects and sorts the cut-offs for a second time at their own site. Rom then on the bags or containers are transport for reuse to Forbo Flooring installation in Krommenie. At the Forbo site the bags and containers are inspected and sorted for a third time.

Waste receipt documents are checked and filed. Then, the container is emptied onto the conveyor belt on the trim for the final visual check and before transport to the crusher for possible final foreign waste is separated as regular waste, collected and removed by Forbo Flooring BV.

In the crusher the cutting material is further broken into chips. The chips are further ground into recycling dust, which is stored in the recycling silos. The recycled material is used as a raw material in the production of the underlay of new linoleum products. In 2023, for example, Forbo collected and recycled 65 tons of linoleum and 185 tons of vinyl.

Through this recycling method, Forbo Flooring helps reduces waste and supports the circular economy by reusing materials in the production process.

9.3 Roof2Road in Vijfhuizen

Roof2Road, is a company that has been working for closing the recycling loop of bituminous roofing materials. The operator has established a recycling chain in the Netherlands and built a factory to save roofing bitumen from incineration and recycle it into secondary raw material for the roofing or the asphalt industry.

The process begins with a size and age determination. The size determination is for profitability and the age is to rule out roofing material placed before 1985. After that age the production of high PAH concentrated was stopped in the Netherlands. This inspection is followed up with an on-site cutting inspection of the used roofing material to determine if it's suitable for reuse. The company uses a company inspection protocol to determine if the roofing is appropriate for recycling. This means it has to be clear a high concentration of PAH (<75 mg/kg) this is done through age determination, visual inspection and subsequent analysis. The analysis is

done with a GCMS-method for PAH 10 and PAH 16. After a positive result the material is then cleanly dismantled[1].

After dismantling the material, it is transported to the facility in Vijfhuizen. At the site a visual and odour inspection takes place together with a supplemented PAH-marker spray sampling.

Roof2Road collects and produces bitumen as a secondary raw material. It has a permit for maximum of 50 tons a day. It is not considered a cat. 5.3a IED-installation because the installation is not meant for disposal but solely for recovery. The input material includes, besides bitumen from young used roofs, also cutting residues from new roof installations, and rejected new roofing bitumen. The collected roofing bitumen is grounded into secondary raw material and the new project is to export to asphalt factories abroad. The circular bitumen is used to replace fossil raw materials in the production of new roofing rolls and asphalt. This would make it fully circular[1].

Source

(1) Roof2Road, founded Gerben Bijker, recyclet dakbitumen. https://roof2road.nl/over-ons/.

9.4 Cargill Multiseed Amsterdam area

Cargill is a multinational company with three production sites in the northern Amsterdam area. These are categorized as 6.4(b) II IED installation for the treatment and processing, other than exclusively packaging, of the following raw materials, whether previously processed or unprocessed, intended for the production of food or feed from only vegetable raw materials with a finished product production capacity greater than 300 tonnes per day or 600 tonnes per day where the installation operates for a period of no more than 90 consecutive days in any year. Two sites produce cacao powder.

Cargill's cacao production process involves several stages:

1. Sourcing: Cocoa beans are sourced from various regions and brought to the installation.
2. Cleaning and roasting: Beans are cleaned to remove debris and roasted to develop flavour and colour.
3. Cracking and Winnowing: Roasted beans are cracked, and their husks are removed.
4. Grinding: The nibs are ground into cocoa liquor. This liquor can be further processed into cocoa butter and cocoa powder[5].
5. Pressing: The cocoa liquor is pressed at high temperatures and pressures to separate the cocoa butter from the cocoa cake[5].
6. Milling: Cocoa cake is milled into cocoa powder.

One the residues that derives from the two cacao factories are the cacao husks. These husks have a limited purpose as a mulch or fodder. The larger part is used as a renewable fuel source in energy plants.

Cargill Multiseed Amsterdam is an IED 6.4bii installation for the processing of oilseeds, such as sunflower and rapeseed, into crude and/or refined oil and flour, whether or not in the form of pellets. The refined vegetable oil is mainly sold in the food industry. The pellets are mainly sold in the animal feed industry. The refinery's production capacity is a maximum of 350,000 tons of oil per year according.

Cargill Multiseed realized a biomass boiler (CBC) for steam generation within the context of the climate objectives. In 2024 this unit will be fully operational and only a gas fired support installation is installed. The CBC combustion plant in which heat is usefully applied within the production process. The CBC will use pellets form the local installation and cacao husks from it's other installations as a byproduct and fuel therefore limiting the use of fossil fuels for the main production process while decreasing it's waste to ashes. These remaining ashes have the potential to be used as a byproduct for fertilizer in accordance with EU Regulation 2019/1009 on fertilising products. Ashes are specifically named as a Component Material Category in Annex 2 of the EU Fertilising Product Regulation 2019/1009 which can be used in the production of fertilisers.

9.5 Port of Amsterdam – allocation and shared infrastructure

The Port of Amsterdam has been given a mandate by the Municipality of Amsterdam to regulate land allocation. With its directing role as a land lessor, this gives the Port a unique position to actively guide and organically promote the circular economy. By strategically allocating and managing leasehold and ground lease, the Port can attract companies that fit within the circular ecosystem and promote sustainability. These companies are allowed based on the knowledge of the existing industry and it needs or available materials/waste, energy or waste water. However, it is bound by policy to make land available only to companies related to port activities. This is organized into four different levels to optimise port usage.

The Port operates within an established industrial area in transition, where key industries include chemicals, waste processing, oil terminals, waste incineration facilities, and food logistics and processing. This allows the Port to act as a director and connect companies that can use each other's by-products (for example, by-products from juice processing for use in fermentation plants). By acting as a kind of "matchmaker," the Port helps create closed loops of resources and energy.

The Port can also invest in or apply for subsidies for shared infrastructure, such as pipelines, heat networks, or energy storage facilities, to enable this collaboration and more efficient resource use among companies. For example, the heat and energy from AEB (Waste and Energy Company) are effectively used within the port, strengthening the circular economy. Additionally, the Port can provide subsidies for sustainable infrastructure projects.

As a land lessor, the Port can make space available for innovative companies testing or scaling circular solutions. This provides a platform for startups and innovative projects focused on circular processes that fit within the existing area. Interesting projects that do not fully align with core port activities can be facilitated in the surrounding area.

Annexes

Annex I. Circular Plan: a part of the IED permit application

This annex provides information on progress towards fulfilment of the environmental policy objectives and Rating EMS environmental policy progress. The IMPEL WMCE report 2020[25] provides some structure to the content of a circular plan. Recommendations on what to include in a plan includes:

- What they contribute to a Circular Economy. By using the LCA or Carbon Footprint tool this can describe how this initiative relates to the r-ladder of circularity strategies.
- Provide a detailed description of the production process of the plant, and the (raw)material-water - and energy balance.
- Provide detailed information about (potential) substances of very high concern in the process. Investigate how to minimalize these substances.
- Provide alternatives with less impact on the environment:
- How to reduce the energy-use (for example to use steam from a company nearby and to reuse process-heat)
- Different possibilities to use the CO2 (for example a pipe to another company)
- Reduce the nitrogen-emission (Nox) (for example industrial design and electric transportation)
- Broaden the discussion to the use phase. We are used to business-to-business schemes; consider also business to users.
- Use the idea of a Circular quality plan for the IED application.
- Use the circular index to summarize the info requested in the application (monitoring, indicators)

CONTENT OF THE CIRCULAR ECONOMY PLAN: IED APPLICATION

A) INTRODUCTORY PART

- **Activities at the installation**

The applicant has to provide a detailed description of the activities carried out within the installation including process flow diagrams for the main activities which have an environmental impact. A number of flow diagrams may be utilised in order to explain various (sub)processes to someone who is not familiar with the installation. The description should include all the material and energy inputs, processes and outputs. Besides the product outputs, the application should also describe all emissions, effluent discharges, odour, noise and waste

[25] 202003_FR WMCE 2020.pdf

generated by the process, providing a clear link with the source of each output. This is an opportunity to identify potential circular loops within the installation.

This section shall describe the role the installation plays in promoting circular economy. As a minimum, there should be clear consideration of the immediate upstream and downstream elements of the value chain in the context of the product lifecycle.

Regulatory background

The application shall include a detailed list of international, national and local regulatory instruments together with a description of which aspects of the proposed activities these shall relate to, this is typical as a requirement of an EMS. This shall include but no be limited to any guidance and regulatory frameworks relating to classifications and criteria related to eco-design, end-of-waste, and by-products. It may also include product quality requirements which might affect decisions related to circular and production processes within the installations. This legal register may also include a brief description of how compliance with that obligation shall be achieved.

Environmental Management System

A description of the type of environmental management system in place shall be provided with details of whether this shall be an in-house system or accredited one (e.g. EMAS, ISO 14001 etc.). A copy of the Environmental Policy endorsed by top management together with the latest audit findings is to be provided. The applicant shall also describe the objectives and targets associated with a time frame. This section shall clearly demonstrate how the EMS in-place considers circularity. If chemicals are handled on site, a description of an existing or proposed chemical management system shall also be provided. Periodic audit checks shall also ensure that there is continuous improvement in circularity aspects of the installations.

B) ELEMENTS THAT CONTRIBUTE TO THE CIRCULAR ECONOMY

- **Production process**
- **Product end of life**
- **Production of waste**
- **Decommissioning**

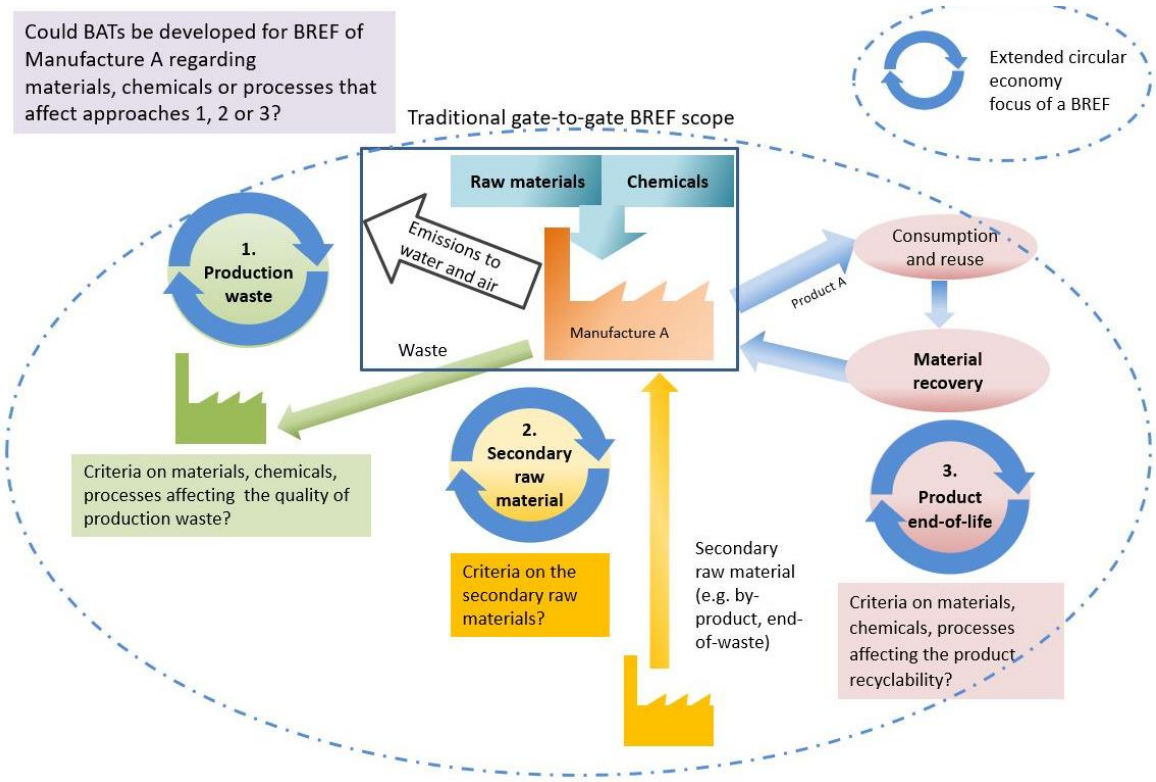


Figure 4 View of an approach for a circular economy application plan (HAZBref Project)

B.1) PRODUCTION PROCESS

Whilst installations are to ensure that BAT are adopted, operators are also to look further into the future and are to set plans for the transformation of their operations to promote a circular economy. Such transformation plans are to be included in their respective environmental management systems and shall include key performance indicators to track their progress towards meeting circular targets.

Operators may analyse their procurement and supply chain decisions, energy and material flows in order to identify opportunities whereby more sustainable production processes may be adopted. Such opportunities may include the re-use of resources including by-products, heat and wastewater for secondary use (such as ancillary processes). Options for the efficient use of material resources and water, including through re-use are to be explored.

It is often the case that in industry, the amount of energy required to operate a facility is well monitored, however, the energy required for each individual activity is not known. Therefore, energy audits can provide useful insights as to where energy saving opportunities lie. The same applies for water usage, and thus by delving deeper into the water audit findings and also considering the water quality requirements for each activity, opportunities for cascading the use of water may be identified. Examples of cascading of used water

include the re-use of water for other activities, equipment or sanitary purposes either within the same installation or otherwise.

Operational aspects and alternatives – various alternatives to each of the below aspects have to be described.

1. Raw materials –

- consideration of procurement practices and types of inputted materials sourced in order to commence the activity. Material inputs, water and energy, consumption are to be considered here.
- Focusing on the use of secondary raw materials (materials that can be used in a manufacturing process instead of or alongside virgin raw materials, e.g. by-products or end-of-waste) at the installation.
- Provide detailed information about (potential) substances of very high concern in the process. Investigate how to minimise these substances**.**

Once the function/purpose and quality requirements of the product/service have been determined, a material selection process is to be carried out as part of the preliminary design stages. A holistic approach to the selection of the raw materials is to be taken. Hence, the material selection process shall involve a comparison of material consumption, energy consumption, water consumption, toxicity of materials, waste generation, cost of manufacture, as well as the end-of life strategies for each of the potential raw materials to be selected. The operator shall attempt to select the material that provides the best trade-off between the various factors, whilst preserving the required quality standards for the product.

2. Main production process/activity/technology used on site

This is where change may need to come. Can circularity be achieved by simply changing the inputs and the outputs to the process, or does the process itself need to change? Innovation in product design may demand innovation in manufacturing. An understanding of future resource availability may drive ambition to ensure sustainable future production.

Emerging techniques may be identified in the Bref for the industry sector. Operator economies of scale may influence adoption of emerging techniques as it may be difficult to justify the financing of overhauling their manufacturing process. A full scale overhaul may not necessarily be required. Exploring options for redesign of process flows and plant layout or minor equipment modifications including parameter settings on equipment may provide environmental improvements. Designing products in a manner that facilitates material recovery and recycle is an option.

Operators are to provide a comparison of the various production processes that may be adopted to produce the final product or provide the desired service. A comparison between the environmental impacts apart from capital and operational costs as well as other operational aspects (such as cycle times, production capacities, space limitations, human resources required, equipment accessibility, etc) for each of the different production processes, technologies and techniques is to be carried out. The comparison of environmental impacts shall take into consideration aspects such as renewable materials, water and energy consumption, emissions to air,

waste and by-product generation as well as end-of life strategies such as opportunities for the re-use, remanufacturing and recycling of materials.

Whilst it is important that operators keep up to date with the latest emerging techniques, it may also be possible to improve the environmental performance of their current production processes/practices through the modification of current equipment (including equipment parameter settings), plant layout, process flow, raw material selection and their respective supply chains. Such scenarios would not require a full-scale overhaul of their manufacturing processes and thus may be more feasible.

3. Emissions to air

There should be no lessening of BAT-AELs for emissions to air. Circular economy cannot come at the cost of air quality. Residues from abatement systems are a waste, these can be liquid (effluent) or solid. If thermal abatement systems become problematic due to climate change concerns and alternative treatments are needed, the quantity of residues could increase.

Emissions to air are to be taken into consideration during the assessment and selection of raw materials and production processes. The decisions taken in relation to materials and production processes may determine the abatement technologies required to meet BAT-AELs. Whilst more environmentally friendly raw materials and production processes may seem to be more expensive to source at first glance, actually, these materials/processes may provide overall costs savings as costs relating to abatement technologies and the associated waste residues. There should be full consideration of cross media effect to ensure issues are not passed from air–water for example. Therefore, a holistic approach is to be taken when conducting a life cycle cost analysis.

4. **Effluent discharges –** assessment of feasibility for effluent re-use including identification of technologies required.

Effluents can be treated to recover water for reuse. There are lots of available techniques here. However, there will still be residues for disposal. Cascading of water/effluent use in line with quality requirements is also to be considered. For instance, clean water consumed for equipment cleaning or as part of the manufacturing process may then be used as second-class water for the facilities toilets/sanitary, possibly without the need to treat such effluent (so long as the properties of the effluent to be used meet the property requirements of its intended use).

5. Final Product environmental performance

Products are to be designed to minimize the environmental impacts incurred during the use phase as well as end–of-life phase. For instance, products are to be designed to consume low amounts of electricity and water

and are to generate minimal waste volumes upon reaching end of life. Products should be designed for maximum lifetime and ability to be returned to reuse *triggers broom**

Industrial symbiosis

Infrastructural feasibility and site ownership arrangements shall be explored to consider the possibility for the material or energy outputs of one site can be used in a neighbouring installations thereby avoiding their procurement from further afar or the need for virgin raw materials. The operator shall describe existing and prospective links with other installations or industrial areas leading to better circularity.

Adaptation to climate change

The installation shall make plans to ideally mitigate or adapt to climate change. It shall explore how current processes will have to change to meet any regulatory mitigation targets including zero Carbon ambitions. Moving to alternative fuel sources be considered. Climate adaptation will need to understand the impacts of raw material availability (a warmer climate may change the nature of the raw materials available) requiring changes in manufacturing processes or changes in product specifications.

B.2) PRODUCT END OF LIFE

End-user strategy

A strategy aimed at the end-user of the intended material output promoting circularity. If applicable, this may also include an internal policy on the preference of more circular end-users of the output. The waste hierarchy shall also be considered when creating such a strategy.

Operators are to conduct a life cycle assessment of the product and seek opportunities to extend the product/components' lifetime. The market as well as consumer behaviour patterns may also dictate the product's life span, regardless of the quality and build of a product, especially with electronic products due to technological advancements.

The recoverability of products is very dependent on the materials used within the product and hence sustainable material selection at design stage is crucial. Market research to determine if there is a demand for these secondary materials at production facilities if such materials shall not be re-used/recycled/remanufactured by the original producer is also essential. The possibility to design a product which is easier to repair shall also be considered.

In order to move towards a circular economy, operators are to consider opportunities to adopt a cradle-to-cradle approach in their design of products. In this regard, operators may provide a means to facilitate the recollection of products at their end of life so as to recycle/re-use components and materials, within the next generation of product.

Producers of products are responsible for their recovery or disposal once they reach their end of life. This also includes packaging and hence organisations are to prioritize the minimization of packaging waste as far as possible and should provide recycling information of such waste to the end user. Producers are to adopt sustainable packaging practices and shall evaluate the type of material to be used, the production processing and end-of life of packaging material. Shipments of products are often restricted by both weight and volume constraints and hence packaging may be designed to utilize such space most efficiently. Reference may be made to the objectives and targets stipulated in the Packaging Waste Directive for example.

B.3) PRODUCTION OF WASTE

Waste – further to the definition in the Waste Framework Directive, these are the material outputs of the installation which are not intended to be produced by the activity but are nonetheless produced. This could also include assessment of feasibility of re-use of certain wastes and/or by-products including achievement of End of waste.

The most resource efficient operations are to be adopted and hence techniques ranking according to the 'waste hierarchy' of the Waste Framework Directive are to be applied. Production processes, products and plant operations are to be designed to minimize the production of waste. Where waste is generated, it should be prepared for re-use, recycled or for recovery.

B.4) DECOMMISSIONING

The applicant shall prepare an outline plan on aspects to be considered in case of a future decision to cease operations. Such a plan shall include a list of possible waste streams that would be generated by the decommissioning process. Every effort should be made to divert equipment, and materials away from the waste regime in a manner that it can be re-used elsewhere (e.g. repurposed, sold, transferred donated etc. to other installations) as long as it is still in good working order. A description of how this good working order will be ensured (e.g., third party certification, inspections etc.) is to be provided.

For the remaining equipment and materials which are considered as waste, applicant shall demonstrate how they will be appropriately classified using the EWC code system and possible fate using the waste hierarchy. Where possible their use as by-products or transformation into end-of-waste products as required by the Waste Framework Directive is to be explored. Documentation shall be retained showing the amount, type and fate of each waste stream.

The outline decommissioning plan shall also describe how the decommissioning process itself shall use methodologies (e.g. for dismantling and cleaning) which consumer as little resources as possible whilst generating the least amount of waste and managing environmental risks such as spills, leaks or contaminated

soils. The decommissioning process should ensure that the risk to land and groundwater contamination is kept to the minimum possible and any residual risks are adequately mitigated.

C) REPORTING

Monitoring and reporting the success of a circular economy quality plan involves several key steps and considerations:

- Define Clear Objectives: Establish specific, measurable goals for circular economy initiatives. These could include targets for waste reduction, recycling rates, resource efficiency, and product lifespan.
- Regulatory requirements: Ensure all regulatory requirements are clearly understood and incorporated within the Circular economy plan. These may include CSRD and Packaging waste directive for example.
- Develop Key Performance Indicators (KPIs): Identify KPIs that align with objectives. Common KPIs include the percentage of recycled materials used, the amount of waste diverted from landfills, and the reduction in raw material consumption.
- Data Collection and Analysis: Implement systems to collect relevant data on KPIs. This can involve tracking material flows, monitoring waste streams, and conducting regular audits.
- Regular Reporting: Establish a schedule for reporting progress. Regular reports help in assessing the effectiveness of initiatives and identifying areas for improvement.
- Stakeholder Engagement: Involve stakeholders, including employees, suppliers, and customers, in the monitoring process. Their feedback can provide valuable insights and help in refining strategies.
- Continuous Improvement: Use the data and feedback collected to make informed decisions and continuously improve your circular economy practices. This may involve updating quality plan, adopting new technologies, or revising goals.
- Benchmarking: Compare performance against industry standards or best practices. This can help to understand the company position relative to others and identify opportunities for further improvement

Below is a schematic version of the Circularity Plan to be included in the application, outlining the main contents.

CIRCULARITY PLAN (IED PERMIT APPLICATION ATTACHMENT)	
Section A1: INSTALLATION	Name of the installation
	Location
	Industry Sector
Section A2: INTRODUCTORY PART	Activities at the installation
	Regulatory background
Section A3: ENVIRONMENTAL MANAGEMENT SYSTEM	Circular economy objectives included in the EMS
Section B: CONTRIBUTE TO THE CIRCULAR ECONOMY	Production process: → Raw materials → Main production process/activity/technology used on site → Emissions to air → Effluent discharges → Waste/residue management → Energy management → Adaptation to climate change
	Supply chain, policy and social impact
	Industrial symbiosis
	Product design and end of life; final Product environmental performance
	Decommissioning of the plant
Section C: REPORTING	Monitoring and performance indicator
	Link to CSRD
	Circularity Index: current performance assessment. Sources of data Key areas for improvement Proposed measures and investments

Scope and field of application of the Circularity Index

Regulators and industry may benefit from a common methodology for establishing how effective efforts to increase circularity are. The development of the Circularity Index has been inspired by the principles and methodology of the Italian UNI/TS 11829 standard. Without following the standard rigidly, it can be adapted to provide regulators with a simplified tool that is more aligned with the use of the identified indicators in the permitting and inspection processes of IED installations.

The index is therefore applied at the level of individual IED installations and defines a set of circular economy indicators that allow for an evaluation through a rating system based on 100.

Methodology

The methodology takes a holistic approach to circularity, considering not only the production processes but also the entire life cycle of a product, from design to end-of-life management.

It makes use of a rating system that evaluates the level of circularity achieved by an installation. The system provides a score, typically on a scale from 0 to 100, where 100 represents the highest level of circularity. This allows installations to track their progress over time, set improvement goals, and benchmark their performance against industry standards.

The approach encourages continuous improvement in circular practices. It is not a one-time assessment but rather an ongoing process that promotes periodic reviews and adjustments to optimize circularity performance.

It is recognised that the circular economy Index needs may differ by sector. Therefore, the methodology is adaptable to various IED categories and can be customised to account for the unique characteristics and challenges of different sectors.

Below is a proposed flowchart for constructing a circularity index that can be adapted based on the needs of the competent authorities:

1. **Define Key Performance Indicators (KPIs):**
   - The first step requires to identify relevant KPIs that reflect circular economy principles. Below is a non-exhaustive list of indicators grouped into the following seven categories:

→ *Raw material management*
→ *Water, emissions and energy management*
→ *Product design*
→ *Waste/residue management*
→ *Supply Chain and Logistics*
→ *Policy and social impact*

→ *Transparency and Reporting*

Indicators can be divided into **core** and **rewarding** (to be defined based on the IED category). A simplified list of KPI can be chosen depending on the availability of data.

Topic	KPI Indicators	Structure	Type
Raw material management	1. Raw material replaced by by-products and EoW (secondary raw material)	Quantity of secondary raw materials used / Total raw materials used	Quantitative
	2. Material intensity	Total raw material consumption (kg) / Unit of production	Quantitative
	3. Raw and secondary materials purchased from local suppliers	Quantity of primary and secondary raw materials from internal market / Total raw materials used	Quantitative
	4. Reduction in the use of substances of very high concern (SVHC) in the raw material	Raw material containing SVHC replaced / Total Raw material containing SVHC used	Quantitative
Water, emissions and energy management	5. Use of recycled waste water	Quantity of recycled water reused / Total water consumption	Quantitative
	6. Reduction of water consumption	Total water consumption / Unit of production	Quantitative
	7. Reduction of energy consumption	Total energy consumption / Unit of production Level of energy efficiency (thresholds)	Quantitative Thresholds
	8. Production of energy from renewable sources	Quantity of energy used from renewable sources (self-produced or not) / Total energy consumption	Quantitative
	9. GHG Emissions	Quantity of greenhouse gases emitted by the installation / Unit of production.	Quantitative
Product design	10. Reverse Logistics: Efficient handling of product returns (including recycling). Destination after use	Recyclability/reuse of products or components (qualitative or quantitative). e.g.: Mass of recycled materials in product / Total mass of product	Yes/No or Quantitative

Topic	KPI Indicators	Structure	Type
	11. Circular design	Investments in the circular design of process or products	Yes/No or Quantitative (€)
Waste/residue management	12. Reduction of generated waste (prevention of waste)	Total waste produced / Unit of production	Quantitative
	13. Produced waste sent to recycling/recovery plants	Quantity of waste sent to recycling installations / Total waste production	Quantitative
	14. Produced By-products reused in other industrial cycles	Quantity of by-products reused or sold as raw materials /Total production of residues	Quantitative
Supply Chain and Logistics	15. Type of fuel used	Set different points from 0 to 1 for different sources: Coal, gas, waste, biomass, syngas.	Set-points
	16. Industrial symbiosis initiatives	Implementation of industrial symbiosis mechanisms	Yes/No or Quantitative
	17. Supplier Engagement	Integration of circular economy principles into supplier selection and relationships.	Yes/No
Policy and social impact	18. Environmental Management System	Presence of an EMS (ISO14001, EMAS, not certified)	Yes/No
	19. Circular economy strategy	Presence of a Circular economy strategy in the EMS	Yes/No
	20. Training on circular economy	Presence of a training programme for employees on circular economy	Yes/No
	21. Community Engagement	Projects involving local communities and initiatives promoting circular practices	Yes/No
Transparency and Reporting	22. Public Reporting: Transparency in disclosing circular economy initiatives, progress, and impact	The organization communicates externally its sustainability and circularity performance.	Yes/No

2. **Data Collection:**

The following step is the gathering of data for each KPI from internal sources (e.g., self-monitoring Annual Report) and external sources (e.g., industry databases, government reports).

The data must demonstrate accuracy, completeness, integrity, stability, precision, and repeatability. They should be publicly accessible and verifiable. Their source must always be referenced and traceable. It is essential for the information to be easily accessible; therefore, the selection of indicators will focus on those that can be easily populated by each competent authority/operator.

It is also important to consider the interdependencies among the three dimensions of sustainability (environmental, economic, and social) in the overall evaluation.

3. **Normalization and Weight Assignment:**

Normalize the data for each KPI to bring them to a common scale, usually between 0 and 1, to facilitate comparison.

KPI will be divided into core and rewarding and a different weight will be assigned based on its importance in reflecting circular economy performance. It is appropriate to assign the same set of weights to core and rewarding indicators for the same IED category to achieve comparable results at the regional and national levels. The set of indicators to be used for each IED category must also be defined.

It would be wise to use expert opinions or stakeholder consultations to determine weights.

4. **Index Calculation:**

Calculate the Circularity Index by dividing the sum of the normalized KPIs multiplied by their respective weights by the sum of the weights. The Circularity index will be expressed in percentage (%).

The suggested formula for the Circular Index calculation is the following:

$$\text{Circularity Index} = \frac{\sum(KPI_i \cdot w_i)}{\sum w_i}$$

Where:

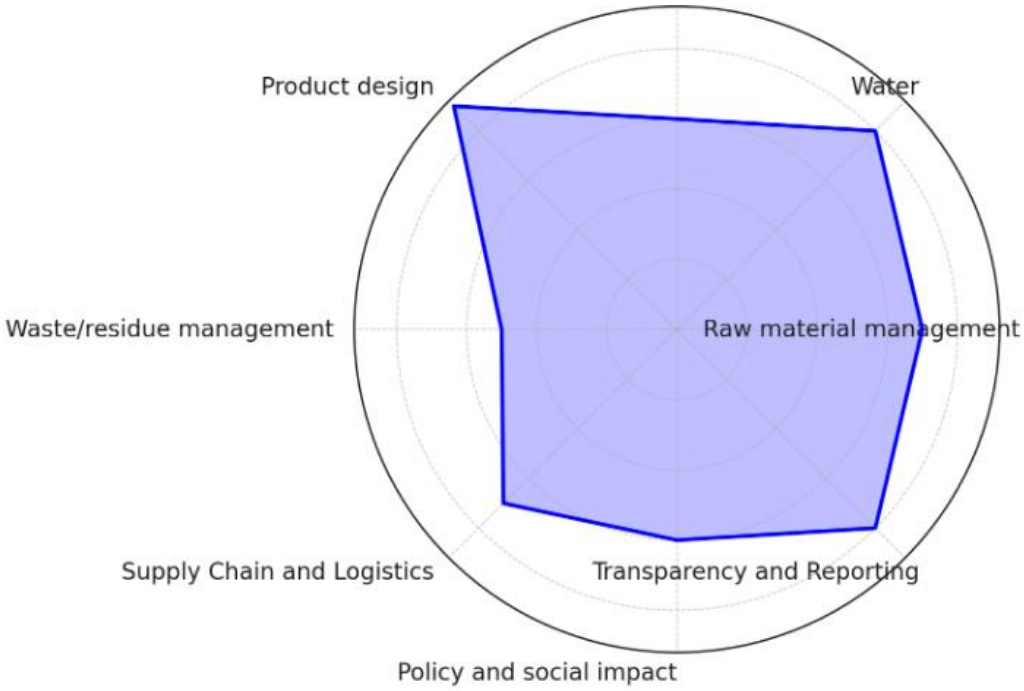
- KPI: Value of the i-th KPI (normalized)
- w_i: Weight assigned to the i-th KPI (rewarding or core)
- $\sum w_i$: Sum of all weights
- i = 1 to n (number of used KPI)

5. Results Interpretation

It is recommended to calculate the circularity level for each of the seven categories of indicators in order to more precisely assess the areas of intervention needed to improve the overall circularity level.

The circularity index for each category would be calculated using the same formula, considering only the relevant indicators.

The results can be graphically represented using a radar chart, with one axis for each category, allowing to visualize and compare the performance across the different areas.



The chart visually shows how the values for each category compare to one another, with higher values indicating stronger performance or focus.

Benchmarks can be used as well. Threshold-based evaluation systems can therefore be adopted as defined below.

- 0-30%: Low circularity (needs substantial improvement).
- 30-70%: Moderate circularity (progressive efforts required).
- 70-100%: High circularity (excellent practices).

Installations, especially if belonging to the same IED category, can be ranked based on their index scores to identify leaders and slow movers in circular economy performance.

One of the main goals of the index is to compare the index scores over time to track progress and identify trends within the same installation.

The results of the analysis form the basis for determining recommendations for improvements, highlighting strengths and weaknesses in circularity performance.

6. Sensitivity Analysis

A sensitivity analysis should be conducted to assess the robustness of the index to changes in weights or KPIs; therefore, how variations in weights or inclusion/exclusion of certain KPIs affect index rankings has to be evaluated.

7. Documentation and Reporting

The determination of the circular index must be accompanied by a summary document that defines the methodology, data sources, and calculations used to build the index to ensure transparency and reproducibility. Clear and accessible reports or visualizations of the index results should be provided to facilitate understanding and interpretation.