ILNAS

TECHNICAL STANDARDIZATION

STANDARDIZATION ANALYSIS

SUSTAINABLE DEVELOPMENT

Version 1.0 · October 2025
ISBN 978 99987 734 7 9

ANEC


H2
CO2

STANDARDIZATION ANALYSIS

SUSTAINABLE DEVELOPMENT

Version 1.0 · October 2025

ILNAS
Institut Luxembourgeois de la Normalisation, de l'Accréditation, de la Sécurité et qualité des produits et services

ANEC
Agence pour la Normalisation et l'Economie de la Connaissance

Foreword

In response to the growing risks posed by climate change and the urgent need for a green transition, the Grand Duchy of Luxembourg has broadened, over the last decade, its strategic focus to encompass environmental preservation and societal advancement, while maintaining a robust economic development of the country. Within this framework, several national strategic and political initiatives have been undertaken, demonstrating Luxembourg's commitment to sustainable development and alignment with the United Nations 2030 Agenda, including the Sustainable Development Goals.

Technical standardization, while primarily serving the national economic development and innovation, also plays an important role in achieving global environmental objectives, such as those outlined in the European Green Deal or in the Paris Agreement, without compromising economic prosperity.

In this frame, the *Institut Luxembourgeois de la Normalisation, de l'Accréditation, de la Sécurité et qualité des produits et services* (ILNAS) extended its focus to the national priorities by integrating the sustainable development domain into the *Stratégie normative luxembourgeoise 2024-2030*. This decision has been endorsed by the Minister of the Economy, SME, Energy and Tourism, who signed the document.

This initiative laid the foundation for the development of the *Politique pour la normalisation technique du domaine du développement durable (2024-2026)* by ILNAS, which is responsible for its implementation, with the support of the Economic Interest Group *Agence pour la Normalisation et l'Économie de la Connaissance* (ANEC EIG - Standardization Department). Among its focus areas, the policy aims to promote and strengthen the adoption of technical standards within the national market, while encouraging active participation of national stakeholders in standardization efforts for sustainable development. In addition, the policy encompasses activities targeting innovation through standardization, education and research.

This report, first deliverable published under the above-mentioned policy, serves as an initial exploration of standardization in the context of sustainable development with the specific goal to transfer valuable standardization knowledge to the national market and to support national stakeholders in their daily business.

Jean-Marie REIFF
Director
ILNAS

Jean-Philippe HUMBERT
Deputy Director
ILNAS

Acknowledgements

The working group appreciates the support it received from Mr. Jérôme Petry from the Ministry of the Economy, which helped provide more accurate information regarding the sustainable development domain.

THE GOVERNMENT
OF THE GRAND DUCHY OF LUXEMBOURG
Ministry of the Economy

Table of contents

Abbreviations

AHG	Ad Hoc Group
AI	Artificial Intelligence
ANEC EIG	Economic Interest Group *"Agence pour la Normalisation et l'Économie de la Connaissance"*
APEE	Application Platform Energy Effectiveness
CEAP	Circular Economy Action Plan
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CFP	Carbon Footprint of a Product
C-ITS	Cooperative Intelligent Transport System
CLC	European Committee for Electrotechnical Standardization
CNCD	*Conseil National pour la Construction Durable*
CO_2	Carbon Dioxide
COG	Coordination Group
CPR	Construction Products Regulation
CPU	Central Processing Unit
CRTI-B	*Centre de Ressources des Technologies et de l'Innovation pour le Bâtiment*
DCIM	Data Centre Infrastructure Management
DPP	Digital Product Passport
EAP	Environment Action Programme
EC	European Commission
eCAV	Electric, Connected and Autonomous Vehicle
ECD	Environmental Conscious Design
ECHA	European Clean Hydrogen Alliance
EDD	Environmental Due Diligence
EEE	Electrical and Electronic Equipment
EE	Environmental Engineering
EMAS	Eco-Management and Audit Scheme
EMC	Electromagnetic Compatibility
EMS	Environmental Management System
EnB	Energy Baseline
EnMS	Energy Management System
EnPI	Energy Performance Indicator
EPBD	Energy Performance Building Directive
EPD	Environmental Product Declaration
EPE	Environmental Performance Evaluation
EPIA	Energy Performance Improvement Action
ERI	Energy Related Investment
ErP	Energy-related Product

ESG	Environmental, Social, and Governance
ESO	European Standardization Organization
ESPR	Ecodesign for Sustainable Products Regulation
ETSI	European Telecommunications Standards Institute
EU	European Union
EV	Electric Vehicle
FC	Fuel Cell
FUAK	*Fonds d'Urbanisation et d'Aménagement du Plateau de Kirchberg*
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GHLV	Gaseous Hydrogen Land Vehicle
GPS	Global Positioning System
GW	Gigawatt
H2	Molecular Hydrogen
HDV	Heavy-Duty Vehicle
HLF	High-Level Forum on Standardisation
ICT	Information and Communication Technologies
IEC	International Electrotechnical Commission
IED 2.0	Industrial and Livestock Rearing Emissions Directive
IEM	Internal Electricity Market
ILNAS	*Institut Luxembourgeois de la Normalisation, de l'Accréditation, de la Sécurité et qualité des produits et services*
ISO	International Organization for Standardization
ITS	Intelligent Transport System
ITU-T	International Telecommunication Union's Telecommunication Standardization Sector
IWA	International Workshop Agreement
KPI	Key Performance Indicator
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
M&V	Measurement and Verification
MaaS	Mobility-as-a-Service
MFCA	Material Flow Cost Accounting
NSB	National Standards Body
OAI	*Ordre des Architectes et des Ingénieurs-Conseils*
OMS	Operation Management Score
PAS	Publicly Available Specification
PBB	Polybrominated Biphenyl
PBDE	Polybrominated Diphenyl Ethers
PCDS	Product Circularity Data Sheet
PCR	Post-Consumer Recyclate

PIR	Post-Industrial Recyclate
PNDD	*Plan National pour un Développement Durable*
PNEC	*Plan National Intégré en matière d'Energie et Climat*
PNGDR	*Plan National de Gestion des Déchets et Ressources*
PPWR	Packaging and Packaging Waste Regulation
PrES	Predicted Energy Savings
PRR	*Plan pour la Reprise et la Résilience*
PSU	Power Supply Unit
R&D	Research and Development
R2RD	Right to Repair Directive
RES	Renewable Energy Source
RESS	Rechargeable Energy Storage System
RFNBOs	Renewable Fuels of Non-Biological Origin
SA	Subsistence Activity
SAG	Strategic Advisory Group
SC	Subcommittee
SDG	Sustainable Development Goal
SG	Study Group
SME	Small and Medium-sized Enterprise
SMS	Structure Management Score
SUMPs	Sustainable Urban Mobility Plans
TAS	Target Achievement Score
TC	Technical Committee
TEN-T	Trans-European Transport Network
TMB	Technical Management Board
TMBG	Technical Management Board Group
TR	Technical Report
TS	Technical Specification
UN	United Nations
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
V2X	Vehicle-to-Everything Communication
WD	Working Draft
WEEE	Waste Electrical and Electronic Equipment
WG	Working Group
WTO	World Trade Organization
ZLEV	Zero- and Low-Emission Vehicle
ZWE	Zero Waste Europe

List of figures

1 Introduction

1 Introduction

1.1 Background of the United Nations Sustainable Development Goals

Known as the Brundtland Report, the United Nations Commission on Environment and Development published a report in 1987 that defines sustainable development [1] as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. To achieve sustainable development, we must consider the concept of sustainability which encompasses three dimensions: environmental protection, economic growth, and social well-being. Sustainable development lies at the intersection of these three pillars, aiming to balance them in a way that ensures long-term resilience and equity.

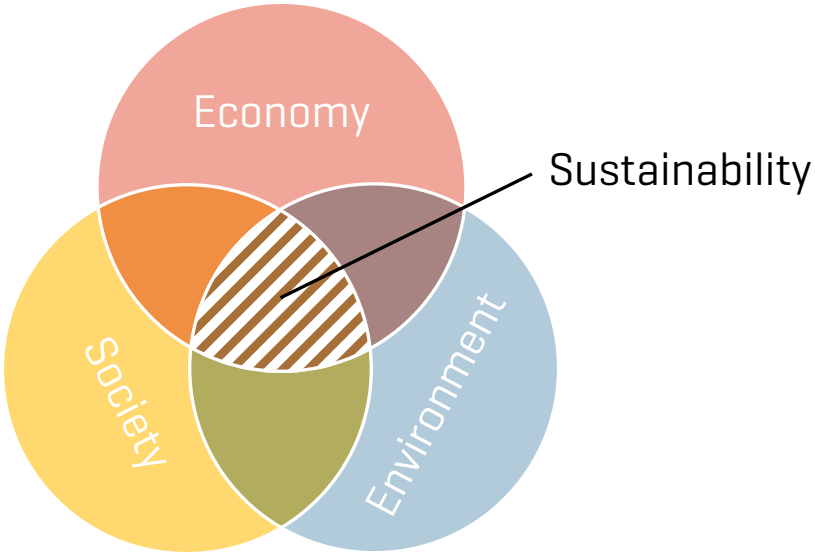

Figure 1 - Sustainability Venn diagram

The 2030 Agenda for sustainable development, defined by the United Nations and adopted by all its member states in 2015, has outlined 17 Sustainable Development Goals (SDGs) (see Figure 2) that aim to achieve "peace and prosperity for the planet and people, both now and in the future"[1].

The SDGs provide the commonly used basis for projects and initiatives that consider environmental and societal aspects, in addition to the economic aspect. They are applicable to most of the stakeholders, such as governments, businesses, civil society, and individuals. Thus, most of the major international agreements, such as the Paris Agreement on Climate Change, government's roadmaps, and organizations' visions are based on the SDGs.

The UN tracks progress towards achieving the SDGs through annual reports and voluntary national reviews submitted by participating countries. Many governments have integrated the SDGs into their national policies and development strategies, while the private sector contributes through corporate sustainability initiatives. To accelerate progress, the UN launched the Decade of Action (2020-2030), calling for stronger commitments across all sectors, and advocating for ambitious yet necessary measures to advance a more sustainable and equitable global future.

1 citation [ref] - https://sdgs.un.org/goals

Figure 2 - The United Nations Sustainable Development Goals

1.2 National context for sustainable development

The Grand-Duchy of Luxembourg has committed to the 17 Sustainable Development Goals (SDGs) set by the United Nations (UN) under the 2030 Agenda. Acknowledging the importance of a focused and strategic approach, the Luxembourg Government has articulated its national priorities in the *Plan national pour un développement durable* (PNDD). This comprehensive roadmap outlines Luxembourg's actions and contributions toward achieving the 2030 Agenda both within its borders and globally. The PNDD identifies 10 strategic key areas, aligning the national objectives with a strong commitment to global sustainability efforts.

From the social perspective, the PNDD priorities include ensuring social inclusion and education for all. The plan emphasizes equal opportunities, lifelong learning, and access to high-quality education. Public health is also a focus area, with efforts directed at improving healthcare services and advancing preventive measures to ensure the conditions for a healthy population.

Environmental protection is at the heart of Luxembourg's sustainability agenda. The country is actively working to halt environmental degradation and respect the capacity of natural resources, ensuring that biodiversity and ecosystems are preserved. Climate action is also a central focus point, with Luxembourg being committed for protecting the climate, to adapting climate change, and ensuring an increasing use of sustainable energy.

With respect to the economic perspective, Luxembourg is actively pursuing diversification and inclusivity to build a resilient future. This commitment is reflected in its support for innovation, digital transformation, and economic stability without compromising environmental aspects. Therefore, sustainable urban planning, with the Government focusing on coordinating land use to balance development needs, plays key role in the economic development of the country. Alongside this, sustainable mobility remains a top priority, supported by investments in public transportation, in green mobility solutions, and in infrastructure improvements. Additionally, Luxembourg aims to promote sustainable consumption and production, encouraging businesses and individuals to adopt environmentally responsible practices. Last but not least, Luxembourg's financial sector plays an important role in sustainable development, with initiatives promoting responsible investment and green finance policies.

By aligning its national policies with the 2030 Agenda, Luxembourg demonstrates its commitment to fostering a sustainable, inclusive, and resilient future both domestically and on a global scale.

1.3 Sustainable development and standardization in Luxembourg

Recognizing national priorities and the pivotal role of standards in advancing sustainable development, ILNAS — *Institut Luxembourgeois de la Normalisation, de l'Accréditation, de la Sécurité et qualité des produits et services* — conducted, with the support of the Ministry of the Economy, an analysis in 2023. This initiative aimed to identify Government activities and projects supporting SDGs, to assess the interests of the Luxembourg's market in this context and finally to draw a parallel with the related ongoing efforts in technical standardization.

As a result, several thematic areas were identified to orient Luxembourg's standardization activities in the field of sustainable development. Concrete actions to further develop these topics have been detailed in the dedicated National Policy for the *Politique pour la normalisation technique du domaine du développement durable (2024-2026)* (more details can be found in section 2.4.2).

1.4 Goals and outline of the report

In line with this approach, the current report focuses on 8 of the topics identified in the policy. It intends to provide insights on each of the topics, specifically connecting them to the related standardization activities. Key information about standardization is provided through the identification of relevant technical committees and standards. The following topics are addressed in this document:

Environmental management

Environmental management is a management practice internally undertaken by organizations or externally enforced by a government, community or market that aims at reducing negative environmental impacts of organizations. Environmental management practices can help organizations to align with EU and national policies and legislation, such as those adopted in the framework of the European Green Deal and of Luxembourg's *Plan National pour un développement durable* (PNDD). In this frame, standards provide accurate and effective tools for the implementation of a comprehensive environmental management in support of sustainable development, also including social and economic aspects. They may allow different actors to effectively control and communicate on their environmental impacts, thus representing a strategic tool for meeting voluntary and compulsory environmental objectives and targets.

Energy efficiency and management

Energy management is a management practice that aims at optimizing energy consumption. This includes, among others, monitoring, controlling and improving energy use. On EU and national levels, policies and legislation including the Energy Efficiency Directive and Luxembourg's Plan national intégré en matière d'énergie et de climat (PNEC) for the period 2021-2030 set the framework for

energy efficiency and management topics, also encouraging improvements in organizational energy consumption. Energy efficiency and management standards may allow different actors to effectively control their energy usage, thus representing a strategic tool for meeting voluntary and compulsory energy-related objectives and targets, and ultimately improving organizations' climate and environmental impact, while reducing cost and increasing resilience.

Circular economy

Circular economy, as opposed to traditional linear economy, is meant as a system where the products and materials are kept in circulation instead of being wasted. It aims to create growth that is independent from the usage of finite resources, which is essential to achieve the global sustainability objective of living well within the planetary boundaries. European Union has adopted in 2020 its Circular Economy Action Plan setting a framework and outlining the actions necessary to switch to the circular economy model. Following the guidance from the European Action Plan, Luxembourg's national strategy on circular economy identifies key priority sectors for the country such as construction, food and biomaterials, industry, and retail, proposing specific action items and roadmaps for each. Moreover, Luxembourg highlights the need for education and financial incentives, supporting both businesses and general public in their transition to circular economy. Luxembourg also recognizes standardization as a mean to achieve its objectives having initiated and led to publication the international standard ISO 59040:2025 Circular economy - Product circularity data sheet.

Sustainable construction

Sustainable construction represents a critical paradigm shift in the building industry, aimed at mitigating environmental impact through the integration of eco-friendly materials, energy-efficient technologies, and responsible design practices. This approach not only targets the reduction of the carbon footprint of construction activities but it also fosters long-term economic resilience and social well-being. The urgency of adopting sustainable construction methods is driven by global challenges such as climate change, resource scarcity, and environmental degradation. Efforts to align construction practices with sustainability goals are underway at both European and national levels. The European Commission has introduced key regulatory and strategic revisions, emphasizing the importance of harmonized standards and technical frameworks to ensure compliance and drive innovation. In parallel, Luxembourg's Government faces the dual challenge of maintaining construction market competitiveness and affordability while meeting ambitious ecological and sustainable national targets. In today's regulatory landscape, the convergence of sustainable construction activities and standardization is increasingly vital. Heightened legislative requirements and growing market demand for environmentally responsible construction are compelling stakeholders to adopt standardized approaches that ensure transparency, accountability, and measurable impact. Together, these dynamics underscore the central role of sustainable construction in shaping a resilient and future-proof built environment.

Hydrogen

Hydrogen is a versatile energy carrier that can be generated from diverse sources and utilized across a wide range of sectors, positioning it as a crucial solution for decarbonizing industries, transportation, and energy systems. When produced through renewable powered electrolysis, often referred to as green hydrogen, it offers a pathway to store renewable energy and replace fossil fuels without emitting greenhouse gases at the point of use. The European Union has set ambitious targets for the share

of green energy, aiming to reach 32% of total energy consumption by 2030, with ongoing discussions to raise this goal to 42.5%, reflecting an increasing commitment to climate action. In line with this collective ambition, Luxembourg considers hydrogen as a pivotal and rapidly emerging element in its *Plan national intégré en matière d'énergie et de climat du Luxembourg pour la période 2021-2030* (PNEC). The country recognizes hydrogen's potential to significantly reduce carbon emissions while enhancing energy security, especially in hard-to-decarbonize sectors. Luxembourg's focus is on the development and deployment of green hydrogen, produced through renewable-powered electrolysis, alongside investments in infrastructure, and its integration into industrial and transport applications. To support this transition, Luxembourg is also investing in research, innovation, and enabling policy frameworks, with the goal of establishing itself as a proactive player in the European hydrogen economy. These efforts are integral to Luxembourg's broader objective of achieving carbon neutrality in the coming decades.

Sustainable mobility

Sustainable mobility in transportation is an urgent and growing demand in today's world. In response, Luxembourg is placing strong emphasis on reducing carbon emissions and enhancing public transportation through a range of key initiatives. These include the introduction of free public transport for all users, support for the adoption of electric and hydrogen-powered vehicles, and significant investments in cycling infrastructure to promote active and eco-friendly travel options. The country's commitment is clearly reflected in strategic frameworks such as the Modu 2.0 - Strategy for sustainable mobility and the *Plan national intégré en matière d'énergie et de climat du Luxembourg pour la période 2021-2030* (PNEC), which together aim to build an integrated, efficient, and sustainable transport system. These strategies focus not only on reducing emissions but also on improving connectivity between different transport modes, optimizing infrastructure use, and ensuring equitable access to mobility services. In addition to national efforts, Luxembourg actively fosters cross-border cooperation with neighbouring countries to address the challenges of regional mobility, recognizing the importance of seamless travel for the large number of daily commuters. Public awareness campaigns further support these goals by encouraging citizens to adopt greener travel habits and understand the environmental benefits of sustainable mobility.

Green ICT

As digital technologies continue to grow, their environmental impact has become a key concern. Green ICT refers to the sustainable design, use, and disposal of information and communication technologies in order to reduce energy consumption, greenhouse gas emissions, and electronic waste. The European Union promotes sustainable digitalization as part of its broader climate and energy objectives, notably through the European Green Deal. In Luxembourg, where the digital economy is strongly based on software development, cloud services, and research, Green ICT is particularly relevant. The country focuses on promoting energy-efficient digital infrastructure, encouraging responsible software engineering, and supporting the optimization of ICT systems through awareness, policy, and participation in European and international standardisation. These efforts contribute to national sustainability goals while supporting innovation and economic resilience in the digital sector, with standardization helping to define clear guidelines for energy efficiency, sustainable software practices, and greener ICT infrastructures.

E-waste

E-waste, or electronic waste, refers to discarded electrical or electronic devices. This waste stream includes a wide range of products such as household appliances, office equipment, entertainment devices, lighting equipment, and more. E-waste is one of the fastest-growing waste streams globally, driven by rapid technological advancements and shorter product lifespans. Improper disposal of e-waste can lead to severe environmental pollution and health risks. At the same time, it contains valuable materials such as gold, silver and copper that can be recovered and recycled. Thus, e-waste management pursues two main objectives, prevent the harm and exploit the potential benefits. The European Waste Electrical and Electronic Equipment (WEEE) Directive aims at reducing the environmental impact of e-waste by promoting its proper collection, recycling, and recovery. One of actions Luxembourg took in that direction, in line with the national law of 06/09/2022, was the establishment of a non-profit organization Ecotrel that ensures the legal obligations imposed on producers and importers of Electronics, Electrical Equipments (EEE) are met. Additionally, Luxembourg leverages European and international e-waste standards to support sustainable practices. Though national involvement is limited, standards can help national organizations innovate in recycling and comply with EU legislation.

This report is organized as follows:

Chapter 2 introduces the concept of technical standardization by defining its key principals and its relevance to the SDGs.

Chapter 3 explores the identified sustainability-related topics, presenting their challenges, strategic and legal frameworks, as well as dedicated standardization activities. Each section of this section is designed to be read independently.

Chapter 4 discusses the motivations and opportunities for engaging in technical standardization.

Chapter 5 outlines the services provided by ILNAS and ANEC EIG.

2

Technical standardization in support of the SDGs

2 Technical standardization in support of the SDGs

2.1 Overview

2.1.1 Technical standards

The European Regulation (EU) N°1025/2012 on European standardisation gives the following definition of a standard:

> "a technical specification, adopted by a recognised standardisation body, for repeated or continuous application, with which compliance is not compulsory [...]"

and defines 'technical specification' as:

> "a document that prescribes technical requirements to be fulfilled by a product, process, service or system [...]"

Standards are meant to bring solutions to recurrent technical and business problems, on a broad scale, and may apply to products, services, and processes, but also, indirectly, to reduce trade barriers. Therefore, the World Trade Organization (WTO) has listed a set of fundamental principles [12] that international standards and standards development should adhere to in order to be considered as such. These are:

- **Transparency of technical work programs.**
  All essential information regarding current work programs, as well as on proposals for standards, guides and recommendations should be made easily accessible to all interested parties.
- **Openness in participation.**
  Membership within an International Standards Body should be open available on a non-discriminatory basis.
- **Impartiality and consensus.**
  All relevant bodies should be provided with meaningful opportunities to contribute to the elaboration of an international standard so that the standard development process will not give privilege to, or favour the interests of, a particular supplier, country or region. Consensus procedures should be established allowing to take into account the views of all parties concerned and to reconcile any conflicting arguments;
- **Effectiveness and relevance.**
  International standards need to be relevant and effectively respond to regulatory and market needs, while acknowledging scientific and technological developments in various countries. They should not distort the global market, have adverse effects on fair competition, or stifle innovation and technological development. In addition, they should not give preference to the characteristics or requirements of specific countries or regions whenever different options exist in other countries or regions. As far as possible, international standards should provide high level performance-oriented requirements rather than quantitative characteristics.

- **Coherence.**
  In order to avoid the development of conflicting international standards, it is important that international standardization bodies avoid duplication of, or overlap with, the work of other international standardization bodies. In this respect, cooperation and coordination across various standardization bodies is essential.
- **Development dimension.**
  The constraints faced namely by developing countries in effectively participating in standards development should be carefully considered throughout the process. Proactive and practical measures should be explored to facilitate their meaningful involvement in international standardization efforts.

2.1.2 International and European standards organizations

The overall worldwide standards landscape encompasses officially recognized international and regional standardization bodies as well as thousands of industrial fora, consortia, associations, etc. that develop technical specifications and other normative deliverables.

According to the European Commission related regulation, only six standardization bodies are recognized, three at the international level and three at the European level.

The three recognized international standardization bodies are:

- **the International Organization for Standardization** (ISO)**;**
- **the International Electrotechnical Commission** (IEC)**;**
- **the International Telecommunication Union's Telecommunication Standardization Sector** (ITU-T)**.**

The three recognized European Standardization Organizations (ESOs) are:

- **European Committee for Standardization** (CEN)**;**
- **European Committee for Electrotechnical Standardization** (CENELEC)**;**
- **European Telecommunications Standards Institute** (ETSI)**.**

In accordance with European regulation, National Standards Bodies can also issue technical specifications and standards, thereby increasing the diversity of available documentation sources. In Luxembourg, ILNAS is the National Standards Body (NSB).

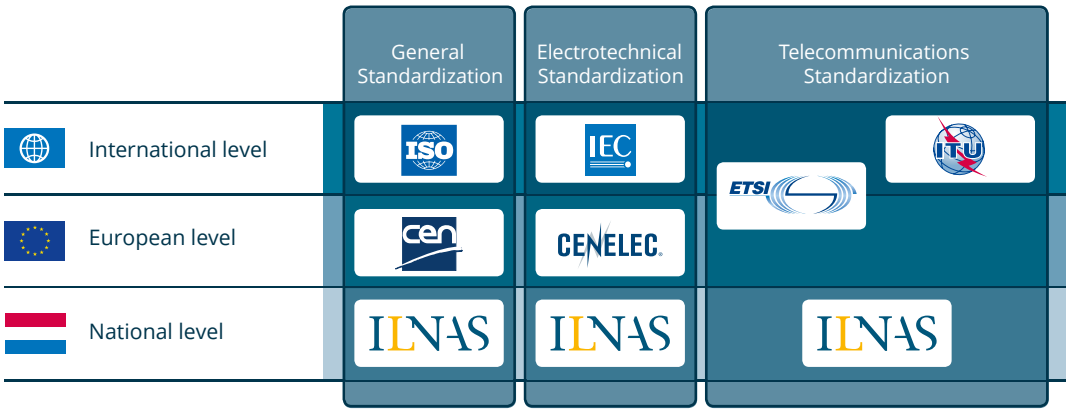

Figure 3 - Relative positioning of the main standards developing organizations

2.1.3 ILNAS - National standards body

ILNAS is a public administration under the authority of the Minister of the Economy, SME, Energy and Tourism of the Grand Duchy of Luxembourg.

Founded in 2008, ILNAS represents a network of competencies relating to quality, safety and conformity of products and services (see Figure 4), and its mission is to support national competitiveness. The legal missions of ILNAS are described in the Law of 4 July 2014 on the reorganization of ILNAS.

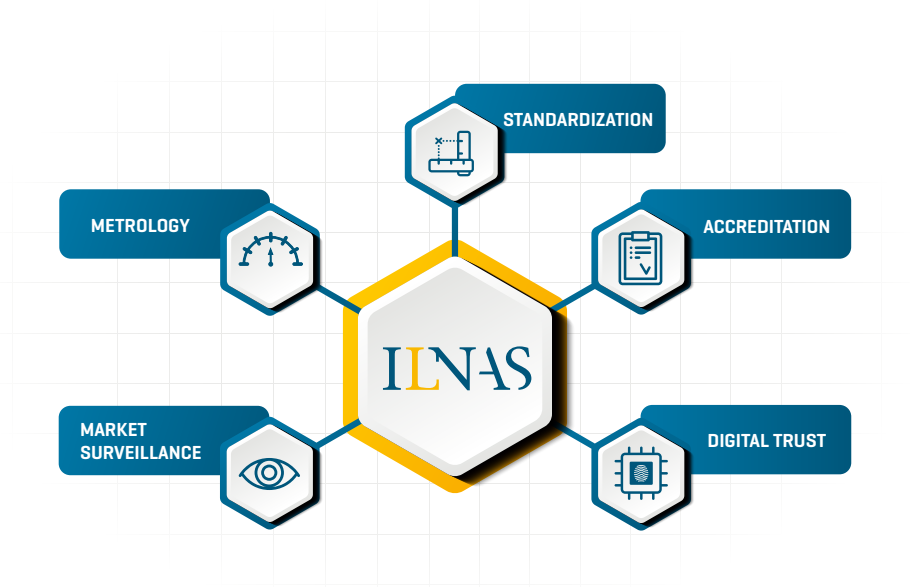

Figure 4 - The departments of ILNAS

In regard to standardization, ILNAS' missions are notably to promote technical standardization and to foster the participation of national stakeholders to standardization. As such, it is the Grand Duchy's only National Standards Body (NSB).

ILNAS organizes its standardization work according to the *Stratégie normative luxembourgeoise 2024-2030* and related standardization policies for ICT, Construction, Aerospace, conformity and sustainable development domains (see section 2.4). Overall, the objectives are to raise awareness on the use of technical standards, promote active participation in the development and publication of standards, enhance Luxembourg's international visibility in standardization, and develop strong links between standardization, scientific research and education.

2.1.4 ANEC EIG

ANEC EIG *(Agence pour la normalisation et l'économie de la connaissance)* is an economic interest group whose partners are the Ministry of the Economy, the Chamber of Skilled Trades and Crafts *(Chambre des Métiers)* and the Chamber of Commerce *(Chambre de Commerce)*. It supports ILNAS in implementing the national standardization strategy and the related national standardization policies.

2.2 Role and benefits of standards in the context of sustainability

Since its inception, standardization has aimed to provide solutions to the challenges posed by technological advancements. At its origin, i.e. in the late 19th and early 20th century, standards provided solutions for interoperability between neighbouring countries, supporting, for example, common railway infrastructure [13], telegraphy protocols [14] or screw sizes [15]. Later, especially during the industrialization era, standardization helped to improve production efficiency, reduce costs and increase economy development [16]. More recently, Information and Communication Technologies (ICT) have based their complete implementations on standardized protocols, processes and interfaces. For more than three decades now, technical standardization has mainly addressed technical and technological challenges. However, since then, the objectives pursued through standardization have evolved to address emerging challenges, most notably environmental concerns and, more generally, sustainability [17].

With its different fundamental characteristics, as discussed in previous section 2.1.1, standardization remains a great tool to efficiently reach targets (results, performance, organization, etc.), independently from the area, including sustainable ones. By involving the different stakeholders in their development, standards reflect the state-of-the-art in a given domain and provide good practices that are accessible and applicable to all. This significantly enhances their potential for widespread implementations. In the context of sustainability, it also contributes to improving global environmental performance. A concrete example is provided by the standards **ISO 14040:2006 Environmental management — Life cycle assessment — Principles and framework** and **ISO 14044:2006 Environmental management — Life cycle assessment — Requirements and guidelines** which lay the foundations of life cycle assessment. These standards are widely used for all types of products as well as for organizations' assessments.

The widespread utilization of standards has undeniable benefits with respect to achieving environmental and economic objectives:

- **Harmonization of terminology, methodologies and good practices.**
  This helps to prevent misunderstandings and inconsistent actions among stakeholders, reducing the risk of ecosystem fragmentation.
- **Improved quality of results.**
  Using standardized methodologies/processes lead to more consistent and reliable outcomes that align with the environmental expectations of stakeholders and community.
- **Enhanced trust.**
  By adhering to commonly adopted solutions, standards convey trust in their application, making the results more readily accepted by other parties.
- **Compliance to regulation.**
  Standards are sometimes used by legislators to provide technical specifications supporting regulation. Aligning with these standards can support conformity with sustainability-related regulations.

2.3 Efforts by standardization organizations towards sustainable development

2.3.1 Shift towards sustainability and environmental preservation

The increasing interest of standardization organizations in sustainability and environment is a consequence of long-term concerns about environmental degradation. In 1996, ISO published its first environment-related standard, **ISO 14001:1996 Environmental management systems — Specification with guidance for use**. This publication marked a turning point when sustainability considerations were embedded in the scope of standardization, as well as into the drafting process. Since then, sustainability-focused standards have abounded across the portfolios of standardization organizations, such as ISO, IEC, ITU-T, CEN, CENELEC, and ETSI, reflecting a wide range of perspectives. This evolution has led to the creation of dedicated technical committees to address the growing complexity and importance of sustainability in standardization (*e.g.* ISO/TC 207 - Environmental Management). Such standards provide frameworks, guidelines, and best practices that help organizations and countries to achieve sustainable development across various sectors, and address global challenges such as climate change, resource efficiency, and social responsibility.

2.3.2 Examples of sustainability-related publications

Guidance for organizations

Recognizing the pivotal role of standardization in information dissemination, ISO published several freely accessible documents that address sustainability from a strategic perspective. Some of these publications have been jointly drafted in collaboration with key partners, such as United Nations Development Programme (UNDP). Together, they provide guidance to help organizations of all types and sizes reach their environmental and sustainability goals. Examples of these documents are:

- **ISO/UNDP PAS 53002:2024 Guidelines for contributing to the United Nations Sustainable Development Goals (SDGs)**

  This is a Public Available Specification that provides a set of guidelines developed by the International Organization for Standardization (ISO) and the United Nations Development Programme (UNDP) to help organizations to contribute to the United Nations Sustainable Development Goals (SDGs). These guidelines provide a structured framework for maximizing positive impacts and minimizing negative ones, especially for vulnerable groups. Applicable to organizations of all sizes and sectors, ISO/UNDP PAS 53002:2024 is aimed at top-level decision-makers. By integrating SDG-related strategies into their operations, organizations can enhance stakeholder engagement, improve sustainability reporting, and support risk management related to sustainability issues.

- **IWA 42:2022 Net zero guide**

  This is an International Workshop Agreement that provides principles and recommendations for achieving net zero greenhouse gas emissions. Developed by ISO/TC 207/SC 7, these guidelines aim to align voluntary initiatives and standards to limit global warming. The guidelines emphasize addressing all greenhouse gas emissions within an organization's value chain and setting targets based on scientific knowledge and good

practices. It also encourages the integration of net zero aspects within organization's strategies and policies, ensuring effectiveness and transparency. Similarly to ISO/UNDP PAS 53002:2024, this normative document is applicable to all organizations, including governance bodies in charge of the development of policies for net zero. By providing common terms and recommendations, this document helps organizations to set climate strategies, reduce emissions, and contribute to nature protection.

➜ **IWA 48:2024 Framework for implementing environmental, social and governance (ESG) principles**

It provides a high-level framework and set of principles for implementing and embedding Environmental, Social, and Governance (ESG) practices within organizational culture. These guidelines aim to support the management of ESG performance, measurement, and reporting, ensuring consistency, comparability, and reliability globally. The guidelines emphasize the importance of integrating ESG principles into business strategies to balance profitability with social responsibility and environmental sustainability. IWA 48:2024 highlights key ESG principles such as integrity, outcomes-focused approaches, and equity.

Guidance for standard developers

To support the integration of sustainability into standardization, ISO has developed dedicated guidance for standards developers. These documents provide practical frameworks to help incorporate sustainability and climate considerations into the drafting and revision of standards, ensuring a more holistic and future-oriented approach:

➜ **ISO Guide 82:2019 Guidelines for addressing sustainability in standards**

It provides guidance to standard developers for incorporating sustainability aspect in normative documents. This document is not limited to the drafting activities and gives a systemic methodology that support also the integration of sustainability aspects in the strategic business plan of ISO technical committees. More specifically, the procedure aims to help stakeholders to understand and identify sustainability issues related to the domain covered by the technical committee, and in addition details several approaches to assess the sustainability issues to be addressed within standards, such as systematic approach, life cycle approach or risk-based approach.

➜ **ISO Guide 84:2020 Guidelines for addressing climate change in standards**

Similarly to ISO Guide 82:2019, the intention of this document is to encourage standards developers to systematically consider the impacts of climate change within their area of standardization. The proposed methodology focuses on both technical committee strategical decisions and underlying Working groups activities.

These two documents allow to have a full assessment of the impact of any sustainability-related standard, and therefore to contribute to the different sustainable development goals.

2.3.3 Comprehensive approach towards achieving the SDGs

ISO's commitment to sustainable development and environment preservation extends beyond the publication of dedicated standards. Recognizing the overarching nature of sustainability challenges, ISO introduced in 2018 a requirement in standard proposals form to identify the SDGs supported. Since then, every new standard is mapped to one or several SDGs, and this mapping has been retroactively applied to existing standards. To facilitate identification of standards supporting specific SDGs, ISO created a dedicated tool allowing users to explore standards per SDG (see Figure 5). Other standardization organizations followed ISO's initiative and created similar tools (e.g. CEN/CENELEC, IEC).

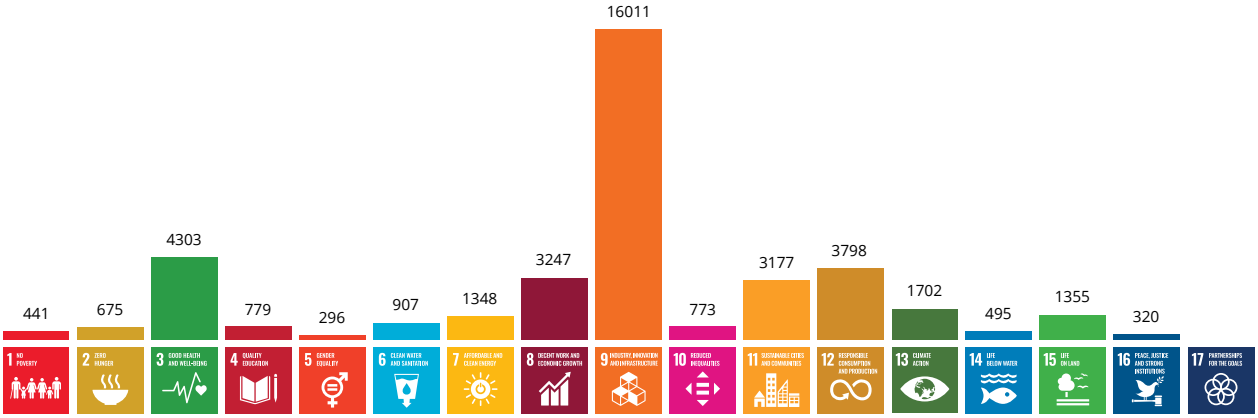

Figure 5 - ISO tool for standards classification according to SDGs

More broadly, these different activities align with the strategic directions adopted by standardization organizations, which have increasingly embedded the SDGs into their long-term missions and priorities over the period 2021-2030. Namely, in its Strategy 2030, ISO defines its Goal 2 as "Meeting global needs" and sets more specifically its priority 2.3 to "Advance environmental sustainability through ISO standards" [18]. IEC, for its part, dedicates an entire theme [19] of its strategy — titled "Fostering a sustainable world" — to this effort. At the European level, CEN and CENELEC have jointly committed to supporting EU policies outlined in the EU Green Deal shared through European standardization efforts.

This strategic shift has also influenced organizational structures, leading to the creation of specialized groups focused on sustainability. The role of these groups is essentially to translate the strategic goals into actionable tasks within technical committees. Thus, at ISO level, advisory groups, such as ISO/TMBG/ESG Coordinating Committee, have been established to support Technical Management Board (TMB) and provide recommendations on the drafting of sustainability-related standards and their supporting structures, including committee scopes, working group mandates, etc. Similar entities have emerged within the European standardization organizations, notably the Coordination Groups (COGs) and Strategic Advisory Groups (SAGs). For example, CEN and CENELEC have set up COGs on *Circular Economy*, *Climate* and *Environment*, as well as a SAG focused on their Action Plan on Climate change. These groups are instrumental in ensuring that sustainability remains a core consideration throughout the whole standardization process.

2.4 National standardization context

2.4.1 National standardization strategy

In Luxembourg, standardization activities are framed by the *Stratégie normative luxembourgeoise 2024-2030*. This document, signed by the Minister of the Economy, SME, Energy and Tourism, provides the national priorities in terms of standardization and identifies the growth-sectors and domains actively supporting the national economy.

It defines 4 pillars aiming at reaching performance and excellence with respect to standardization, thereby contributing to the development of the national economy.

Toward performance

- **Pillar I** - To value and promote the use of relevant technical standards by economic stakeholders in sectors identified as growth-sectors and in nationally relevant domains.
- **Pillar II** - To foster the involvement of national stakeholders to standardization activities.

Toward excellence

- **Pillar III** - Active participation of the NSB in the European and international standardization organizations.
- **Pillar IV** - To organize and develop research and education about standardization programmes related to growth-sectors and relevant domains.

To align with the national priorities and define boundaries to standardization activities, the current strategy identifies 3 growth-sectors (ICT, Construction and Aerospace) and 2 cross-cutting domains (Conformity, sustainable development), the latter applicable to all areas of activities.

Sustainability was formally added as a new domain in 2024, aligning Luxembourg's standardization efforts with national priorities on environmental protection and sustainable development. This addition reinforces the role of standardization in supporting sustainability, while maintaining its core objective of serving the national economy. Each of the growth-sectors and relevant domains identified in the national standardization strategy, including sustainable development, is supported by a dedicated policy, outlining the activities to be conducted by ILNAS and ANEC EIG to achieve the pillars defined in the strategy.

2.4.2 Standardization policy for sustainable development

Following its inclusion into the national strategy, the field of sustainable development was elaborated in 2024, through a dedicated standardization policy *(Politique pour la normalisation technique du domaine du développement durable (2024-2026))*.

This document outlines 3 axes, translating the National standardization strategy 2024-2030 into concrete tasks:

- **Axis I** - Promote technical standardization of identified sub-topics to stakeholders.
- **Axis II** - Strengthen the valorisation of technical standardization and involvement of stakeholders.
- **Axis III** - Support innovation via standardization, research and education.

This policy also identifies the key sub-topics most relevant for the national development, as validated by the Ministry of the Economy. Currently, 11 topics are explored by ILNAS and ANEC EIG.

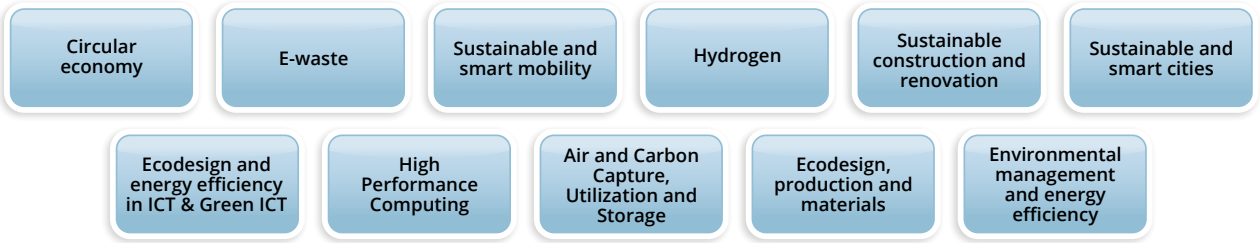

Figure 6 - Topics covered in the frame of the national standardization policy for sustainable development

The current selection of subjects aligns with the national priorities while also taking into account the European objectives related to environmental and sustainability challenges, particularly where they intersect with standardization activities.

3

Overview of sustainable development activities at European and national level

3 Overview of sustainable development activities at European and national level

This report fully aligns with **Axis I** - Promoting technical standardization of identified sub-topics to stakeholders and **Axis III** - Supporting innovation through standardization, research and education - of national standardization policy for sustainable development and covers several of the identified thematic areas listed in the section 1.4. Each of the sub-chapters of this section will explore the challenges faced within each subject area, along with the policies and strategies at both national and European levels. It will also explore the current legal frameworks and ongoing standardization initiatives.

3.1 Environmental management

3.1.1 Background

Since the start of the Industrial Era around 1750, and especially since 1950, human activities such as the burning of fossil fuels, the high resource extraction and consumption, the use of chemicals and intensified agricultural practices have contributed to environmental issues which are increasingly impacting the social and economic wellbeing worldwide [20]. According to the United Nations Environment Program (UNEP), main environmental challenges include: climate change, nature and biodiversity loss, pollution and waste [21]. Many aspects of these three main issues are interconnected and consequences lead to devastating and in part irreversible changes around the World.

Climate change refers to an increase in global average temperatures and a shift in weather patterns [22]. This contributes among others to a higher frequency and intensity of severe weather events, to increasing water scarcity, drought and desertification, to ice and glacier melting, to rising sea levels and to ocean acidification [23]. Pollution and waste are drivers of important health-related risks, while also negatively affecting biodiversity and ecosystems [24] [25]. Waste transporting, processing and disposing contributes to additional greenhouse gas emissions which further intensify climate change [24]. Nature and biodiversity loss — partly driven by climate change, waste and pollution — puts ecosystem services that we depend on at risk [26]. Ecosystem services are the benefits that ecosystems provide to the humankind [27]. They contribute, among others to our food supply, clean water and air, materials, climate regulation, and others [26].

Environmental degradation and climate change induced problems — affecting for example infrastructure, physical property, natural resource availability or supply chains — can pose increasing risks to organizations if no accurate prevention, mitigation and adaptation measures are taken. From an economic point of view, also increasing environmental legislation efforts, stakeholder demands and shifting consumer trends towards sustainable products and services may require organizations to adapt to fast-changing developments. This may also include the provision of an organization's sustainability performance information to relevant stakeholders. Sustainability disclosures are in fact not only necessary in the framework of mandatory sustainability reporting requirements, but can also improve, among others, the access to investment, to markets and to skilled workforce.

3.1.2 Challenges of the sector

Environmental management practices are becoming more and more common among organizations [28]. However, even though companies from various sectors start implementing sustainability programs, environmental management at scale is not often reached [28].

This seems to be partly due to internal structural, cultural and operational factors [28] [29] [30].

In fact, sustainability-related responsibilities are often transferred to isolated departments, such as ESG (environmental, social and governance) departments [28]. This however keeps the topic far away from other key functions such as strategy and innovation or business operations making it difficult for sustainability to be practiced throughout the whole organization [28].

Conventional processes and metrics lack the integration of sustainability aspects by design [28]. Most procedures and criteria commonly used when formulating strategies or evaluating projects were designed in times where profit and finance were in the focus [28]. Sustainability-related metrics and tools remain limited in their adoption and penetration within organizational management [28] [30]. And even if some organizations now include environmental or sustainability-related metrics, these are often inconsistent or fragmented [28] [30]. For example, ESG reports are often based on unverifiable or inaccurate data that lack the accounting rigor of conventional financial metrics [28]. However, without familiarity of management and all employees with coherent and accurate sustainability frameworks that are embedded into day-to-day practices, judgements and decisions based on sustainability may not easily be made [28] [29] [30].

All in all, organizational culture and skills must be further oriented towards sustainability [28] [29] [30]. Embedding sustainability at the heart of the organizational activity and purpose may require a deep cultural and structural transition, which can only be fully embraced with full leadership support [28] [29] [30].

Other challenges for the implementation of comprehensive sustainability strategies and practices can include funding, and collaboration between stakeholders [29] [30]. In fact, major investments are often needed to finance large-scale transformations that put environmental considerations at the center of an organization's activity, including its products and services [29] [30]. Additionally, a sustainable transformation may require collaboration along whole supply chains and among different stakeholders [29] [30]. This can make accurate environmental management complex and lengthy.

All in all, it can be noted that even if technology and tools such as frameworks or methods for sustainability management approaches exist today, among others current practices and the design of the following elements can challenge effective environmental management within organizations:

- **Funding**
- **Stakeholder collaboration (e.g. along the supply chain)**
- **Corporate structure and organization**
- **Organizational culture and skills**

Technical standardization may help organizations overcome challenges in scaling up environmental management while also supporting them in meeting and preparing for new market demands, whether these come from legislation, customer preferences, investors, or other external influences.

3.1.3 Policies and strategies

In the framework of European and national policies, different legislation is introduced, and finance is mobilized, to encourage and facilitate among others the implementation of sustainable business practices, including measures to reach net zero greenhouse gas emissions. Depending on the type of measure, this can help to overcome environmental management related challenges, such as a lack of funding, poor stakeholder engagement or collaboration, insufficient integration of sustainability aspects into the design of processes and metrics, or the lack of sustainability among core organizational values. The policies and associated legislation furthermore acknowledge the need for organizations to contribute more transparently and effectively to the mitigation of environmental degradation and climate change, in line with stakeholder expectations (consumer trends, employee and investor demands, etc.).

European level

On European level, a variety of relevant strategies, action plans, agendas and policies exist to tackle sustainability-related challenges, implying some form of environmental management. General initiatives include the European Green Deal and the 8th Environment Action Programme (EAP).

➜ **The European Green Deal**

The EU Green Deal consists of a package of policy initiatives and was launched in 2019. It aims at supporting the development of a new clean and circular economic growth model through a green transition.

In fact, it is based on the Paris Agreement's goal to keep global warming to under +1.5°C compared to pre-industrial levels.

Key topics also include: climate neutrality by 2050, circular economy, clean industry, healthier environment, more sustainable farming, and climate justice and fairness.

➜ **8th Environment Action Programme (EAP) to 2030**

The 8th EAP entered into force in 2022 and is the EU's common agenda for environment policy until 2030.

The action programme aims at assuring long-term well-being within planetary boundaries. It sets out objectives for 2030 and their framework. Based on the European Green Deal, the 8th action programme aims to support the transition to a resource-efficient and climate-neutral economy, recognizing the dependence of human wellbeing and prosperity on healthy ecosystems. The action programme expects active engagement of all stakeholders at all governance levels, to ensure the effective implementation of EU climate and environment laws. It forms the basis for the EU to achieve the United Nation's 2030 Agenda, including the Sustainable Development Goals.

The six priority objectives of the 8th environmental action programme include: climate change mitigation, climate change adaptation, regenerative circular economy, zero-pollution, enhanced biodiversity and natural capital, environmentally friendly production and consumption.

National level

At national level, particularly the *Plan national pour un développement durable (PNDD)* sets Luxembourg's general framework for sustainable development.

➔ ***Plan national pour un développement durable* (PNDD)**

Published in 2019, the PNDD identifies key sustainability policy areas, concrete objectives and actions to take until 2030.

It includes ten fields of action focusing on social inclusion and education, a healthy population, sustainable production and consumption, a diversified and inclusive future-oriented economy, planification and coordination of land/territory use, sustainable mobility, stop of environmental degradation and respect of natural resource capacities, climate change mitigation and adaptation, and renewable energy, contribution to global poverty eradication and coherence of sustainability policies and sustainable finance.

Other environmental management related national policies and strategies include the following:

- **Circular Economy Strategy Luxembourg** (2021): positioning of Luxembourg as a hotspot for circular economy *(this strategy is further explained in the chapter 3.2.1)*.
- **The Data-Driven Innovation Strategy for the Development of a Trusted and Sustainable Economy in Luxembourg** (2019)
- **Strategy "Null Offall Lëtzebuerg"** (2019): policies for improved resource management.
- ***Plan national de gestion des déchets et des ressources* (PNGDR)** (2018): document defining the main areas for waste management policies.

3.1.4 Legal frameworks

European level

At EU level, a broad range of sustainability-related regulations and directives exist in the field of sustainability, encouraging organizations to improve their environmental management practices. Hereunder some important examples:

➔ **Regulation (EU) 2021/1119 establishing the framework for achieving climate neutrality**

The Regulation (EU) 2021/1119 is also called the European climate law. In fact, it is the most important piece of legislation within the Green Deal and entered into force in 2021, making the goal of reaching climate neutrality by 2050 a legal obligation for all member countries of the EU.

➔ **Regulation (EC) No 1221/2009 on the voluntary participation by organizations in a Community eco-management and audit scheme (EMAS)**

The so-called EMAS (Eco-Management and Audit Scheme) regulation establishes EMAS, a management instrument designed to improve organizations' environmental impact. The evaluation, reporting and improvements in environmental performance may also contribute to energy savings and an optimized resource usage. Participation in the Eco-Management and Audit Scheme is voluntary.
ANNEX II of the regulation addresses the compatibility of EMAS with the international standard ISO 14001

for environmental management systems. In fact, the environmental management system requirements of section 4 of ISO 14001 are the ones also applicable under EMAS. However, EMAS requires organizations to address additional issues linked to elements of section 4 of the ISO 14001 standard. Those issues are as well specified in ANNEX II of the EMAS Regulation.

- **Directive 2010/75/EU on industrial and livestock rearing emissions (integrated pollution prevention and control)**

  The directive 2010/75/EU is amended by Directive (EU) 2024/1785 and aims at prevention and control of emissions from large European industrial and livestock installations. It is the most important instrument of the EU to reduce such emissions into water, land and air and to prevent waste generation at these installations. Among others, the Industrial and Livestock Rearing Emissions Directive may enable improvements in material efficiency, decarbonization and accessibility of environmental data, while discouraging the use of hazardous chemicals.

Other EU regulations and directives related to environmental management may include the following:

- **Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the environment**
- **Regulation (EU) 2021/783 establishing a Programme for the Environment and Climate Action (LIFE)**
- **Directive (EU) 2022/2464 as regards corporate sustainability reporting**
- **Commission Delegated Regulation (EU) 2023/2772 as regards sustainability reporting standards**
- **Directive (EU) 2024/1760 on corporate sustainability due diligence**
- **Directive (EU) 2024/825 as regards empowering consumers for the green transition through better protection against unfair practices and through better information**

National level

Relevant national legislation in the field of sustainability and environmental management is listed hereunder:

- ***Loi du 15 décembre 2020 relative au climat et modifiant la loi modifiée du 31 mai 1999 portant institution d'un fonds pour la protection de l'environnement***
- ***Loi du 29 mai 2024 portant modification de la loi modifiée du 15 décembre 2020 relative au climat***
- ***Loi du 19 décembre 2008 établissant un cadre pour la fixation d'exigences en matière d'écoconception applicables aux produits consommateurs d'énergie***
- ***Loi du 15 décembre 2010 modifiant la loi du 19 décembre 2008 établissant un cadre pour la fixation d'exigences en matière d'écoconception applicables aux produits consommateurs***

3.1.5 Standardization activities

Technical standardization is responding to current needs and challenges in the field of environmental management, supporting organizations on their pathway to adapting to EU and national objectives, policies and legislations, but also to stakeholder requirements, in a credible and transparent way. The international standardization committee ISO/TC 207 with its 6 subcommittees develops standards that may be applied by most organizations and sectors, covering topics such as environmental management systems, environmental auditing, labelling, environmental performance evaluation, life cycle assessments and greenhouse gas management, including greenhouse gas accounting.

Relevant technical committees

➜ **ISO/TC 207 Environmental management**

Scope: Standardization in the field of environmental management to address environmental and climate impacts, including related social and economic aspects, in support of sustainable development.

➜ **ISO/TC 207/SC 1 Environmental management — Environmental management systems**

Scope: Standardization in the field of environmental management systems to support the achievement of sustainability.

➜ **ISO/TC 207/SC 2 Environmental management — Environmental auditing and related practices**

Scope: Standardization in the field of environmental auditing and related practices, in support of sustainable development. Environmental auditing related practices include, for example, EMS auditing, environmental due diligence, environmental risk assessment, verification and validation of environmental information, such as environmental claims and declaration, environmental reporting, etc.

➜ **ISO/TC 207/SC 3 Environmental management — Environmental labelling**

Scope: Standardization in the field of communication on environmental aspects of products (i.e. goods and services), including related social and economic aspects. Such communication includes various types of an environmental statement (e.g. self-declared claims, ecolabelling, environmental product declarations and environmental footprints) and their associated programmes.

➜ **ISO/TC 207/SC 4 Environmental management — Environmental performance evaluation**
Scope: Standardization in the field of environmental performance evaluation in support of sustainability.

➜ **ISO/TC 207/SC 5 Environmental management — Life cycle assessment**

Scope: Standardization in the field of life cycle assessment and related management systems and tools for products (and services) and the product portfolio of organizations, including related environmental, social, and economic aspects, in support of sustainable development. Including life cycle based environmental, social, economic, and technical assessments. Such assessments can apply to e.g. circularity of resources and eco-efficiency. The outcome of the assessment provides input for decision making to minimize or to prevent potential adverse impacts.

➜ **ISO/TC 207/SC 7 Environmental management — Greenhouse gas and climate change management and related activities**

Scope: Standardization to manage GHG emissions, as well as to adapt to the effects of climate change in support of sustainability.

Relevant technical standards supporting sector challenges

Environmental Management Systems

➜ **ISO 14001:2015 Environmental management systems — Requirements with guidance for use**
This standard has been adopted at European level. This standard supports the European regulation (EC) No 765/2008.

Abstract: ISO 14001 is the internationally recognized standard for environmental management systems (EMS). It provides a framework for organizations to design and implement an EMS, and continually improve their environmental performance. By adhering to this standard, organizations can ensure they are taking proactive measures to minimize their environmental footprint, comply with relevant legal requirements, and achieve their environmental objectives. The framework encompasses various aspects, from resource usage and waste management to monitoring environmental performance and involving stakeholders in environmental commitments.

➜ **ISO 14002-1:2019 Environmental management systems — Guidelines for using ISO 14001 to address environmental aspects and conditions within an environmental topic area — Part 1: General**
This standard has been adopted at European level.

Abstract: The standard series ISO 14002 is based on ISO 14001 Environmental management systems and provides guidelines for organizations seeking to systematically manage environmental aspects or respond to the effects of changing environmental conditions within specific environmental topic areas. ISO 14002-1 gives general guidelines and constitutes a framework for common elements of subsequent parts of the ISO 14002 series.

➜ **ISO 14002-2:2023 Environmental management systems — Guidelines for using ISO 14001 to address environmental aspects and conditions within an environmental topic area — Part 2: Water**
T*his standard has been adopted at European level.*

Abstract: The standard series ISO 14002 is based on ISO 14001 Environmental management systems and provides guidelines for organizations seeking to systematically manage environmental aspects or respond to the effects of changing environmental conditions within specific environmental topic areas. ISO 14002-2 addresses issues for environmental management related to water quantity and quality, such as water withdrawal, efficient use of water, and water discharge, as well as approaches to cope with water-related events such as flooding and droughts. The document considers the interconnections of water with other environmental media and takes a holistic approach to the management of water due to its impacts on ecosystems, ecosystem services, related biodiversity, as well as human life and well-being.

➜ **ISO 14006:2020 Environmental management systems — Guidelines for incorporating ecodesign**
This standard has been adopted at European level.

Abstract: ISO 14006 provides guidelines for assisting organizations in establishing, documenting, implementing, maintaining and continually improving their management of ecodesign as part of an environmental management system (EMS). This document is intended to be used by organizations that have implemented an EMS in

accordance with ISO 14001, but it can also help in integrating ecodesign using other management systems. It is applicable to product-related environmental aspects and activities that an organization can control and those it can influence.

Strategic and Monetary Evaluation of Environmental Aspects

➜ **ISO 14007:2019 Environmental management — Guidelines for determining environmental costs and benefits**
This standard has been adopted at European level.

Abstract: ISO 14007 gives guidelines for organizations on determining the environmental costs and benefits associated with their environmental aspects. It addresses the dependencies of an organization on the environment, for example, natural resources, and the context in which the organization operates or is located. Environmental costs and benefits can be expressed quantitatively, in both non-monetary and monetary terms, or qualitatively. This document also provides guidance for organizations when disclosing related information.

➜ **ISO 14008:2019 Monetary valuation of environmental impacts and related environmental aspects**
This standard has been adopted at European level.

Abstract: ISO 14008 specifies a methodological framework for the monetary valuation of environmental impacts and related environmental aspects. Environmental impacts include impacts on human health, and on the built and natural environment. Environmental aspects include releases and the use of natural resources. The monetary valuation methods in this document can also be used to better understand organizations' dependencies on the environment.

Environmental Auditing Related Practices

➜ **ISO 14015:2022 Environmental management — Guidelines for environmental due diligence assessment**
This standard has been adopted at European level. This standard supports the European regulation (EC) No 765/2008.

Abstract: ISO 14015 gives guidance on how to conduct an environmental due diligence (EDD) assessment through a systematic process of identifying environmental aspects, issues and conditions as well as determining, if appropriate, their business consequences.

➜ **ISO 14016:2020 Environmental management — Guidelines on the assurance of environmental reports**

Abstract: ISO 14016 defines principles and guidelines for assuring the environmental information an organization includes in its environmental reports. This document is applicable to assuring other types of reports in principle provided that special consideration is paid to identifying the competence needed by the assurance provider.

➜ **ISO 14064-3:2019 Greenhouse gases — Part 3: Specification with guidance for the verification and validation of greenhouse gas statements**
This standard has been adopted at European level.

Abstract: ISO 14064-3 specifies principles and requirements and provides guidance for verifying and validating greenhouse gas (GHG) statements. It is applicable to organization, project and product GHG statements.

Communication on Environmental Aspects

➜ **ISO 14020:2022 Environmental statements and programmes for products — Principles and general requirements**

This standard has been adopted at European level. This standard supports the European regulation (EC) No 765/2008.

Abstract: ISO 14020 is applicable to product-related communications. It establishes principles and specifies general requirements that are applicable to all types of product-related environmental statements and environmental statement programmes. Environmental statements result from environmental statement programmes and include self-declared environmental claims, ecolabels, environmental product declarations (EPDs) and footprint communications. This document is intended to be used in conjunction with other standards in the ISO 14020 family.

➜ **ISO 14021:2016 Environmental labels and declarations — Self-declared environmental claims (Type II environmental labelling)**

This standard has been adopted at European level. This standard supports the European regulation (EC) No 765/2008.

Abstract: ISO 14021 is applicable to product-related communications. It specifies requirements for self-declared environmental claims, including statements, symbols and graphics, regarding products. It further describes selected terms commonly used in environmental claims and gives qualifications for their use. This International Standard also describes a general evaluation and verification methodology for self-declared environmental claims and specific evaluation and verification methods for the selected claims in this International Standard.

➜ **ISO 14026:2017 Environmental labels and declarations — Principles, requirements and guidelines for communication of footprint information**

This standard has been adopted at European level.

Abstract: ISO 14026 is applicable to product-related communications. It provides principles, requirements and guidelines for footprint communications for products addressing areas of concern relating to the environment. It also provides requirements and guidelines for footprint communication programmes, as well as requirements for verification procedures.

➜ **ISO 14063:2020 Environmental management — Environmental communication — Guidelines and examples**

This standard has been adopted at European level. This standard supports the European regulation (EC) No 765/2008.

Abstract: ISO 14063 is applicable to all organizations and provides guidelines to organizations for general principles, policy, strategy and activities relating to both internal and external environmental communication. It uses proven and well-established approaches for communication, adapted to the specific conditions that exist in environmental communication.

Environmental Performance Evaluation

➜ **ISO 14031:2021 Environmental management — Environmental performance evaluation — Guidelines**

Abstract: ISO 14031 gives guidelines for the design and use of environmental performance evaluation (EPE) within an organization. It is applicable to all organizations. The guidance in this document can be used to support an organization's own approach to EPE including its commitments to compliance with legal and other requirements, the prevention of pollution and continual improvement, among others.

➜ **ISO 14033:2019 Environmental management — Quantitative environmental information — Guidelines and examples**

Abstract: ISO 14033 gives guidelines for organizations on the general principles, policies, strategies and activities necessary to obtain quantitative environmental information for internal and/or external purposes. Such purposes can be, for example, to establish inventory routines and support decision making related to environmental policies and strategies, aimed in particular at comparing quantitative environmental information. The information is related to organizations, activities, facilities, technologies and products. Quantitative information specifically addresses quantification of environmental performance in the form of environmental performance indicators in accordance with ISO 14031.

Life Cycle Assessment

➜ **ISO 14040:2006 Environmental management — Life cycle assessment — Principles and framework**
This standard has been adopted at European level.

Abstract: ISO 14040:2006 describes the principles and framework for product life cycle assessment (LCA) including: definition of the goal and scope of the LCA, the life cycle inventory analysis (LCI) phase, the life cycle impact assessment (LCIA) phase, the life cycle interpretation phase, reporting and critical review of the LCA, limitations of the LCA, the relationship between the LCA phases, and conditions for use of value choices and optional elements.

➜ **ISO 14044:2006 Environmental management — Life cycle assessment — Requirements and guidelines**
This standard has been adopted at European level.

Abstract: ISO 14040:2006 describes the principles and framework for product life cycle assessment (LCA) including: definition of the goal and scope of the LCA, the life cycle inventory analysis (LCI) phase, the life cycle impact assessment (LCIA) phase, the life cycle interpretation phase, reporting and critical review of the LCA, limitations of the LCA, the relationship between the LCA phases, and conditions for use of value choices and optional elements.

➜ **ISO 14072:2024 Environmental management — Life cycle assessment — Requirements and guidance for organizational life cycle assessment**

Abstract: ISO 14072 specifies additional requirements and gives guidance for an effective application of ISO 14040 and ISO 14044 to organizations. It is applicable to any organization that has interest in applying LCA. This document provides, the application of life cycle assessment (LCA) principles and methodology to organizations, the benefits that LCA can bring to organizations by using LCA methodology at an organizational level, the system boundary, specific considerations when dealing with life cycle inventory (LCI), life cycle impact assessment (LCIA) and interpretation, and the limitations regarding reporting, environmental declarations and comparative assertions.

➜ **ISO 14045:2012 Environmental management — Eco-efficiency assessment of product systems — Principles, requirements and guidelines**
This standard has been adopted at European level.

Abstract: ISO 14045 describes the principles, requirements and guidelines for eco-efficiency assessment for product systems including: the goal and scope definition of the eco-efficiency assessment; the environmental assessment; the product-system-value assessment; the quantification of eco-efficiency; interpretation (including quality assurance); reporting; and the critical review of the eco-efficiency assessment.

➜ **ISO/TS 14074:2022 Environmental management — Life cycle assessment — Principles, requirements and guidelines for normalization, weighting and interpretation**

Abstract: ISO/TS 14074 is a technical specification providing principles, requirements and guidelines for normalization, weighting and life cycle interpretation, in addition to those given in ISO 14040 and ISO 14044. The document is applicable to any life cycle assessment (LCA) and footprint quantification study.

Water Footprint

➜ **ISO 14046:2014 Environmental management — Water footprint — Principles, requirements and guidelines**
This standard has been adopted at European level.

ISO 14046 specifies principles, requirements and guidelines related to water footprint assessment of products, processes and organizations based on life cycle assessment (LCA).

Quantification and Reporting of Greenhouse Gas Emissions

➜ **ISO 14064-1:2018 Greenhouse gases — Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals**
This standard has been adopted at European level.

Abstract: ISO 14064-1 specifies principles and requirements at the organization level for the quantification and reporting of greenhouse gas (GHG) emissions and removals. It includes requirements for the design, development, management, reporting and verification of an organization's GHG inventory.

➜ **ISO 14067:2018 Greenhouse gases — Carbon footprint of products — Requirements and guidelines for quantification**
This standard has been adopted at European level.

Abstract: ISO 14067 specifies principles, requirements and guidelines for the quantification and reporting of the carbon footprint of a product (CFP), in a manner consistent with International Standards on life cycle assessment (LCA) (ISO 14040 and ISO 14044).

Transition to Net Zero

➜ **ISO 14068-1:2023 Climate change management — Transition to net zero — Part 1: Carbon neutrality**

Abstract: ISO 14068 provides principles, requirements, and guidance for achieving and demonstrating carbon neutrality. It focuses on quantifying, reducing, and offsetting carbon footprints, utilizing a hierarchical approach prioritizing direct and indirect GHG emission reductions and removal enhancements within the value chain over offsetting. It is applicable to various subjects such as organizations and products.

Mitigation and Adaptation to Climate Change

➜ **ISO 14090:2019 Adaptation to climate change — Principles, requirements and guidelines**
This standard has been adopted at European level.

Abstract: ISO 14090 specifies principles, requirements and guidelines for adaptation to climate change. This includes the integration of adaptation within or across organizations, understanding impacts and uncertainties and how these can be used to inform decisions.

➜ **ISO 14091:2021 Adaptation to climate change — Guidelines on vulnerability, impacts and risk assessment**

This standard has been adopted at European level.

Abstract: ISO 14091 gives guidelines for assessing the risks related to the potential impacts of climate change. It describes how to understand vulnerability and how to develop and implement a sound risk assessment in the context of climate change. It can be used for assessing both present and future climate change risks.

➜ **ISO 14080:2018 Greenhouse gas management and related activities — Framework and principles for methodologies on climate actions**

Abstract: ISO 14080 provides a framework and principles for establishing approaches and processes to:

- identify, assess and revise climate action methodologies;
- develop methodologies;
- manage methodologies.

It is applicable to climate actions to address climate change, including adaptation to its impacts and greenhouse gas (GHG) mitigation in support of sustainability. Such actions can be used by or for projects, organizations, jurisdictions, economic sectors, technologies and products, policies, programmes and non-government activities.

National involvement/activities on identified technical committees

As currently several national delegates are registered in a technical standardization committee related to environmental management (ISO/TC 207 and subcommittees), and a national mirror committee exists in this field at this state.

Further national delegates can be added to the national mirror committee by registering in a technical committee or subcommittee related to environmental management:

- **ISO/TC 207:** Environmental management
  - 2 national delegates registered
- **ISO/TC 207/SC 1:** Environmental management — Environmental management systems
  - 2 national delegates registered
- **ISO/TC 207/SC 2:** Environmental management — Environmental auditing and related practices
- **ISO/TC 207/SC 3:** Environmental management — Environmental labelling
- **ISO/TC 207/SC 4:** Environmental management — Environmental performance evaluation
  - 1 national delegates registered
- **ISO/TC 207/SC 5:** Environmental management — Life cycle assessment
- **ISO/TC 207/SC 7:** Environmental management — Greenhouse gas and climate change management and related activities
  - 2 national delegates registered

Impact of standards on the national economy

The listed standards provide accurate and effective tools for a comprehensive environmental management. Environmental management standards may allow different actors to effectively control and communicate on their environmental impacts, thus representing a strategic tool for meeting voluntary and compulsory environmental objectives and targets. The standards organization setting the main framework for environmental management is ISO, through its technical committee ISO/TC 207.

Some relevant fields of standardization that provide information and tools for including sustainability practices, metrics and methods into day-to-day activity, decision making and strategy of all organizations, independent of size, sector or geographical location, include the following:

- Environmental management systems
- Environmental performance evaluation
- Life cycle assessment
- Greenhouse gas accounting
- Transition to net zero
- Communication on environmental aspects

In the field of environmental management systems, the additional ISO standard **ISO 14005:2019 Environmental management systems — Guidelines for a flexible approach to phased implementation** *(adopted at European level)* may be particularly of relevance to SMEs as it allows small and medium enterprises to develop their environmental management system in a flexible way at their own pace, ultimately satisfying the requirements of ISO 14001. ISO has furthermore published a handbook, that aims to help small businesses understand the requirements of an environmental management system and to help them implement ISO 14001 successfully.

The standards allow for controlling and continuous improvement of environmental aspects. They can also provide a pool of relevant information for the development of sustainability-related skills and culture throughout an organization. Furthermore, they provide consistent and interoperable systems or guidelines that facilitate collaboration and sharing of sustainability information along the supply chain and among all stakeholders. Even topics of green finance are currently covered by technical standardization, potentially further driving funding of sustainable projects and activities. Finally, several environmental management standards developed by the technical committee ISO/TC 207 and its subcommittees require leadership commitment, acknowledging that way the importance of leadership support for the integration of sustainability practices.

In fact, environmental management standards enable organizations to assess, monitor, improve and communicate their environmental performance in a well-established, credible and transparent and manner. This may be relevant with respect to increasing sustainability-related legal and stakeholder requirements (including shifting investor and customer demands). Ultimately, environmental management standards allow organizations to contribute to a more sustainable world and future, by effectively improving their environmental and climate impacts.

3.2 Energy efficiency and management

3.2.1 Background

Our current social and economic wellbeing depends on a reliable and affordable energy supply. However, energy — and especially fossil energy — production and consumption are negatively impacting the environment and our climate, emphasizing the need of a clean energy system [31].

An improved energy efficiency may mitigate negative energy-related impacts. In fact, energy efficiency means using less energy for the same output or increasing the output by using the same energy input and thus minimizing energy waste [31]. At the large scale, a higher energy efficiency can lower energy demand and price as well as energy-related greenhouse gas emissions and that way improve energy security while mitigating climate change [31]. In clean energy transitions, energy efficiency provides some of the most cost-effective and quickest options to reduce CO_2 emissions [32]. Also individual organizations and households are benefitting from energy efficiency improvements which usually reduce energy-related cost due to achieved energy savings [32].

3.2.2 Challenges of the sector

Global energy intensity is the amount of energy needed to produce a unit of GDP. It represents a key measure of energy efficiency of the economy [32]. Accelerating energy efficiency improvements could contribute to over a third of all carbon dioxide emission reductions until 2030 in a pathway aiming at net zero energy sector emissions by 2050 [32]. Nevertheless, while energy efficiency policies have been globally strengthened in recent years, progress on energy efficiency may have to double in order to reach net zero [32].

Despite the urgent need for a clean energy system supporting net zero ambitions, global energy efficiency progress, which is measured by the rate of change in primary energy intensity, sees only a small improvement in 2024 [32]. In fact, intensity improvements in advanced economies slowed, and progress in most developing and emerging economies held steady or increased slightly [32].

Potential for further progress on energy efficiency may be found in sectors such as industry and building. In the building sector, energy performance is improving, but especially retrofitting existing buildings can provide a means to generate additional and quick efficiency gains [32]. A more important driver of slower global energy intensity progress in past years has been the strong increase in energy consumption combined with poor efficiency improvement in the industrial sector [32]. Other challenges to energy efficiency include a shortage of skilled workforce across key efficiency occupations, a lack of investment and the need for technological innovation and the fast deployment of such [32]. However, in the light of current energy security threats as well as high energy prices adding to climate concerns, the urgency of solid energy efficiency improvements seems evident [31] [32].

In order to overcome current energy-related issues, it becomes essential to improve energy performance at all levels. While energy efficiency-related policies have already been strengthened, the tools to align with such policies and to anticipate future requirements become particularly important. In that sense, technical standardization may enable effective improvements in energy management, especially at organizational level. Energy efficiency of buildings is complemented and specifically addressed in the report's chapter of sustainable construction and renovation (see section 3.6.1).

3.2.3 Policies and strategies

In the framework of European and national policies, different legislation is introduced, and finance is mobilized, to encourage and facilitate a clean energy transition, including measures to improve energy security, to increase energy efficiency and savings, and to decarbonize the energy sector. Depending on the type of measure, this can help to overcome energy related challenges, such as a lack of funding, skills or innovation, while encouraging energy management improvements in key sectors, such as industry. The policies and associated legislation furthermore acknowledge the need for organizations to contribute more transparently and effectively to the clean energy transition, in line with stakeholder expectations (consumer trends, employee and investor demands, etc.).

European level

On European level, a variety of relevant strategies, action plans, agendas and policies exist to tackle energy and greenhouse gas-related challenges, implying improvements in energy efficiency or management. General initiatives include the Energy Union Strategy, REPowerEU, and the Clean Industrial Deal.

➜ **Energy Union Strategy**

Launched in 2015, the Energy Union Strategy aims at providing EU consumers secure, sustainable, competitive and affordable energy, and has resulted in several packages of measures and yearly progress reports.

The energy union is based on the following five related and mutually reinforcing dimensions:

- security, solidarity and trust between EU countries
- a fully integrated internal energy market which enables the free flow of energy through the EU
- energy efficiency to reduce dependence on energy imports, avoid emissions, and increase jobs and growth
- climate action and decarbonization of the economy, also by encouraging the use of renewable energy
- research and innovation to drive the energy transition and improve competitiveness through technology.

➜ **REPowerEU**

REPowerEU is a European plan that was launched in 2022, in response to global energy market challenges and especially the market disruption.

The plan counts the following three main objectives:

- energy savings
- diversification of energy supplies
- production of clean energy

➜ **Clean Industrial Deal**

Launched in 2025, the Clean Industrial Deal aims at improving the EU industries' competitiveness and decarbonization against the background of high energy costs and strong global competition. It targets particularly the clean-tech sector and energy-intensive industries such as metals, steel, and chemicals.

To lower energy prices, while promoting a low-carbon economy, an **Action Plan for Affordable Energy** has been adopted by the European Commission in the context of the Clean Industrial Deal. This plan includes 8 proposed actions, among which the delivery of energy savings through a higher energy efficiency. Market actors providing energy efficiency solutions for businesses will be supported through the so-called **European**

Energy Efficiency Financing Coalition. Additionally, the **EU's Energy Labelling and Ecodesign legislations** may be updated to further increase resulting energy savings which could rise from about €120 billion of savings on energy bills in 2023 up to €162 billion in 2030.

Also, a future **Industrial Decarbonisation Accelerator Act** will aim at increasing the demand for EU-made clean products, through the introduction of sustainability, resilience, and 'made in Europe' criteria for public and private procurements. Other elements of the Clean Industrial Deal include plans for financing the clean transition, for developing necessary skills and for improving circularity and access to materials.

National level

➜ ***Plan national intégré en matière d'énergie et de climat (PNEC) du Luxembourg pour la période 2021-2030***

Updated in 2024, the *Plan national intégré en matière d'énergie et de climat du Luxembourg pour la période 2021-2030* (PNEC) sets the national climate and energy objectives for 2030, consistent with EU policies and climate neutrality goals. Main targets include:

- reduction of greenhouse gas emissions by 55% compared to 2005 levels,
- achieve 37% renewable energy in final consumption, improve energy efficiency by 42%, and strengthen renewable energy, and
- energy efficiency targets (e.g. deployment of wind, solar, heat pumps, and electromobility).

➜ ***Plan national pour un développement durable (PNDD)***

Published in 2019, the national plan for sustainable development identifies key sustainability policy areas, concrete objectives and actions to be taken until 2030. These policy areas include among others climate change mitigation and renewable energy aspects.

➜ ***Plan pour la reprise et la résilience (PRR)***

Published in 2024 by the national Ministry of Finance, Luxembourg's recovery and resilience plan aims at recovering from the COVID-19 crisis, while preparing for future challenges. It also includes national ambitions resulting from the **REPowerEU** plan.

3.2.4 Legal frameworks

European level

EU legislation covers several energy-related topics through, among others, the following regulations and directives:

➜ **Directive (EU) 2023/1791 on energy efficiency**

This directive significantly raises the EU's ambition on energy efficiency and covers topics such as energy consumption targets, annual energy savings obligations, energy audit obligations, heating and cooling and energy performance of data centers. Standards, such as **EN 16247-1:2022 Energy audits — Part 1: General requirements** and the European adoption of **ISO 50001:2018 Energy management systems — Requirements with guidance for use** are specifically referenced in the directive and can support compliance with Directive (EU) 2023/1791.

➜ **Directive (EU) 2023/2413 as regards the promotion of energy from renewable sources**

Directive (EU) 2023/2413 raises the overall renewable energy target of at least 42.5% at EU level by 2030 - but aims for 45%.

➜ **Directive (EU) 2024/1788 on common rules for the internal markets for renewable gas, natural gas and hydrogen**

This directive establishes the commitment to achieving 32% of renewable energy sources in the EU's energy mix by 2030.

➜ **Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action**

This regulation requires each EU country to establish integrated 10-year national energy and climate plan (NECP) (in Luxembourg this document is the *Plan national intégré en matière d'énergie et de climat du Luxembourg pour la période 2021-2030* **-** PNEC). These NECPs are the EU countries' plans to achieve their targets on the 5 dimensions of the energy union.

➜ **Regulation (EU) 2024/1735 establishing a framework of measures for strengthening Europe's net-zero technology manufacturing ecosystem**

➜ **Directive 2009/125/EC establishing a framework for the setting of ecodesign requirements for energy-related products**

➜ **Directive 2010/30/EU on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products**

➜ **Regulation (EU) 2017/1369 setting a framework for energy labelling**

National level

National legislation relevant to topics of energy efficiency and management may include the following:

➜ ***Loi du 15 décembre 2020 relative au climat***

- ***Règlement grand-ducal du 22 juin 2022 déterminant les allocations d'émissions de gaz à effet de serre annuelles pour la période allant jusqu'au 31 décembre 2030 des secteurs visés à l'article 5 de la loi modifiée du 15 décembre 2020 relative au climat***
- ***Loi du 29 mai 2024 portant modification de la loi modifiée du 15 décembre 2020 relative au climat***

➜ ***Règlement grand-ducal du 5 juillet 2016 relatif à l'efficacité énergétique***

➜ ***Loi du 24 juillet 2011 concernant l'indication, par voie d'étiquetage et d'informations uniformes relatives aux produits, de la consommation en énergie et en autres ressources des produits liés à l'énergie***

3.2.5 Standardization activities

Technical standardization is responding to current needs and challenges in the field of energy management, supporting organizations on their pathway to adapting to EU and national objectives, policies and legislations, but also to stakeholder requirements, in a credible and transparent way. The European standardization committee CEN/CLC/JTC 14 and the international standardization committee ISO/TC 301 develop standards that may be applied by most organizations and sectors, covering topics such as energy management systems, energy performance measurement, energy efficiency and savings, and energy audits.

Relevant technical committees

➜ **CEN/CLC/JCT 14 Energy management and energy efficiency in the framework of energy transition**

Abstract: Standardization in the field of energy management within the energy transition framework including subjects such as: energy management systems, energy audits, energy efficiency and energy performance improvement, energy and savings calculation methodologies, energy efficiency improvement financing, energy services providers, energy measurement and monitoring, and the role of enabling technologies and RES within the energy management and energy efficiency framework.

➜ **ISO/TC 301 Energy management and energy savings**

Abstract: Standardization in the field of energy management for continual energy performance improvement and calculation of energy savings for all sizes and types of organizations, groups, networks, cities, countries and regions.

Relevant technical standards supporting sector challenges

Energy Management Systems

➜ **ISO 50001:2018 Energy management systems — Requirements with guidance for use**
This standard has been adopted at European level.

Abstract: ISO 50001 specifies requirements for establishing, implementing, maintaining and improving an energy management system (EnMS). The intended outcome is to enable an organization to follow a systematic approach in achieving continual improvement of energy performance and the EnMS.

➜ **ISO 50004:2020 Energy management systems — Guidance for the implementation, maintenance and improvement of an ISO 50001 energy management system**

Abstract: ISO 50004 gives practical guidelines and examples for establishing, implementing, maintaining and improving an energy management system (EnMS) in accordance with the systematic approach of ISO 50001:2018. The guidance in this document is applicable to any organization.

➜ **ISO 50005:2021 Energy management systems — Guidelines for a phased implementation**
This standard has been adopted at European level.

Abstract: ISO 50005 provides guidance for organizations on establishing a phased approach to implement an energy management system (EnMS). This phased approach is intended to support and simplify the implementation of an EnMS for all types of organizations, in particular for small and medium-sized organizations (SMOs).

➜ **ISO/TS 50011:2023 Energy management systems — Assessing energy management using ISO 50001:2018**

Abstract: ISO/TS 50011:2023 is a technical specification providing guidance based on ISO 50001:2018 to measure the status of energy management in an organization. The measurement results are described by using three scores: structure management score (SMS), operation management score (OMS) and target achievement score (TAS). This document presents methodologies on how the basic and advanced scores can be calculated. It can be used to identify areas for improvement or to identify areas in which improvement has taken place.

Energy Performance Measurement

➜ **ISO 50006:2023 Energy management systems — Evaluating energy performance using energy performance indicators and energy baselines**

Abstract: ISO 50006 gives guidance on how to establish, use and maintain energy performance indicators (EnPIs) and energy baselines (EnBs) to evaluate energy performance in any organization including those using ISO 50001. Additional guidance is given on how to measure and monitor energy performance and demonstrate energy performance improvement.

➜ **ISO 50015:2014 Energy management systems — Measurement and verification of energy performance of organizations — General principles and guidance**

Abstract: ISO 50015 establishes general principles and guidelines for the process of measurement and verification (M&V) of energy performance of an organization or its components. It can be used independently, or in conjunction with other standards or protocols, and can be applied to all types of energy.

➜ **EN 17267:2019 Energy measurement and monitoring plan — Design and implementation - Principles for energy data collection**

Abstract: EN 17267:2019 specifies the requirements and principles for the design and implementation of an energy measurement and monitoring plan for an organization to improve its energy performance. The measurement and monitoring plan defines a measurement system for monitoring and analyzing the energy performance of an organization, considering its influencing factors. This document applies to all forms of energy, to all energy uses and to all types of organizations.

Energy Efficiency and Savings

➜ **ISO 17741:2016 General technical rules for measurement, calculation and verification of energy savings of projects**

Abstract: ISO 17741 specifies the general technical rules for measurement, calculation and verification of energy savings in retrofits projects or new projects.

➜ **ISO 17743:2016 Energy savings — Definition of a methodological framework applicable to calculation and reporting on energy savings**

Abstract: ISO 17743 establishes a methodological framework that applies to the calculation and reporting of energy savings from existing (implemented) and prospective measures and actions which intend to save energy. This framework standard will be applicable to other standards in the field of energy saving determination.

➜ **ISO 50046:2019 General methods for predicting energy savings**

Abstract: ISO 50046 specifies general methods for the calculation of predicted energy savings (PrES), using measure-based calculation methods, also known as bottom-up or energy performance improvement actions (EPIAs)-based methods.
This document provides general principles for categorizing and choosing the method, taking account of the context, targeted accuracy and resources available for calculating the PrES. It also provides guidance on the conditions for ensuring the quality of the PrES, their documentation and validation.

➜ **ISO 50047:2016 Energy savings — Determination of energy savings in organizations**

Abstract: ISO 50047 describes approaches for the determination of energy savings in organizations. It can be used by all organizations, whether or not they have an energy management system, such as ISO 50001.

➜ **EN 16212:2012 Energy Efficiency and Savings Calculation, Top-down and Bottom-up Methods**

Abstract: EN 16212 provides a general approach for energy efficiency and energy savings calculations with top-down and bottom-up methods. The general approach is applicable for energy savings in buildings, cars, appliances, industrial processes, etc. The standard covers energy consumption in all end-use sectors.

➜ **EN 16231:2012 Energy efficiency benchmarking methodology**

Abstract: EN 16231 specifies requirements and provides recommendations for energy efficiency benchmarking methodology. The purpose of energy efficiency benchmarking is to establish the relevant data and indicators on energy consumption, both technical and behavioural, qualitative and quantitative in comparing performance between or within entities. Energy efficiency benchmarking can be either internal (within a specific organization) or external (between organizations including competitors).

Energy Audits

➜ **ISO 50002-1:2025 Energy audits — Requirements with guidance for use — Part 1: General requirements with guidance for use**

➜ **ISO 50002-2:2025 Energy audits — Requirements with guidance for use — Part 2: Guidance for conducting an energy audit using ISO 50002-2 in buildings**

➜ **ISO 50002-3:2025 Energy audits — Requirements with guidance for use — Part 3: Guidance for conducting an energy audit using ISO 50002-3 in processes**

Abstract: The ISO 50002 series includes international standards that define the general requirements and guidance for conducting energy audits. They provide a structured methodology for evaluating energy use and identifying opportunities for improving energy performance across buildings, processes, systems, and transport. They are designed to support both standalone audits and those integrated into broader energy management systems like ISO 50001.

➜ **EN 16247-1:2022 Energy audits — Part 1: General requirements**
This standard has been developed in the frame of standardization request M/479

Abstract: EN 16247-1 specifies the requirements, common methodology and deliverables for energy audits. It is applicable to all forms of establishments and organizations, all forms of energy and energy uses.

➜ **EN 16247-2:2022 Energy audits — Part 2: Buildings**
This standard has been developed in the frame of standardization request M/479

Abstract: EN 16247-2 is applicable to specific energy audit requirements in buildings. It specifies the requirements, methodology and deliverables of an energy audit in a building or group of buildings.

➜ **EN 16247-3:2022 Energy audits — Part 3: Processes**
This standard has been developed in the frame of standardization request M/479

Abstract: EN 16247-3 specifies the requirements, methodology and deliverables of an energy audit within a process. These consist of: organizing and conducting an energy audit; analysing the data from the energy audit; reporting and documenting the energy audit findings. This part of the standard series applies to sites or parts of sites where a significant part of the energy use is due to processes.

➜ **EN 16247-4:2022 Energy audits — Part 4: Transport**
This standard has been developed in the frame of standardization request M/479

Abstract: EN 16247-4 specifies the requirements, methodology and deliverables specific to energy audits in the transport sector, including every situation in which a displacement is made, no matter who the operator is. This document advises on both the optimization of energy within each mode of transport, as well as selecting the best mode of transport in each situation; the conclusions drawn by the energy audit can influence decisions on infrastructure and investment.

Guarantees of Origin related to Energy

➜ **EN 16325:2013+A1:2015 Guarantees of Origin related to energy — Guarantees of Origin for Electricity**

Abstract: EN 16325+A1 specifies requirements for Guarantees of Origin of Electricity from all energy sources. This standard establishes the relevant terminology and definitions, requirements for registration, issuing, transferring and cancellation in line with the RES (Renewable Energy Sources), Energy Efficiency and IEM (Internal Electricity Market) Directives. This standard will also cover measuring methods and auditing procedures. These Guarantees of Origin may be traded and/or used for Disclosure/Labelling.

Valuation of energy related investments

➜ **EN 17463:2021 Valuation of Energy Related Investments (VALERI)**

Abstract: EN 17463 specifies requirements for a valuation of energy related investments (VALERI). It provides a description on how to gather, calculate, evaluate and document information in order to create solid business cases based on Net Present Value calculations for ERIs. The standard is applicable for the valuation of any kind of energy related investment. The document focusses mainly on the valuation and documentation of the economic impacts of ERIs (energy related investments).

National involvement/activities on identified technical committees

Currently 1 national delegate is registered in a technical standardization committee related to energy efficiency and management. Consequently, no national mirror committee exists in this field at this state.

However, the creation of a national mirror committee may take place after the registration of further national delegates in the technical committees developing standards related to energy efficiency and energy management:

- **CEN/CLC/JTC 14:** Energy management and energy efficiency in the framework of energy transition
  - 1 national delegate registered
- **ISO/TC 301**: Energy management and energy savings

Impact of standards on the national economy

The international and European energy efficiency and management standards, developed by ISO/TC 301 and CEN/CLC/JTC 14 mainly provide frameworks, guidelines, principles and requirements for general aspects of energy management. Therefore, most standards are applicable to all types of organizations, sectors and activities.

Some relevant and generally applicable fields of standardization include:

- Energy management systems
- Energy performance measurement
- Energy efficiency and savings
- Energy audits

Especially the implementation of an energy management system according to ISO 50001 may be relevant to a large number of organizations in Luxembourg as it allows for a general and practical way to improve energy use, enhancing energy efficiency, reducing operational costs, and improving environmental performance. **ISO 50005:2021 Energy management systems — Guidelines for a phased implementation** provides guidance for a phased approach, intended to support and simplify the implementation of an energy management system for all types of organizations, but in particular for small and medium-sized organizations (SMOs).

Energy efficiency and management standards provide recognized, coherent, powerful and effective tools for a clean energy transition and for reaching the global objective of net zero energy sector emissions by 2050. As energy intensity improvements of advanced economies have slowed in 2024, while energy prices, energy security threats and climate concerns are prevalent, the importance of European and international standards for energy efficiency and savings increases. The rise in energy consumption in the industrial sector implies the need for the sector to focus on its energy management in order to mitigate negative effects on resource availability, resilience, environment and economy. Against the background of a skilled workforce shortage across key energy efficiency occupations, international and European standardization may also contribute to fill the gap of missing knowledge and skills by providing aggregated technical information of the field, accessible to all.

All in all, energy efficiency and management standardization shows to play an important role in the response to current energy-related challenges by allowing different actors to effectively control their energy usage, thus representing a strategic tool for meeting voluntary and compulsory energy-related objectives and targets, and ultimately improving organizations' climate and environmental impact, while reducing cost and increasing resilience.

3.3 Circular economy

3.3.1 Background

The term "circular economy" was coined in a 1990 paper entitled "Economics of natural resources and the environment" by D.W. Pearce and R.K Turner. The concept of the circular economy was born due to the understanding of the drawbacks of the traditional linear economic system, such as overconsumption and growing ecological deficit, and driven by the principal that "everything is an input to everything else" [33]. Thus, the circular economy is meant as a system where the products and materials are kept in circulation instead of being wasted. It is regenerative by design and aims to create growth that is independent from the usage of finite resources [34]. The main principles of the circular economy are well aligned with the so-called 3Rs — reuse, reduce, recycle — of sustainable consumption [33] [34]:

- **Eliminate waste and pollution**: consider waste a design flaw. Use the eco-design to reduce the waste and toxic substances from the start, thus causing less pollution.
- **Circulate products and materials**: extend the product life period, reuse, refurbish, remanufacture the products and materials to minimize the extraction of virgin resources and reduce waste.
- **Regenerate nature**: use energy sources that are restorative, reduce environmental degradation, increase biodiversity, return the organic materials to the earth.

The concept of circular economy can be depicted as a diagram (see Figure 7) showing the continuous flow of materials in circular economy, following the biological cycles that focus on regeneration on one hand and technological cycles that focus on maintaining the products, materials, and resources in the economy for as long as possible on the other hand.

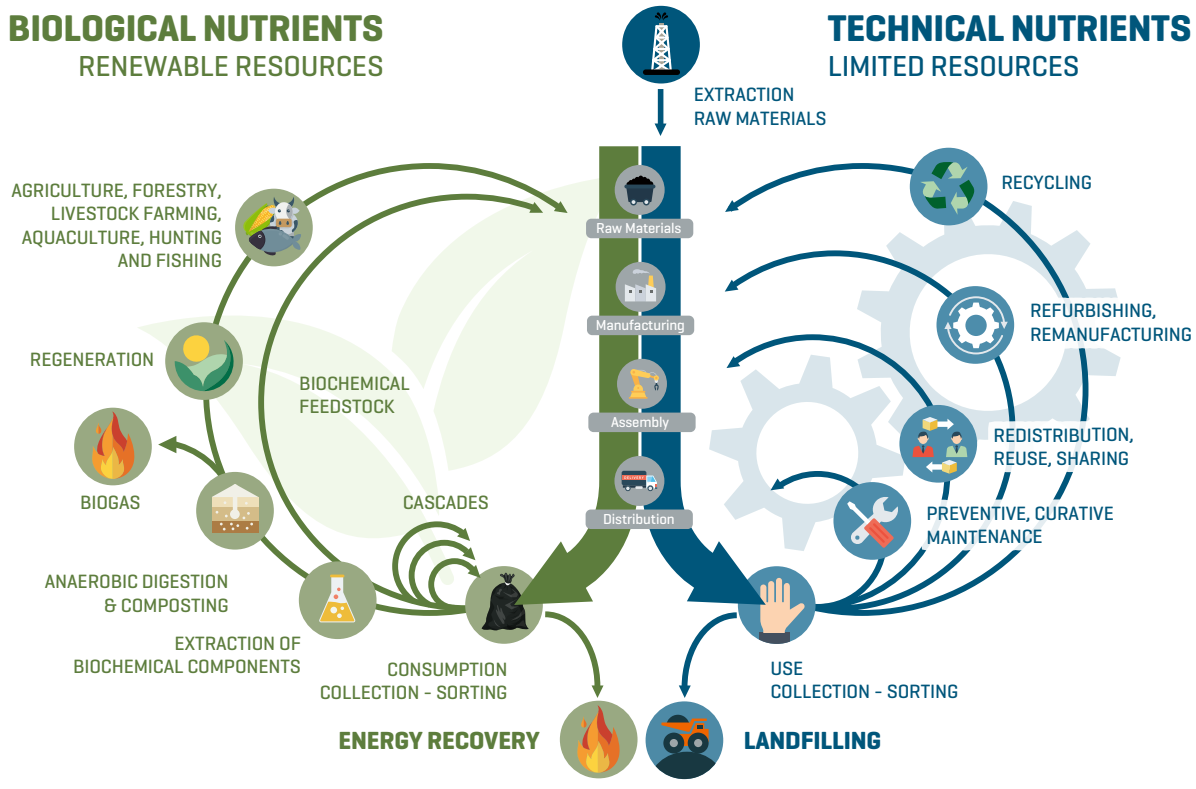

Figure 7 - The butterfly diagram as depicted by the National strategy on circular economy

To switch from linear economic model to a circular one, the organizations should follow relevant circular practices [33]:

- Using less primary resources,
- Maintaining the highest value of materials and products,
- Changing utilization patterns.

3.3.2 Challenges of the sector

Each of the circular practices described above represent particular challenges.

Using less primary resources

- **Supply chain integration**: Integrating circular principles into supply chains requires collaboration and coordination among various stakeholders, which can be complex and difficult to manage [35] [36].
- **Product design**: Designing products for durability, repairability, and recyclability requires a shift in the traditional design approach. Moreover, the replacement of some raw materials can compromise product quality [35].

Maintaining the highest value of materials and products

- **Recycling technologies:** Current recycling technologies may not be efficient or advanced enough to handle the complexity of modern products, especially those made from mixed materials [36] [37].
- **Infrastructure:** Many regions lack the necessary facilities and infrastructure for collection, sorting, and processing of waste materials [37].

Changing utilization patterns

- **Consumer behavior and expectations:** Consumers are accustomed to the convenience of single-use products and linear consumption patterns. Moreover, there is often a perception that recycled or reused products are of lower quality compared to new products. Changing these habits requires significant effort in education and awareness [35] [37].
- **Information sharing:** Ensuring transparency in the supply chain and in reporting the lifecycle impacts of products is crucial for building trust and accountability [35].

Additionally, it can be challenging to **measure the impact of circularity and the economic benefits** it could bring — given the initial investment that could be substantial — which results in the absence of proper transition planning.

More global challenges involve the environmental uncertainty where not all circular practices guarantee net environmental benefits (ex. energy use in recycling) and impacts that circular practices can have on global value chains (ex. circular practices in the EU may have unintended effects in non-EU countries) [33].

3.3.3 Policies and strategies

European level

➜ Circular Economy Action Plan

Under the European Green Deal, the European Commission proposed the first package of measures to speed up transition towards a circular economy, as announced in the Circular Economy Action Plan adopted in 2020. This action plan sets down seven key areas essential to achieving a circular economy:

- **Plastics**: The increasing usage of plastics is a serious concern for the environment. To address it the EU adopted a European strategy for plastics in 2018 where it suggests measures to transform the way plastics products are designed, produced, used and recycled in the EU. This strategy is complemented by the EU policy framework on biobased, biodegradable and compostable plastics to guide the exploiting of "biodegradable" and "compostable" labelling.
- **Textiles**: The textile industry is one of the biggest consumers of water and primary raw materials. To boost the innovation and support the industries adopting textile reuse and recycling, the EU published in 2022 a Strategy for sustainable and circular textiles.
- **Electronics and ICT (e-waste):** With the electrical and electronic equipment increasingly contributing to the production waste in the EU, the proposed Circular Electronics Initiative that aims to improve the durability, design, and recyclability of electronics, reduce hazardous substances, and enhance reparability and upgradability.
- **Food, water and nutrients**: The exploitation of natural resources for food production and the usage of chemicals to enhance this production contribute to the loss of biodiversity and pollution respectively. The sustainable use of bio-based materials is one of the targets of the Bioeconomy Strategy and Action plan, while Integrated nutrient management plan outlines the way towards the sustainable usage of nutrients.
- **Packaging**: With the packaging waste generation having reached the historical record in 2017, the objective is to ensure that all the packaging on the EU market is reusable and recyclable by 2030, towards which the new Packaging and Packaging Waste Regulation 2025/40 (PPWR) is an important milestone.
- **Batteries and vehicles:** To enhance the sustainability of emerging battery value chain for electro-mobility and improve the circularity of all batteries, the Commission proposed New Batteries Regulation that entered into force in 2023. This regulation fits within the frame of the European strategy on sustainable and smart mobility that paves the way towards green and digital transformation of the EU transport system.
- **Buildings and construction**: The waste generation from the construction sector amounted at 35% of the EU's total waste generation in 2016, and its reliance on materials extraction and manufacturing contribute largely to the national greenhouse gas emissions. The Commission published in 2020 the Circular Economy Principles for Building Design.

The Circular economy monitoring framework allows to follow the measures of various indicators and adjust the actions.

National level

➜ National strategy on circular economy

The Ministry of the Economy published a national strategy on circular economy in 2021. The document outlines Luxembourg's approach to transitioning from a linear to a circular economy. It emphasizes the importance of managing material stocks and flows holistically, to create lasting positive economic, environmental, and social

impacts. The strategy also highlights the importance of collaboration among public and private stakeholders, including municipalities, to ensure successful implementation. Six key sectors for circular economy are identified such as construction, education, finance, food and biomaterials, industry, and retail, proposing specific action items and roadmaps for each.

1. **Construction:** The strategy emphasizes integrating circular criteria into public procurement, spatial planning, and construction regulations. It promotes the use of material passports for better traceability, encourages the use of bio-sourced materials, and supports the development of marketplaces for secondhand construction components.
2. **Education & Training:** The strategy calls for the development of a coherent educational framework that includes circular economy principles at all levels, from primary education to lifelong learning. It highlights the need for skills training in repair and maintenance, awareness-raising activities, and the integration of circular economy topics into various disciplines.
3. **Finance:** The strategy aims to leverage Luxembourg's strong financial sector to support circular business models. It proposes developing new financial tools, such as venture capital for start-ups and private equity for SMEs, and creating dedicated insurance and banking products. The strategy also emphasizes the importance of integrating circular economy principles into public incentive programs, supporting other sectors and promoting Luxembourg as a circular business hub.
4. **Food & Biomaterials:** The strategy focuses on closing nutrient and water cycles to regenerate productive soils and support sustainable agriculture. It promotes the use of bio-sourced materials in various applications, encourages urban farming, and supports the development of transparent labels for resource consumption. Particular attention is paid to reduce food waste, recover nutrients from organic waste streams, and support sustainable agricultural practices.
5. **Industry:** The strategy encourages the adoption of circular design principles and business models, such as Product-as-a-Service (PaaS). It supports the development of shared infrastructure in economic activity areas, promotes the use of transparent data management schemes and circular business models. Training and support for developing circular economic activity areas are also highlighted.
6. **Retail:** The strategy aims to integrate circular criteria into public procurement for consumer products and develop labels for describing the circular properties of products. It promotes the reuse and sharing of consumer goods, supports the development of marketplaces for secondhand products, and encourages the transformation of recycling centres into resource centres.

3.3.4 Legal frameworks

While there is no one dedicated law for circular economy, a number of legislations are being updated or developed to address sector-specific challenges identified in the European Circular Economy Action Plan. Note, that, even if relevant to the circular economy, the legal acts related to e-waste (section 3.8) and sustainable construction (section 3.6.1) are covered in dedicated sections.

European level

➜ **Regulation (EU) 2024/1781 establishing a framework for the setting of ecodesign requirements for sustainable products (ESPR)**

The Regulation (EU) 2024/1781, commonly known as Ecodesign for Sustainable Products Regulation (ESPR), aims to enhance the environmental sustainability of products throughout their lifecycle by focusing on improved design, durability, and circular economy principles. It sets requirements for a wide range of products,

including electronics, textiles, and furniture, to reduce waste, promote reuse and recycling, and enhance energy efficiency. Manufacturers are required to comply with these standards and provide information on the environmental performance of their products. The benefits of this regulation include reduced pollution, resource conservation, cost savings for consumers and businesses, and improved product quality and longevity. One of the elements introduced by the ESPR is the Digital Product Passport (DPP), which will store relevant information to support products' sustainability (for example, products technical performance) and circularity (for example, materials and their origins and recycling capabilities).

➜ **Directive (EU) 2024/1799 on common rules promoting the repair of goods (R2RD)**

In 2024 the EU has adopted the Directive (EU) 2024/1799 on common rules promoting the repair of goods (R2RD), commonly referred to as Right to Repair Directive (R2RD). The R2RD aims to empower consumers by ensuring they can repair their goods, thus extending product lifespans and reducing waste. It mandates that manufacturers provide repair information and spare parts for a minimum period after purchase. This directive covers various products, including household appliances, electronics, and machinery. By facilitating repairs, the directive seeks to promote sustainability, reduce environmental impact, and support the circular economy. It also aims to enhance consumer rights and foster competition in the repair market, ultimately leading to more affordable and accessible repair services. The R2RD amends the existing Sale of goods Directive (EU) 2019/771 by extending the legal guarantee in case of repair and not the replacement.

➜ **Regulation (EC) No 66/2010 on the EU Ecolabel**

Regulation (EC) No 66/2010 on the EU Ecolabel is a voluntary label awarded to products and services meeting high environmental standards throughout their life cycle, from raw material extraction to production, use, and disposal. It aims to promote sustainable consumption and production by encouraging businesses to develop eco-friendly products. Successful applicants prove they use recycled and/or easy to recycle packaging and avoid hazardous, toxic or other harmful substances. The label covers a wide range of products, including cleaning products, appliances, paper products, and services like tourism accommodations. EU Ecolabel is the only EU-wide ecolabelling scheme based on ISO 14024.

➜ **Regulation (EU) 2025/40 on packaging and packaging waste (PPWR)**

The rules, first laid out in the Packaging and Packaging Waste Directive 94/62/EC (PPWD) and now the Packaging and Packaging Waste Regulation (PPWR), regulate what kind of packaging can be placed on the EU market, as well as packaging waste management and prevention measures. The PPWR aims to reduce the environmental impact of packaging waste by promoting recycling and reuse. It sets targets for the recovery and recycling of packaging materials, encourages the use of sustainable packaging, and requires member states to implement measures to achieve these goals. The directive also focuses on reducing the amount of packaging waste generated and improving the efficiency of waste management processes.

➜ **Directive 2008/98/EC on waste (Waste Framework Directive)**

The EU Directive 2008/98/EC on waste (Waste Framework Directive) establishes a comprehensive legal framework for waste management within the European Union. It sets out key principles such as the waste hierarchy, which prioritizes prevention, reuse, recycling, and recovery over disposal. The directive also includes measures to protect human health and the environment, promote resource efficiency, and reduce the overall impact of waste generation and management. It requires member states to develop waste management plans and waste prevention programs, and to ensure that waste is managed in an environmentally sound manner. The directive supports the transition to a circular economy by encouraging sustainable waste practices and the use of secondary raw materials. In 2023 the Commission proposed an amendment to the Waste Framework Directive introducing mandatory and harmonized Extended Producer Responsibility (EPR) schemes for textiles in all EU Member States.

National level

Aside from the set of laws related to waste reduction, known as *Paquet économie circulaire*, which transpose the European Directives, Luxembourg has not adopted any legislation specifically dedicated to circular economy.

3.3.5 Standardization activities

Circular economy covering numerous domains, only the committees that directly address the topic are introduced in this section. Some committees that are relevant to circular economy but focusing on environmental management in general (see section 3.1), or on specific areas, such as e-waste (see section 3.8) or sustainable construction (see section 3.4), are presented in the dedicated sections.

Relevant technical committees

➜ **ISO/TC 323 Circular economy**

Scope: Standardization in the field of Circular Economy to develop frameworks, guidance, supporting tools and requirements for the implementation of activities of all involved organizations, to maximize the contribution to sustainable development.

➜ **CEN/TC 473 Circular economy**

Scope: Standardization in the field of Circular Economy to develop horizontal standards that address European specific prerequisites, legislation, and policy. The standards aim to provide guidance, recommendations, requirements, methodologies and tools to implement, support and measure transition towards a Circular Economy at an organizational level. The deliverables aim to complement international and European standardization in the advancement in the transition towards a Circular Economy, while contributing to sustainable development.

➜ **CEN/CLC/JTC 24 Digital Product Passport — Framework and System**

Scope: Development of deliverables for the Digital Product Passport (DPP) framework and system.

➜ **ITU-T/SG 5 Environment, climate change and circular economy**

Scope: ITU-T Study Group 5 (SG 5) is responsible for studies on methodologies for evaluating ICT effects on climate change and publishing guidelines for using ICTs in an eco-friendly way. Under its environmental mandate SG5 is also responsible for studying design methodologies to reduce ICTs and e-waste's adverse environmental effects (see sections 3.7 and 3.8), for example, through recycling of ICT facilities and equipment.

➜ **ISO TC 61/SC 14 Plastics/Environmental aspects**

Scope: All standardization activities in the field of plastics relating to environmental and sustainability aspects. The focus is on, but not limited to biobased plastics, biodegradability, environmental footprint incl. carbon footprint, resource efficiency incl. circular economy, characterization of plastics leaked into the environment incl. microplastics, waste management incl. organic, mechanical and chemical recycling.

➜ **CEN/TC 249 Plastics**

Scope: Standardization of:

- terminology,
- test methods,
- specifications, classifications and designation systems,
- environmental aspects,
- joining systems and techniques of plastics, plastic-based materials, semi-finished products and products (thermoplastics, thermosets, degradable plastics, bio-based polymers, thermoplastic elastomers, composites, reinforcement products for plastics, recyclates).

NOTE: Of particular interest with respect to circular economy is the work of WG 9 on Bio-based and biodegradable plastics, WG 11 on Plastics recycling, and WG 24 on Environmental aspects.

➜ **CEN/TC 248/WG 39 Circular Economy for textile products and the textile chain**

Scope: Standardization in the field of the circular economy of textile materials, products made with textile materials, and combined products containing textile and nontextile components.

Relevant technical standards supporting sector challenges

Standards related to supply chain

➜ **ISO 59010:2024 Circular economy — Guidance on the transition of business models and value networks**

Abstract: ISO 59010 provides guidance for organizations wishing to transition their value creation models and networks from a linear to a circular framework. This standard focuses on business-oriented strategies to implement circular economy practices at both organizational and inter-organizational levels. It complements ISO 59004 by offering more detailed guidance on assessing current value creation models, mapping value chains and value networks, and developing strategies for circularity.

Standards related to product design

NOTE: there are no standards covering general aspects of product design in the frame of circular economy. However, domain-specific standards exist for textile, construction, electrical equipment. The latter are introduced in the dedicated sections (sections 3.4 and 3.8).

Standards related to recycling practices

➜ **ISO 59014:2024 Environmental management and circular economy — Sustainability and traceability of the recovery of secondary materials — Principles, requirements and guidance**

NOTE: This standard is aligned with the product lifecycle assessment as introduced in ISO/TC 207/SC5.

Abstract: This document provides principles, requirements and guidance for organizations in fostering the sustainability and traceability of activities and processes for the recovery of secondary materials. The collection, classification, sorting and non-destructive processes can lead to the recovery of components and products. The preparation and processing of products or components for their reuse or reprocessing (e.g. for repurposing,

remanufacturing, refurbishment and repair) are outside the scope of this document. This document also specifies requirements and provides guidance for organizations that engage with individuals involved in subsistence activities (SAs) as part of the organization's activities and processes for the recovery of secondary materials.

➜ **ISO 5412:2022 Plastics — Industrial compostable plastic shopping bags**

Abstract: This document specifies the requirements, test methods, test regulations, packaging, transportation and storage of industrial compostable plastic shopping bags. This document is applicable to plastic shopping bags made from industrial compostable plastic resin as the main raw material, processed by heat sealing or bonding, etc. and does not apply to industrial compostable plastic bags such as industrial compostable roll bags. This document enables to characterise the compostable plastic bags following two testing approaches that bring to the definition of two classes (class I and class II).

➜ **ISO 15270:2008 Plastics — Guidelines for the recovery and recycling of plastics waste**

Abstract: ISO 15270:2008 provides guidance for the development of standards and specifications covering plastics waste recovery, including recycling. The standard establishes the different options for the recovery of plastics waste arising from pre-consumer and post-consumer sources. It also establishes the quality requirements that should be considered in all steps of the recovery process, and provides general recommendations for inclusion in material standards, test standards and product specifications. Consequently, the process stages, requirements, recommendations and terminology presented in the standard are intended to be of general applicability.

➜ **ISO 16636:2025 Plastics — Disintegration field test of plastics under water environmental conditions**

Abstract: This document specifies test methods for the determination of the degree of disintegration of plastic materials floating in water.

➜ **ISO 24187:2023 Principles for the analysis of microplastics present in the environment**
This standard has been adopted at European level.

Abstract: This document describes the principles to be followed in the analysis of microplastics in various environmental matrices. This includes the unique particle size classification of plastics, the use of certain apparatus with regard to sampling, sample preparation, and the determination of representative sample quantities. The purpose of this document is to specify minimum requirements until specific standards for the different case situations are available to ensure the consistency of future developments.

➜ **CEN/TR 18160:2025 Plastics recycling — Classification of plastic recyclates as post-consumer recyclates (PCR) and post-industrial recyclates (PIR)**

Abstract: This document has been developed to ensure transparency regarding the input stream for recycling and to assist all plastic industry stakeholders in the development of new and improved standards for plastic recycling. The aim of this report is to present the current state of the debate on how to distinguish waste materials that are suitable for the production of plastic recyclates from those that cannot be used for recycling.

Standards related to transparency and reporting

➜ **ISO 59004:2024 Circular economy — Vocabulary, principles and guidance for implementation**

Abstract: ISO 59004 is a part of the ISO 59000 family of standards, specifically designed to foster a shift towards a circular economy. It includes defining key terms and concepts, outlining a vision for a circular economy,

elucidating core principles, and offering practical guidance for actionable steps towards sustainability. The standard aims to support organizations in contributing to the United Nations Agenda 2030 for sustainable development by facilitating a transition to a circular use of resources.

➜ **ISO 59040:2025 Circular economy — Product Circularity Data Sheet**

Abstract: This document establishes a general methodology for information exchange supporting the interoperability of circular economy related information, based on the use of a product circularity data sheet (PCDS). This document specifies requirements for completing a PCDS by an organization when acquiring or supplying products in order to permit the exchange of circular economy related information about those products, without disclosing confidential business information. This document also specifies requirements for the reporting format to be used when creating a PCDS template, based on the selection and use of various product circularity statements, according to the characteristics of the product. In addition, this document gives guidance on managing and sharing a PCDS, as well as guidance on creating a PCDS template.

➜ **EN 17615:2022 Plastics — Environmental Aspects — Vocabulary**

Abstract: This document specifies terms and definitions in the field of plastics related to environmental aspects and provides a common vocabulary for: - bio-based plastics; - biodegradability; - carbon and environmental footprint; - circular economy; - design; - plastics in natural environments; - reuse and recycling; - waste management.

➜ **ISO/TR 16340:2023 Application of blockchain-based traceability platform for cold chain food**

Abstract: This document addresses a blockchain-based traceability platform for cold chain food which realizes continuous and effective tracking of the cold chain food.

Standards related to impact assessment and performance

➜ **ISO 59020:2024 Circular economy — Measuring and assessing circularity performance**

Abstract: ISO 59020 sets forth requirements and guidance for organizations to measure and assess their circularity performance within defined economic systems. This document aims to standardize the process by which organizations collect and calculate data using mandatory and optional circularity indicators, ensuring consistent and verifiable results. It provides a structured framework for setting system boundaries, selecting appropriate indicators, and interpreting data to evaluate the circularity performance at multiple levels—from regional and inter-organizational to organizational and product-specific levels.

➜ **ITU-T L.1604 Development framework for bioeconomy in cities and communities**

Abstract: The aim of this Recommendation is to provide cities with a framework for the development of the bioeconomy, especially under the lens of circularity and sustainability, for all biological resources.
The main elements examined in this recommendation are:

- The definition and role of bioeconomy in cities, with a focus on circularity and sustainability.
- The determination of factors and key performance indicators (KPIs) that affect bioeconomy development in cities.
- The definition of a generic implementation framework for bioeconomy in cities.

Standards related to changing consumer behaviour via education

➔ **ISO/TR 42507:2025 Sharing economy — Use cases of sharing economy platforms in the public sector**

Abstract: This document provides use cases of sharing economy platforms in the public sector, aiming to support municipalities and administrations to apply suitable models of sharing economy platforms for increasing public values and the efficiency of public services.

➔ **ITU-T L.1620 Guide to circular cities**

Abstract: Recommendation ITU-T L.1620 contains a circular city implementation framework that is designed to improve circularity in cities and support stakeholders in implementing circular actions. The framework consists of a four-step methodology that provides a consistent method for assessing, prioritizing and catalysing different circular actions.

National involvement/ activities on identified technical committees

Out of presented technical committees, the national interest goes mainly to the **ISO/TC 323 Circular economy**. This committee counts currently 12 national delegates. Some of these experts participate also in the work of the European committee **CEN/TC 473 Circular economy**.

Moreover, Luxembourg is at the origins of **ISO 59040:2025 Circular economy — Product circularity data sheet**. Indeed, it was the initiative led by the Ministry of the Economy that proposed the standard in 2020 and followed its development up till the publication.

Impact of standards on the national economy

In Luxembourg, SMEs are actively involved in the circular economy through various initiatives and programs. For example, a position paper from the Luxembourg craft industry underlines the importance of the circular economy for its sector. Additionally, Luxembourg's circular economy strategy includes sector-specific action plans and tools to support SMEs in adopting circular practices.

Different initiatives and support actions are collected on a dedicated platform. Among such actions, one can find the Fit4Sustainability program managed by LuxInnovation. This program helps SMEs limit their use of raw materials, maximize renewable sources, and develop innovative products and services that promote sustainable growth, reduce energy consumption, and increase recyclability.

Standards are also considered as a useful tool for all national stakeholders, including both SMEs and craft industry, in Luxembourg's circular economy strategy. It suggests that standards can provide guidance for reuse of materials, components and products as well as for repair and sharing activities. More globally, as shown in the previous section, standards can help organizations to transition to new business model, measure their performance with respect to circularity and contribute to the reporting of relevant information as a part of bigger value chain. Standards also support the recycling practices, with multiple documents tackling various aspects of plastics handling. Finally, standards can be used as a source of information to increase awareness on various aspects of the topic.

3.4 Sustainable construction

3.4.1 Background

The construction sector plays a pivotal role in shaping the built environment, influencing not only the economic landscape but also the social and environmental fabric of a nation. Despite the adverse effects of the global crises on construction activities [38], Luxembourg's construction sector remains one of the nation's economic pillars. However, the sector also faces several challenges, including the need to reduce carbon emissions, manage waste, and ensure the sustainability of materials and processes. These challenges are defined by regulatory requirements and the need for skilled labor. Despite these obstacles, there are numerous opportunities to be harnessed through the implementation of sustainable standards. By adopting and adhering to these standards, the construction sector in Luxembourg can achieve greater environmental sustainability, improve energy efficiency, and foster innovation. Moreover, sustainable standards can enhance the sector's competitiveness, attract investment, and contribute to the overall well-being of society. [39]

3.4.2 Challenges of the sector

Sustainable construction refers to building practices that prioritize environmental responsibility, resource efficiency, and the wellbeing of occupants and communities with the perspective of achieving climate neutrality by 2050. This approach is essential in addressing the ecological limits that ensure the Earth's life-support systems remain intact. Minimum performance and building energy codes are increasing in scope and stringency across countries, and the use of efficient and renewable buildings technologies is accelerating. Yet the sector needs more rapid changes to get on track with the Net Zero Emissions by 2050 Scenario. This decade is crucial for implementing the measures required to achieve the targets of all new buildings and 20% of the existing building stock being zero-carbon-ready[2] by 2030.

By focusing on key technical aspects, the construction sector can reduce its environmental impact and support climate neutrality by 2050:

- **Climate Crisis Mitigation:** Construction and building operations are major sources of greenhouse gas emissions. Sustainable practices aim to reduce these through energy-efficient designs and renewable energy integration [40] [41].
- **Regional Challenges:** Approaches differ between the Global North and South. In the North, retrofitting older buildings and improving energy efficiency are priorities [40] [41].
- **Passive Design Strategies:** Techniques like optimizing building orientation, natural ventilation, and thermal mass help lower energy demand. These are supported by efficient energy systems and the use of sustainable materials such as wood, alternative bricks, or low-carbon cement.
- **Reuse, Reduce, Recycle:** Sustainable construction emphasizes recycled and renewable materials, designing for adaptability and deconstruction, minimizing waste and energy use, and reusing existing structures [40] [41].

In the long term, sustainable construction is expected to evolve into a broader regenerative approach, aiming not only for carbon neutrality but also addressing social factors like education, water, and healthcare infrastructure — though these are beyond the scope of this document.

2 Zero-carbon-ready buildings are highly energy-efficient and resilient buildings that either use renewable energy directly or rely on a source of energy supply that can be fully decarbonized, such as electricity or district energy. The zero-carbon-ready concept include both operational and embodied emissions.

3.4.3 Policies and strategies

European level

➜ **Sustainable Built Environment Strategy**

In March 2020, the European Commission committed to developing a sustainable built environment strategy as part of the new circular economy action plan and industrial strategy for Europe. The strategy aims to enhance material efficiency and reduce the climate impact of the built environment by promoting circularity principles throughout the building lifecycle. It seeks coherence across related policy areas such as climate, energy, waste management, digitalization, and skills. The Commission's plans include:

- Revising the Construction Products Regulation (CPR) ;
- Promoting circular economy principles in building design and developing digital logbooks for buildings ;
- Considering revisions to EU waste legislation to focus on material recovery targets for construction and demolition waste ; and
- Promoting soil-related initiatives to reduce soil sealing, rehabilitate brownfields, and increase the sustainable use of excavated soils, as outlined in the EU biodiversity strategy for 2030.

Although, many of these initiatives have been launched, no formal sustainable built environment strategy had been published by July 2024. In the absence of a dedicated strategy, the European Green Deal remains the central reference point, promoting decarbonization of the construction sector through building renovation and modernization, fostering the development of digital building logbooks, supporting soil-related initiatives to reduce sealing or even improving waste legislation. Several complementary initiatives support this transition in promoting sustainable and circular principles throughout the lifecycle of buildings:

- Level(s), which offers a unified and voluntary EU framework for evaluating and reporting the sustainability of buildings, using key indicators to measure impacts on carbon, materials, water, health, comfort, and climate change throughout the building's lifecycle. It aligns with EU policies to enhance the sustainability of Europe's buildings and guides investments and financial products.
- The Green Deal's Renovation Wave initiative: To achieve both energy efficiency and economic growth, the Commission introduced the Renovation Wave Strategy in 2020, accompanied by an action plan and a document outlining available EU funding, aiming to double the renovation rate and improve efficiency as well as create jobs and improve quality of life through better buildings.

Supporting publications and platforms include:

- Publications like "Circular Economy - Principles for Buildings Design" play a crucial role in raising awareness about resource efficiency and circular material life. This document outlines key principles that emphasize durability, adaptability, and waste reduction. It addresses the generation of less construction and demolition waste, facilitates the reuse and recycling of construction materials, and aims to reduce the environmental impacts and life cycle costs of buildings.
- Manifesto 2025 - Construction 2050 Alliance: the High-Level Construction Forum has recently enabled the introduction of this document which calls for stronger focus on sustainability, circularity, digitization, skills and affordability, while advocating for smarter regulations and investments as well as a structured dialogue between the sector and EU policymakers.

National level

In recent years, Luxembourg has implemented several strategies to advance sustainable construction. Both public and private organizations have intensified their efforts, while new entities have emerged with the mission

of supporting the market and developing innovative strategies and tools. These initiatives aim to meet European and national requirements for a decarbonized construction sector. They include municipal as well as urban and nationwide planning measures. In the following section, a closer, though selective, look will be taken at some of these initiatives. Most of the aspects related to the Circular Economy are deliberately excluded here, as they are thoroughly examined in a dedicated chapter (see section 3.3).

➜ ***Projet de Stratégie et plan d'action pour l'adaptation aux effets du changement climatique au Luxembourg (2025 - 2035)***

At the end of 2024, a draft strategy and action plan was developed by the Ministry of Environment, Climate and Biodiversity for the period 2025-2035, addressing key areas such as housing and construction in response to Luxembourg's evolving climate challenges. The strategy aims to reduce Luxembourg's vulnerability to climate change and enhance resilience across 16 policy areas, and its establishment involves expert workshops (Feb-Mar 2025), public engagement (Apr-May 2025), and a final presentation of results in summer 2025.

➜ **"Sustainable Construction" unit within the General Directorate for Industry, New Technologies and Research**

The Ministry of the Economy has established a dedicated unit focused on sustainable construction and the circular economy in this specific sector. This unit aims to integrate principles of energy efficiency and renewable energy into construction practices. It promotes the use of renewable resources, modular construction methods, and holistic management of materials and resources throughout the lifecycle of buildings.

The projects and thematic priorities of the unit focused on sustainable construction can be summed up as follows through the following measures which aim at different challenges of the sector:

- **Low Carbon Construction Roadmap**
  - Sets out strategies to reduce the carbon footprint of building, including the annual carbon budget, material databases and the life cycle analysis;
  - INDICATE LIFE Project: Through the development of the Low Carbon Building Roadmap, Luxembourg has been able to join this European project, which aims to reduce greenhouse gas emissions in the construction sector. This initiative focuses on developing Life Cycle Assessment (LCA) tools and national carbon footprint calculation methodologies and is therefore contributing to a better and faster implementation of the EPBD (energy performance of buildings directive).

- **Update of the *"Guide de la construction durable"***
  - In collaboration with CRTI-B (*Centre de Ressources des Technologies et de l'Innovation pour le bâtiment*), CNCD (*Conseil national pour la construction durable*), and OAI (*Ordre des Architectes et des Ingénieurs-Conseils*), this handbook incorporates principles of the circular economy related to aspects, such as deconstruction, modularity, smart flow management, and digitization.

- **Indoor air quality**
  - Establishing a national framework for advice, follow-up, and monitoring of indoor air quality as well as integrating health aspects into sustainable construction rules, including LENOZ certification and PRIMeHouse grants.

- **Energy and materials**
  - Reducing the energy intensity of traditional construction materials and promoting bio-sourced materials, particularly wood, for CO_2 storage, in collaboration with Luxinnovation's "*CleanTech and Wood*" clusters. The use of renewable and recyclable materials is thereby strongly prioritized.

- **Public-sector collaboration**
  - Working with public-sector promoters like the Public Building Administration, FUAK (*Fonds d'Urbanisation et d'Aménagement du Plateau de Kirchberg*), Housing Fund *(Fonds du Logement)*, and SNHBM (*Société Nationale des Habitations à Bon Marché*) and launching public procurement procedures to encourage circular initiatives in construction.

- **Municipal involvement**
  - Acting through the Climate Pact 2.0 in collaboration with Klima-Agence Luxembourg.
  - Engaging municipalities in promoting sustainable construction and the circular economy. As an example, the municipality of Wiltz can be named. Wiltz, a pioneer municipality in circular construction in Luxembourg, has positioned itself as a model for sustainable urban development. Through the Circular Innovation Hub, Wiltz is fostering innovation in the construction sector. Besides promoting circular economy principles in building design, material use, and lifecycle management, the project encourages collaboration between public institutions, private companies, and research organizations to develop and test circular construction methods. Pilot projects aim at demonstrating how buildings can be designed for disassembly, reuse, and minimal environmental impact.
  - Most importantly, the municipality participates in European initiatives like PREUSE (Interreg NWE), which supports the reuse of construction materials and the development of regional marketplaces for reclaimed building components. This initiative not only supports Luxembourg's national circular economy strategy but also serves as a blueprint for other municipalities aiming to reduce their environmental footprint through innovative construction practices.

- **Innovation and skills transfer**
  - Fostering innovation through collaborations with RDI partners such as the University of Luxembourg, LIST, and Neobuild.
  - Promoting the transfer of new skills to the construction sector in collaboration with various training institutes and competence centers.

The different examples described above, some at the ministerial and others at the municipal level, demonstrate that impactful change can be driven from various tiers of governance, collectively influencing society, the economy, and policymaking. Other tools have been developed to support planners and all stakeholders involved in the construction sector in navigating and applying new regulations. The following are some key examples relevant to this context:

- The Baucheck tool is designed to support and raise awareness among local authorities about sustainable and circular building practices for both new constructions and renovations.
- Noba is a Luxembourg-based platform that promotes sustainable construction through educational resources, tools, and examples focused on ecological and circular building practices. It was developed by national entities like CRTI-B, OAI, the Ministry of the Economy, and others.
- The Ministry of Housing and the Order of Architects and Consulting Engineers (OAI) are actively promoting initiatives aimed at standardizing sustainable and affordable housing design. One such initiative includes the development of standard plans and specifications to support affordable housing projects, which were presented publicly in April 2025. These efforts are part of a broader strategy to encourage sustainable construction practices and improve housing accessibility in Luxembourg.

The various projects primarily aim to ensure the smooth implementation of legal requirements and to support the different stakeholders involved in the planning and execution of construction projects. The legal framework underpinning these strategies and organizations will be detailed in the following chapter.

3.4.4 Legal frameworks

European level

Through a framework of directives and regulations, the European Commission lays the groundwork for national implementation. In 2024, significant revisions were made to several construction-related legislative instruments, particularly those tied to sustainability. Those references play a crucial role in shaping sustainable practices within the construction sector and have an impactful meaning for the development of the Member States' ecosystems. The following section highlights the most relevant updates or additions:

➜ **Directive (EU) 2023/1791 on energy efficiency and amending Regulation (EU) 2023/955**

This directive aims to ensure the achievement of the Union's 2020 20% headline target on energy efficiency.

➜ **Directive (EU) 2024/1275 on the energy performance of buildings (EPBD)**

The EPBD mandates energy efficiency measures and life-cycle assessments for buildings, driving decarbonization and sustainability across the EU [42]. It contributes to the increase of the renovation rate in the EU, especially of the least efficient buildings in each country, to the reduction of greenhouse gas emissions (at least 60% in the buildings sector by 2030 compared to 2015) and to the achievement of a decarbonized, zero-emission building stock by 2050. The directive both supports policies that will help achieve a highly energy efficient and decarbonized building stock by 2050 and creates a stable environment for investment decisions, enabling consumers and businesses to make more informed choices to save energy and money.

➜ **Regulation (EU) 305/2011 laying down harmonized conditions for the marketing of construction products**

The initial version of this regulation "(...) *establishes harmonized rules for the marketing of construction products in the EU. (...) It provides a common technical language for assessing the performance of construction products (...) and ensures that reliable information is available to professionals, public authorities and consumers, so that they can compare the performance of products from different manufacturers in different countries*."

➜ **Regulation (EU) 2024/3110 laying down harmonized rules for the marketing of construction products**

This regulation builds upon the core principles of the previous framework while formally repealing it. The revised Construction Products Regulation (CPR), in force since January 2025, reinforces the EU's approach to product safety, sustainability, and digitalization in the construction sector. Its primary goal is to ensure that construction products are safe, energy-efficient, and environmentally sustainable, while fostering a harmonized internal market across the EU. Key innovations include the mandatory reporting of environmental sustainability, the introduction of Digital Product Passports to enhance product traceability, and an expanded CE marking that now reflects environmental impact. The regulation also places a strong emphasis on circular economy principles and actively promotes the use of digital technologies and processes throughout the construction lifecycle. These advancements are designed to support the objectives of the EU Green Deal, encouraging safer, greener, and more transparent construction practices across Member States.

➜ **Regulation (EU) 2024/1781 establishing a framework for the setting of ecodesign requirements for sustainable product**

The regulation establishes a broad framework for setting ecodesign requirements for sustainable products, including construction products. Complementing the Construction Products Regulation, it promotes resource efficiency, durability, and circularity in product design, supporting the transition to a climate-neutral economy. This regulation also encourages innovation and better market surveillance, with digital product passports enhancing transparency across sectors.

National level

One of the key measures stemming from Luxembourg's legal frameworks is the LENOZ certificate, introduced in 2017. This is the country's official sustainability certification scheme for residential buildings. It evaluates dwellings based on three core pillars: environmental preservation (through detailed assessments), economic efficiency, and social organization.

The LENOZ certificate serves a dual purpose: it raises awareness about sustainable housing and contributes to a more transparent property market by providing comprehensive information about individual dwellings. To support its implementation, the Ministry of Housing offers financial subsidies through the PRIMe House 2017 program, which was specifically designed to promote the construction of sustainable homes.

A non-exhaustive list of national laws backing financial subsidies for new construction and the energy-efficient refurbishment of existing buildings[3]:

➜ ***Version consolidée applicable au 08/06/2024 : Loi du 15 décembre 2020 relative au climat et modifiant la loi modifiée du 31 mai 1999 portant institution d'un fonds pour la protection de l'environnement***

The Luxembourg's climate protection law (*"Klimaschutzgesetz"*), together with its implementing Grand Ducal Regulation, reinforces Luxembourg's climate governance framework. It sets out institutional structures for climate policy, defines emission reduction targets, and establishes the Climate and Energy Fund, which finances transition measures and sustainable projects.

These instruments align with the goals of the Paris Agreement and the EU climate strategy, and they include sector-specific strategies, particularly for construction, to support the shift toward climate neutrality by 2050.

➜ ***Loi du 7 avril 2022 modifiant la loi modifiée du 23 décembre 2016 instituant un régime d'aides pour la promotion de la durabilité, de l'utilisation rationnelle de l'énergie et des énergies renouvelables dans le domaine du logement***

This law amends the amended law of December 23, 2016 establishing an aid scheme for the promotion of sustainability, rational energy use, and renewable energy in the housing sector.

➜ ***Règlement grand-ducal du 7 avril 2022 déterminant les mesures d'exécution de la loi modifiée du 23 décembre 2016 instituant un régime d'aides pour la promotion de la durabilité, de l'utilisation rationnelle de l'énergie et des énergies renouvelables dans le domaine du logement***

This Grand-Ducal regulation determines the implementing measures for the amended law mentioned above.

3 The titles have been translated from French to English. The original documents can be consulted via hyperlink or in the references.

➜ ***Version consolidée applicable au 01/07/2024 : Loi du 23 décembre 2016 1. instituant un régime d'aides pour la promotion de la durabilité, de l'utilisation rationnelle de l'énergie et des énergies renouvelables dans le domaine du logement; 2. modifiant la loi modifiée du 23 décembre 2004 établissant un système d'échange de quotas d'émission de gaz à effet de serre***

This consolidated law establishes a greenhouse gas emission allowance trading system.

➜ ***Loi du 3 juillet 2025 instituant un régime d'aides en faveur de la transition vers une économie à zéro émission nette***

This law establishes an aid scheme to support the transition to a net-zero emissions economy.

3.4.5 Standardization activities

The importance of standards in the construction industry cannot be overstated. They act as a common language among professionals (architects, engineers, contractors, and regulators) facilitating collaboration and coherence. In the pursuit of sustainable development, standards help reduce environmental impact, optimize resource use, and enhance the resilience of buildings and infrastructure. The adoption and implementation of sustainable practices through standardization are increasingly recognized as essential for maintaining its robustness and dynamism [43] [44]. Moreover, Luxembourg's regulatory framework actively supports the adoption of such standards, encouraging compliance and driving innovation across the sector.

Various technical committees focus proactively on the achievement of the Sustainable Development Goals through the decarbonization and optimization of the construction sector. Numerous domains related to the construction sector could be included, such as logistics and transport, cultural heritage, or even wastewater management. However, the selection of the present report is being limited to the most relevant committees and standards in order to transmit a general perception of the activities on European and international levels.

Relevant technical committees and standards

➜ **ISO/TC 59/SC 17 Sustainability in Buildings and Civil Engineering Works**

Scope: Standardization in the field of sustainability of new and existing construction works in the context of the UN Sustainable Development Goals and climate change mitigation and adaptation. The environmental, economic, and social aspects of sustainability and circular economy are included as appropriate.

➜ **ISO/TC 59/SC 15 Framework for Functional/User Requirements in Building Construction**

Scope: Standardization in the field of basic performance standards on building construction including general rules for performance requirements for buildings as a whole and for subsystems, e.g., building elements, focusing on performance description and requirements, user requirements, and the means to evaluate housing and other types of building solutions.

A special emphasis is placed on developing housing performance descriptions on aspects (e.g., for trading of houses as a whole), such as:

- Structural integrity, durability and serviceability
- Fire safety
- Operating energy
- Accessibility and usability

Topics covered in more specific detail by other SCs within TC 59 and other technical committees are excluded. Determination of performance level values required for specific purposes is excluded as it will be decided by the stakeholders.

➜ ISO/TC 59/SC 14 Service life planning

Scope: Standardization in the field of Service Life Planning and Design Life of buildings and constructed assets during the period for which they are intended to remain functional and meet their designed performance requirements.

Note: Service life planning for buildings involves the strategic and systematic consideration of a building's life cycle, encompassing its design, construction, commissioning, operation, maintenance, and eventual disposal or reuse. This is to ensure an adequate level of performance of the building, or constructed asset, be resilient to the effects of climate change, and that will maintain its value over its lifespan, whilst minimizing its environmental impact.

➜ CEN/TC 350 Sustainability of Construction Works

In line with Standardization Request M/350 and the CEN-CENELEC Work Program 2025, CEN/TC 350 is revising EN 15978 and supporting the development of the CPR Technical Acquis by establishing environmental criteria.

Scope: The committee is responsible for the development of horizontal standardized methods for the assessment of the sustainability aspects of new and existing construction works (buildings and civil engineering works) in the context of the UN Sustainable Development Goals and of the circular economy. The methodological basis will be developed in the context of current needs, European strategies, such as mitigation, adaptation and resilience to climate change, and life cycle thinking.

The standards describe coherent methodologies for the assessment of sustainability of construction works covering the assessment of environmental, social and economic performance (aspect and impacts) of buildings and civil engineering works, and the provision of construction product environmental information (EPD).
This covers:

- Environmental performance assessment; circularity principles (the circular economy in the construction sector), energy efficiency and decarbonization, sustainable use of resources (resource efficiency, waste minimization), protection of the environment and biodiversity.
- Social performance assessment; health and comfort, safety and security, adaptability and accessibility in response to user needs, resilience against external events such impact of climate change, sourcing of materials.
- Economic performance assessment; life cycle cost, whole life costs and impact on economic value, "green finance" initiatives (taxonomy).
- The implementation of the standards in response to trends in digitalization (e,g. BIM, CAD).

➜ CEN/TC 350/SC 1 Circular Economy in the Construction Sector

Scope: Standardization in the field of circular economy in the built environment specifying circular principles and guidelines and requirements to facilitate the transition to a more sustainable circular economy including tools and processes to achieve this; covering design to de-construction and end-of-life scenarios in all stages of current and subsequent life cycles.

This applies to new and existing construction works (buildings and civil engineering works), including their products, materials and components. The subcommittee deals both with technical issues on circularity, as well as environmental, economic and social challenges.

This work will consider standards of CEN/TC 350 and consider the work of existing committees on subjects that may support the circular economy in the construction sector, such as ISO/TC 323 and CEN-CLC/JTC 10, including initiatives of the European Commission.

Other Relevant Technical Committees

- **CEN/TC 351 Construction Products — Assessment of release of dangerous substances**
- **ISO/TC 71/SC 8 Environmental management for concrete and concrete structures**
- **CEN/TC 104/WG 19 Concrete and related products — Decarbonization, resource efficiency, and sustainability**
- **CEN/TC 38 Durability of wood and wood-based products**
- **CEN/CLC/JTC 10 Material efficiency aspects for products in scope of Eco-design legislation**
- **ISO/TC 163 Thermal performance and energy use in the built environment**
- **CEN/TC 89 Thermal Performance of Buildings and Building Components**
- **CEN/TC 371 Energy performance of buildings**

Relevant technical standards supporting sector challenges

Lifecycle remains an important part for sustainable construction. As this topic is covered by section 3.1, we invite reader to consult this section for more details.

General principles and guidelines

- **ISO 15392:2019 Sustainability in building construction — General principles**

Abstract: This foundational standard outlines the overarching principles of sustainability in the built environment. It establishes a common understanding of sustainability concepts for stakeholders in construction, guiding decision-making across the lifecycle of buildings and infrastructure. It serves as a reference point for more detailed sustainability standards.

- **ISO/TS 12720:2024 Sustainability in buildings and civil engineering works — Guidelines on the application of the general principles in ISO 15392**

Abstract: This technical specification provides practical guidance on implementing the general sustainability principles defined in ISO 15392. It supports stakeholders (designers, builders, regulators) in integrating sustainability considerations throughout the planning, construction, use, and end-of-life phases of buildings and civil engineering works.

➜ **ISO 21931-1:2022 Sustainability in buildings and civil engineering works — Framework for methods of assessment of the environmental, social and economic performance of construction works as a basis for sustainability assessment (Part 1: Buildings)**

Abstract: This standard provides a framework for assessing the environmental, social, and economic performance of buildings throughout their lifecycle. It supports consistent and transparent sustainability evaluations without prescribing specific benchmarks or performance levels.

➜ **EN 15643:2021 Sustainability of construction works.**
This standard has been developed in the frame of standardization request M/350.

Abstract: Provides a comprehensive framework for assessing the sustainability of buildings, covering environmental, social, and economic dimensions. It supports consistent evaluation across the building lifecycle and aligns with European sustainability mandates.

Performance indicators and assessment

➜ **ISO 21929-1:2011 Sustainability indicators for buildings — Framework for the development of indicators**

Abstract: Offers a structured framework for developing and using indicators to assess the sustainability performance of buildings. It helps identify relevant metrics across environmental, social, and economic dimensions, enabling consistent evaluation and comparison of building projects.

➜ **ISO 16745 series Environmental performance of buildings — Carbon metric**

Abstract: This standard defines methods for quantifying and reporting the carbon footprint of buildings. It enables consistent assessment of greenhouse gas emissions associated with building operations and lifecycle stages, supporting climate-conscious design and policymaking.

➜ **EN 15978:2011 Sustainability of construction works — Assessment of environmental performance of buildings — Calculation method.**
This standard has been developed in the frame of standardization request M/350.

Abstract: Defines a methodology for evaluating the environmental performance of buildings using Life Cycle Assessment (LCA). It complements EN 15804 by applying product-level data to building-level assessments.

➜ **EN 16309:2014 Assessment of social performance of buildings. Sustainability of construction works — Assessment of social performance of buildings — Calculation methodology.**

Abstract: Establishes criteria and indicators for assessing the social aspects of buildings, including accessibility, safety, and user well-being. It supports integration of social sustainability into construction evaluations.

➜ **EN 16627:2015 Sustainability of construction works — Assessment of economic performance of buildings — Calculation methods.**

Abstract: Provides methods for evaluating the economic sustainability of buildings, including life cycle cost analysis. It enables comparison of financial impacts across design and operational phases.

Environmental product declaration and material characteristics

➜ **ISO 21930:2017 Environmental declaration of building products**

Abstract: Focused on product-level sustainability, this standard specifies requirements for environmental product declarations (EPDs) in the construction sector. It ensures transparency and comparability of environmental data, supporting informed choices in material selection and sustainable design.

➜ **ISO 18985:2025 Recycled aggregates for concrete**
This standard has been developed in the frame of standardization request M/350. This standard supports regulation (EU) No 305/2011

Abstract: This standard specifies requirements for the use of recycled aggregates in concrete production. It promotes sustainable resource use by enabling safe and effective incorporation of recycled materials, while maintaining structural integrity and performance standards.

➜ **EN 15804:2012 Environmental Product Declarations (EPDs) — Core rules for the product category of construction products.**
This standard has been developed in the frame of standardization request M/350.

Abstract: Specifies core rules for creating Environmental Product Declarations (EPDs) for construction products. It ensures consistency and comparability of environmental data across the sector. Based on ISO 14025:2010 - Environmental labels and declarations - Type III environmental declarations - Principles and procedures.

➜ **EN 15942:2021 Sustainability of construction works — Environmental product declarations — Communication formats business to business.**
This standard has been developed in the frame of standardization request M/350.

➜ **ISO 22057:2022 Sustainability in buildings and civil engineering works — Data templates for the use of environmental product declarations (EPDs) for construction products in building information modelling (BIM).**
This standard has been adopted at European level.

Abstract: Defines standardized data templates to integrate EPDs into Building Information Modelling (BIM). It supports digital workflows and enhances sustainability data accessibility in design processes.

Energy performance of buildings

➜ **ISO 52000-1:2017 Energy performance of buildings — Overarching EPB assessment.**
This standard has been adopted at European level. This standard supports the European directive 2010/31/EU.

Abstract: Part of the EPB (Energy Performance of Buildings) series, this standard provides a comprehensive framework for assessing building energy performance. It integrates various technical aspects — heating, cooling, lighting — into a unified methodology, supporting energy efficiency goals across Europe.

Data quality and selection

➜ **EN 15941:2024 Sustainability of construction works — Data quality for environmental assessment of products and construction work — Selection and use of data.**

Abstract: Provides guidance on selecting and using high-quality data for environmental assessments of construction products and works. It ensures reliability and transparency in sustainability evaluations.

National involvement/activities on identified technical committees

The CEN/TC 350 and CEN/TC 350/SC 1 are mirrored on national level. A total of 17 members is enrolled in the technical committee and the different working groups. This group of experts reflects the highest activity in the identified technical committees. The members represent various domains, such as the university, steel industry, building technologies, circular economy, engineers and public entities (environment). The national mirror committee usually gathers bi-annually and discusses the latest activities, meetings and ballots at European level.

Impact of standards on the national economy

Overall, the integration of sustainable construction practices and standardization is vital for creating a resilient and sustainable built environment. It not only addresses current environmental challenges but also positions the construction industry to meet future demands for sustainability and efficiency.

All types of companies in Luxembourg are increasingly adopting international standards to enhance their competitiveness and ensure compliance with regulatory requirements. This trend is also evident in the construction sector, where sustainable construction standards are gaining prominence due to regulatory pressures and market demand. Standardization helps businesses streamline their operations, reduce costs, and improve product quality. By using standardized materials and methods, companies can lower production costs and minimize waste, which is especially beneficial for smaller enterprises with limited resources. Additionally, standardization facilitates the integration of new technologies and practices, reducing the learning curve and associated costs. Sustainable construction standards promote the use of eco-friendly materials and energy-efficient technologies, helping businesses reduce their environmental footprint and appeal to environmentally conscious consumers. Compliance with these standards can enhance the reputation of SMEs and artisans, making them more attractive to clients who prioritize sustainability. Overall, standardization have a profound impact on SMEs, businesses, and artisans in Luxembourg, fostering a more resilient and sustainable business environment.

To address the issue of time investment and limited (financial) profitability, the Chamber of Skilled Trades and Crafts *(Chambres des métiers)* actively advocated for the interests of various construction stakeholders. It engages in activities through ILNAS, while promoting the knowledge transfer, emphasizing the long-term strategic benefits of standardization and encouraging participation in related activities. However, the CRTI-B remains the Luxembourgish standardization office for construction sector which, through an agreement since 2015, supports the development of normative documents with ILNAS and promotes activities within the sector. It serves as one of the primary points of contact for identifying standardization needs and appointing potential experts for technical committees, subcommittees, or working groups.

3.5 Hydrogen technologies

3.5.1 Background

Hydrogen serves as a versatile and clean energy carrier, with applications across various sectors, including industry, transportation, and energy storage [45]. Unlike fossil fuels, hydrogen does not emit CO_2 when used, making it an ideal solution for decarbonizing sectors where emissions reductions are particularly challenging [46]. This includes heavy industry (such as steel and cement production), short and long-haul transport (including aviation, shipping, and freight), and power generation. Additionally, hydrogen can be stored and transported efficiently, contributing to energy security and grid stability, by balancing intermittent renewable energy sources like wind and solar [4].

Hydrogen technologies are being heavily invested in by governments and industries worldwide, as their potential to complement other renewable energy solutions is increasingly recognized [47]. Hydrogen strategies are being aligned by countries with international climate agreements, such as the Paris Agreement, which aims for carbon neutrality by mid-century [48]. As a result, hydrogen is increasingly being recognized as a cornerstone of national and global energy policies, with its adoption being accelerated by numerous research initiatives, pilot projects, and large-scale investments [49].

3.5.2 Challenges of the sector

As previously mentioned, hydrogen offers great potential as a clean and flexible energy carrier, but its broad adoption depends on overcoming key technical challenges to fully support the global energy transition [50]. These challenges are analyzed in terms of hydrogen production, storage and transport infrastructure, end-use systems, and overall safety challenges of the hydrogen ecosystem.

Hydrogen Production

One of the primary challenges in hydrogen production is its high cost, particularly for green hydrogen produced through renewable energy-powered electrolysis, which remains expensive due to the energy-intensive nature of the process. The cost of renewable electricity further increases the overall expense. Although production costs are expected to decrease over time, scaling up production to meet global demand will require significant investments in renewable energy infrastructure and improvements in electrolysis efficiency. Technological scalability remains a significant challenge [46], as current green hydrogen production methods are still relatively less efficient and less cost-effective than fossil fuel alternatives.

Hydrogen Storage and Transport Infrastructure

A significant challenge for the hydrogen economy is that dedicated infrastructure deployment is still at its beginning. Existing pipelines, storage facilities, and distribution systems remain limited, restricting hydrogen's accessibility and commercial viability [46]. Developing this infrastructure is complex and costly, requiring major capital investment and long-term planning [51]. Additionally, hydrogen's low energy density and its tendency to cause embrittlement of materials increase the technical difficulties of safe transport and storage [52] . Scalability issues remain in creating advanced, cost-effective, and efficient hydrogen storage solutions. Moreover, energy losses during storage and transport further reduce hydrogen's overall energy efficiency, which must be addressed to improve its role in the clean energy mix [52].

Hydrogen End Use

In the end-use phase, a major challenge is the limited network of hydrogen refueling stations, which restricts the deployment of hydrogen-powered vehicles and infrastructure [53]. The high cost and limited technological maturity of fuel cells further hinder adoption, as these systems still require improvements in efficiency, durability, and affordability. Additionally, energy losses during hydrogen conversion back into electricity or heat reduce its overall sustainability. Existing technical frameworks for end-use applications, such as fueling stations and fuel cell systems, provide a strong foundation but may require further development to meet future needs. Advancing toward more harmonized and comprehensive approaches will help ensure safety, interoperability, and greater market adoption.

Overall safety issues of the hydrogen ecosystem

Hydrogen presents several safety challenges due to its high flammability, making leaks potentially explosive even at low concentrations [53]. Its colorless and odorless nature makes leak detection difficult, requiring specialized equipment. Hydrogen can also cause metal embrittlement, weakening infrastructure over time, and its high-pressure storage requirements pose additional mechanical and safety risks, particularly in transport and mobility applications. In addition to safety concerns, the hydrogen sector faces complexity due to the existence of different certification schemes. These schemes, which define how hydrogen is produced and labeled (e.g. green, blue, or grey hydrogen), vary across countries and regions [54] [55]. This lack of harmonization makes it difficult for companies to navigate regulatory requirements, ensure compliance, and trade hydrogen products across borders.

3.5.3 Policies and strategies

European level

➔ **The European Union Hydrogen Strategy**

The European Union Hydrogen Strategy, introduced by the European Commission in July 2020, aims to position hydrogen as a central element in the EU's transition to a carbon-neutral economy and to support the achievement of its climate goals. The strategy outlines a comprehensive framework for scaling up the production, distribution, and use of clean hydrogen, particularly green hydrogen produced from renewable energy sources. The strategy is structured in three phases:

- **2020-2024** - This initial phase focuses on laying the groundwork for a hydrogen economy, with an emphasis on expanding green hydrogen production and establishing pilot projects. The EU plans to install at least 6 GW of renewable hydrogen electrolyzers and develop an early-stage hydrogen infrastructure.
- **2025-2030** - The second phase seeks to scale up hydrogen production to 10 million tons per year and establish a European hydrogen network for transport and storage. This period aims to drive innovation and secure private sector investment, alongside broadening hydrogen usage in key sectors such as industry, transport, and energy production.
- **2030-2050** - By 2050, as a long-term plan, the EU aims to have hydrogen supply up to 13% of total energy consumption, with playing a pivotal role in decarbonizing various sectors of the economy. This phase will focus on large-scale deployment of hydrogen technologies and ensuring full integration of hydrogen into the European energy system.

The strategy stresses the importance of a clear regulatory framework, investment in R&D, and standardization of technologies to ensure the seamless development of the hydrogen sector. In essence, the European Union Hydrogen Strategy seeks to make hydrogen a key enabler of the EU's 2050 carbon neutrality target [56], fostering energy security, reducing greenhouse gas emissions, and boosting economic growth through clean energy innovation.

➜ The Hydrogen Standardization Roadmap

The Hydrogen Standardization Roadmap developed by the European Clean Hydrogen Alliance (ECHA) and supported by the High-Level Forum on European Standardisation (HLF), identifies key gaps and priorities to support safe, interoperable, and scalable hydrogen technologies. Standardization plays a crucial role in enabling hydrogen-based mobility by ensuring common protocols for production, storage, transport, and fuel cell vehicles. These efforts are essential for building an European hydrogen infrastructure and advancing clean, cross-border transport solutions. Section 3.5.5 provides standardization activities in this field including technical committees and relevant standards.

National level

➜ The Hydrogen Strategy of Luxembourg

Closely aligned with the broader European Hydrogen Strategy, Luxembourg's Hydrogen Strategy adopted in 2021 (update is expected by the end of 2025) aims to establish hydrogen as a crucial component in achieving climate neutrality by 2050 [56]. By leveraging these strategic priorities and measures, Luxembourg aims to position itself as a leader in the transition to a hydrogen-based economy, reinforcing its commitment to sustainability and climate neutrality.

This national strategy focuses on the following three strategic priorities:

- **Strategy I: Establishing the role of hydrogen in decarbonization** which defines the context of decarbonization and highlights hydrogen's role in sectors that are challenging to decarbonize through direct electrification, such as heavy industry.
- **Strategy II: Assessing potential and prioritizing key sectors** which evaluates the current landscape and estimates the potential for decarbonization through hydrogen, prioritizing three high-emission sectors: industry, transport, and an integrated future-proof energy system.
- **Strategy III: Implementing key measures to promote renewable hydrogen** which outlines seven critical measures to foster the production, import, and use of renewable hydrogen:
  - Regulatory framework development — Contribute to defining legal and regulatory frameworks at the EU level (e.g. certification of renewable hydrogen).
  - International cooperation — Strengthen partnerships with EU Member States and third countries.
  - Innovation and Research — Identify opportunities in Luxembourg, including public research, innovative industrial applications.
  - Flagship projects — Drive the implementation of pioneering hydrogen projects.
  - Targeted decarbonization — Focus on renewable hydrogen adoption in priority sectors such as industry, transport, and integrated energy systems.
  - Market development — Establish instruments to support the growth of a renewable hydrogen market.
  - Implementation and continuous improvement — Oversee progress through Taskforce H2 Luxembourg to ensure long-term success.

In this context, initiation of the Taskforce H2 Luxembourg intends to bring together public and private actors to develop a national hydrogen ecosystem. Another major initiative LuxHyVal, a pilot project to produce green hydrogen and deploy it in public mobility and logistics, contributing to national and European decarbonization goals, can be considered as the key measure to foster the production, import, and use of renewable hydrogen.

3.5.4 Legal frameworks

European level

➜ **Regulation (EU) No 2023/1804 on the deployment of alternative fuels infrastructure**

This regulation focuses on the deployment of alternative fuels infrastructure, including for hydrogen, to reduce dependence on fossil fuels and mitigate environmental impact. More specifically, the regulation aims to ensure widespread availability of hydrogen infrastructure, by setting out requirements for the development and integration of hydrogen refueling stations across the EU to support the growing use of hydrogen-powered vehicles in transport sectors. In the context of hydrogen, the directive emphasized the need for:

- Development of hydrogen refueling infrastructure to support fuel cell vehicles.
- Common technical specifications to ensure interoperability across Member States.
- National policy frameworks to promote investment and coordinated deployment of hydrogen infrastructure.
- Cross-border connectivity to facilitate a seamless hydrogen supply network across the EU.

➜ **Directive (EU) No 2023/2413 as regards the promotion of energy from renewable sources**

This directive focuses on the promotion of energy from renewable sources, including renewable hydrogen. The directive aims to enhance the EU's energy transition by increasing the share of renewable energy in the overall energy mix, with a specific emphasis on renewable hydrogen as a key solution for decarbonizing sectors like transport and industry. It sets out clear targets and measures to boost hydrogen production using renewable energy, ensuring that hydrogen is produced sustainably and contributes to achieving the EU's climate and energy goals, by reducing greenhouse gas emissions and enhancing energy security.

➜ **Directive (EU) No 2024/1788 on common rules for the internal markets for renewable gas, natural gas and hydrogen**

This directive establishes common rules for the internal markets of renewable gas, natural gas, and hydrogen within the EU. It aims to create a competitive and integrated market for renewable hydrogen, ensuring its production, distribution, and use are aligned with EU climate goals. The directive sets out frameworks for cross-border trade, infrastructure development, and market integration.

➜ **Regulation (EU) No 2024/1789 on the internal markets for renewable gas, natural gas and hydrogen**

This regulation establishes a common framework for the functioning of internal markets for renewable gas, natural gas, and hydrogen within the EU. Its objective is to facilitate the integration and development of renewable hydrogen markets while fostering a competitive, transparent, and efficient energy system. The regulation provides guidelines for cross-border trade, supports the development of dedicated infrastructure, and introduces sustainability criteria to ensure the reliable and environmentally responsible deployment of hydrogen across Member States.

➜ **Delegated Regulation (EU) No 2023/1184 on establishing methodology setting out detailed rules for the production of renewable liquid and gaseous transport fuels of non-biological origin**

This delegated regulation supplements Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources by establishing a standardized methodology for the production of renewable liquid and

gaseous transport fuels of non-biological origin (RFNBOs), including renewable hydrogen. It defines clear criteria for hydrogen to be classified as renewable, ensuring it is produced by using renewable electricity. The regulation also introduces the additionality principle, which requires that renewable hydrogen production does not compete with existing renewable energy supply but is instead supported by additional renewable energy capacity. To align with EU climate goals, the regulation sets strict greenhouse gas reduction requirements for renewable hydrogen production. It also establishes a certification and compliance framework to verify the renewable origin of hydrogen and ensure consistency across EU Member States. By providing these rules, the regulation enhances the credibility, transparency, and sustainability of renewable hydrogen, supporting the EU's transition toward a climate-neutral economy.

➜ **Delegated Regulation (EU) No 2023/1185 establishing a minimum threshold for greenhouse gas emissions savings of recycled carbon fuels and by specifying a methodology for assessing greenhouse gas emissions savings from renewable liquid and gaseous transport fuels of non-biological origin and from recycled carbon fuels**

This delegated regulation supplements Directive (EU) 2018/2001 by setting a minimum threshold for greenhouse gas (GHG) emissions savings for recycled carbon fuels. It also establishes a methodology for assessing GHG emissions savings from liquid and gaseous transport RFNBOs, including renewable hydrogen. This regulation defines the minimum emissions reduction required for recycled carbon fuels to be considered as sustainable alternative under EU climate policies. It also provides a standardized methodology for calculating GHG emissions savings from renewable hydrogen and other RFNBOs, ensuring consistent assessment across EU Member States. By implementing clear sustainability criteria, the regulation ensures that renewable hydrogen production and use contribute meaningfully to EU decarbonization efforts. This framework supports the transition to a climate-neutral economy while maintaining transparency and accountability in hydrogen and alternative fuel markets.

➜ **Commission Delegated Regulation (EU) of 8.7.2025 specifying a methodology for assessing greenhouse gas emissions savings from low-carbon fuels**

This delegated regulation is currently being developed to set specific standards and guidelines for the production and use of low-carbon hydrogen, supporting the EU's transition to a climate-neutral energy system.

National level

➜ ***Loi du 31 mars 2025 relative à l'établissement de réseaux de transport d'hydrogène***

The recently adopted law on the establishment of hydrogen transport networks marks a decisive step in implementing Luxembourg's National Hydrogen Strategy, adopted in 2021. This legislation underscores Luxembourg's commitment to the energy transition and decarbonization by establishing an initial legal framework for the planning, development, and operation of hydrogen transport infrastructure within the country, while ensuring integration with neighboring countries' networks. By facilitating the development of a European renewable hydrogen market, this initiative plays a crucial role in addressing climate challenges and reducing dependence on fossil fuels.

3.5.5 Standardization activities

Relevant technical committees and standards

➜ **ISO/TC 197 Hydrogen technologies**

Scope: Standardization in the field of systems and devices for the production, storage, transport, measurement and use of hydrogen.

➜ **IEC/TC 105 Fuel cell technologies**

Scope: To prepare international standards regarding fuel cell (FC) technologies for all FC types and various associated applications such as stationary FC power systems for distributed power generators and combined heat and power systems, FCs for transportation such as propulsion systems (see note below), range extenders, auxiliary power units, portable FC power systems, micro FC power systems, reverse operating FC power systems, and general electrochemical flow systems and processes.

➜ **ISO/TC 58 Gas cylinders**

Scope: Standardization of gas cylinders and other pressure receptacles, their fittings and requirements relating to their manufacture and use.

➜ **ISO/TC 220 Gas cryogenic vessels**

Scope: Standardization in the field of insulated vessels (vacuum or non-vacuum) for the storage and the transport of refrigerated liquefied gases of class 2 of "Recommendations on the Transport of Dangerous Goods - Model regulations - of the United Nations", in particular concerning the design of the vessels and their safety accessories, gas / materials compatibility, insulation performance, the operational requirements of the equipment and accessories.

➜ **CEN/CLC JTC 6 Hydrogen in energy systems**

Scope: Standardization in the field of systems, devices and connections for the production, storage, transport and distribution, measurement and use of hydrogen from renewable energy sources and other sources, in the context of the European strategy for the development and acceptance of the hydrogen market. The scope includes cross cutting items such as: terminology, Guarantee of Origin, interfaces, operational management, relevant hydrogen safety issues, training and education. It excludes storage and transport of liquid hydrogen which is covered in the scope of CEN/TC 268, storage and transport of compressed hydrogen which is covered in the scope of CEN/TC 23, and vehicle refueling stations and associated equipment and procedures as related to the standardization Request M/533. The injection of hydrogen and the mixture of hydrogen with natural gas (H2NG) in the gas infrastructure, which is covered in the scope of CEN/TC 234. The use of mixtures of natural gas with hydrogen (H2NG).

➜ **CEN/TC 23 Transportable gas cylinders**

Scope: Standardization of transportable gas cylinders, their fittings, and requirements relating to their design, testing and operation. The scope does not include LPG cylinder covered by CEN/TC 286 or non-refillable cartridges covered by CEN/TC 157. The scope does not include containers for cryogenic gases covered by CEN/TC 268.

Relevant technical standards supporting sector challenges

This section is intended to present examples of both published and ongoing standards that respond to the issues raised in section 3.5.2.

Hydrogen production and overall safety related

➜ **ISO 22734:2019 Hydrogen generators using water electrolysis — Industrial, commercial, and residential applications**

Abstract: This standard defines the construction, safety, and performance requirements of modular or factory-matched hydrogen gas generation appliances, herein referred to as hydrogen generators, using electrochemical reactions to electrolyse water to produce hydrogen.

➜ **ISO 22734-1:2025 Hydrogen generators using water electrolysis — Part 1: General requirements, test protocols and safety requirements**
This standard has been adopted at European level.

Abstract: This ongoing standard intends to define the construction, safety, qualification test and documentation requirements of modular or factory-matched hydrogen gas generation appliances or systems, herein referred to as hydrogen generators, using electrochemical reactions to electrolyse water to produce hydrogen.

➜ **ISO/TR 15916:2015 Basic considerations for the safety of hydrogen systems**

Abstract: This technical report provides guidelines for the use of hydrogen in its gaseous and liquid forms as well as its storage in either of these or other forms (hydrid). It identifies the basic safety concerns, hazards and risks, and describes the properties of hydrogen that are relevant to safety.

➜ **ISO/TS 19883:2017 Safety of pressure swing adsorption systems for hydrogen separation and purification**

Abstract: This technical specification identifies safety measures and applicable design features that are used in the design, commissioning, and operation of pressure swing adsorption systems for hydrogen separation and purification. It applies to hydrogen pressure swing adsorption systems that process all kinds of impure hydrogen streams as feed, including both stationary and skid-mounted pressure swing adsorption systems for hydrogen separation and purification in commercial or industrial use. This document also applies to small-scale PSA hydrogen system installed within containers, where allowed by local regulations.

➜ **ISO/TS 19870:2023 Hydrogen technologies — Methodology for determining the greenhouse gas emissions associated with the production, conditioning and transport of hydrogen to consumption gate**
This standard has been adopted at European level. This standard supports the European directive UE N° 2023/2413.

Abstract: This is a technical specification on methodologies for determining the GHG emissions associated with the production, conditioning, and transport of hydrogen. It provides a comprehensive framework for assessing the carbon footprint of hydrogen technologies, from well to delivery gate, covering all stages of the life-cycle analysis. This standard applies to activities related to production, storage, transport, and end use.

Hydrogen storage and transport infrastructure related (e.g. infrastructure production to storage/distribution center)

➜ **ISO 19881:2025 Gaseous hydrogen — Land vehicle fuel containers**

Abstract: This standard contains requirements for the material, design, manufacture, marking and testing of serially produced, refillable containers intended only for the storage of compressed hydrogen gas for land vehicle operation. These containers are permanently attached to the vehicle, have a capacity of up to 1 000 l water capacity, and have a nominal working pressure that does not exceed 70 MPa.

➜ **CEN/TS 17977:2023 Gas infrastructure — Quality of gas - Hydrogen used in rededicated gas systems**

Abstract: This technical standard defines the quality of gaseous hydrogen, i.e. its parameters and limiting values, to be transmitted, injected into and extracted from storages, distributed and utilized in fully and/or partially rededicated gas infrastructure and connected applications in a safe way. It further gives evidence to the end-user which minimum exit hydrogen quality can be expected and ensured from natural gas infrastructure as minimum requirement and without further purification.

➜ **ISO 17268:2020 Gaseous hydrogen land vehicle refuelling connection devices**

Abstract: This standard defines the design, safety and operation characteristics of gaseous hydrogen land vehicle (GHLV) refuelling connectors. GHLV refuelling connectors consist of the following components, as applicable: receptacle and protective cap (mounted on vehicle); nozzle; and communication hardware. It is applicable to refuelling connectors which have nominal working pressures or hydrogen service levels up to 70 MPa.

➜ **EN 17339:2020 Transportable gas cylinders — Fully wrapped carbon composite cylinders and tubes for hydrogen**

Abstract: This standard specifies minimum requirements for the materials, design, construction, prototype testing and routine manufacturing inspections of composite gas cylinders and tubes for compressed hydrogen.

➜ **ISO 11114-4:2017 Transportable gas cylinders — Compatibility of cylinder and valve materials with gas contents — Part 4: Test methods for selecting steels resistant to hydrogen embrittlement**
This standard has been adopted at European level in the frame of standardization request M/086.

Abstract: This standard specifies test methods and the evaluation of results from these tests in order to qualify steels suitable for use in the manufacture of gas cylinders (up to 3 000 l) for hydrogen and hydrogen bearing embrittling gases

➜ **ISO 13985:2006 - Liquid hydrogen — Land vehicle fuel tanks**

Abstract: This standard is expected to specify the construction requirements for refillable fuel tanks for liquid hydrogen used in land vehicles as well as the testing methods required to ensure that a reasonable level of protection from loss of life and property resulting from fire and explosion is provided. ISO/WD 13985 is under development to replace ISO 13985:2006.

Hydrogen End use (e.g. fuelling stations) related

➜ **ISO 19882:2025 Gaseous hydrogen — Thermally activated pressure relief devices for compressed hydrogen vehicle fuel containers**

Abstract: This standard specifies minimum requirements for pressure relief devices intended for use on hydrogen fuelled vehicle fuel containers that comply with various standards such as ISO 19881, IEC 62282-4-101.

➜ **ISO 19880 series Gaseous hydrogen — Fuelling stations**

- Part 1: 2020 General requirements
- Part 2: Dispensers and dispensing systems
- Part 3: 2018 Valves
- Part 5: 2019 Dispenser hoses and hose assemblies
- Part 7: Rubber O-rings
- Part 8: 2021 Fuel quality control
- Part 9: Sampling for fuel quality analysis
- Part 10: Mobile fueling stations

Abstract: Several parts of this standard define the minimum design, installation, commissioning, operation, inspection and maintenance requirements, for the safety, and, where appropriate, for the performance of public and non-public fuelling stations that dispense gaseous hydrogen to light duty road vehicles (e.g. fuel cell electric vehicles).

➜ **ISO 19885 series Gaseous hydrogen — Fuelling protocols for hydrogen-fuelled vehicles**

- Part 1: Design and development process for fuelling protocols
- Part 2: Definition of communications between the vehicle and dispenser control systems
- Part 3: High flow hydrogen fuelling protocols for heavy duty road vehicle

Abstract: Several parts of this standard address the design and development of fuelling protocols for compressed hydrogen gas dispensing to vehicles with compressed hydrogen storage of fuel as well as communication protocols between dispenser and vehicles.

➜ **ISO 26142:2010 Hydrogen detection apparatus — Stationary applications**

Abstract: This standard defines the performance requirements and test methods of hydrogen detection apparatus that is designed to measure and monitor hydrogen concentrations in stationary applications.

National involvement/activities on identified technical committees

Luxembourg is actively engaged in hydrogen-related standardization efforts by participating in key international and European technical committees. As of the writing of this report, three national experts from Luxembourg are officially registered as delegates in ISO/TC 197, and one expert is engaged in ISO/TC 58, ensuring the country's active representation in shaping international hydrogen standards. ILNAS holds P-member (participating member) status in ISO/TC 197, meaning it actively contributes to the development of standards rather than just observing the work of these committees.

At the European level, CEN-CLC JTC 6 - Hydrogen in Energy Systems, which develops standards supporting the integration of hydrogen into energy networks, including its use in industry, transport, and power generation, currently doesn't include any national experts. However, one expert is currently registered in CEN/TC 23.
In addition to its international and European participation, ILNAS expects to establish a dedicated National Standards Commission on hydrogen by year 2026. This commission would serve as a coordination platform for Luxembourgish stakeholders, including industry representatives, researchers, and policymakers, to engage them in the standardization process, contribute to ongoing developments, and ensure alignment with national priorities. Through this initiative, ILNAS seeks to strengthen Luxembourg's role in the standardization of hydrogen sector, facilitate the adoption of international standards at the national level, and support the country's transition toward a sustainable hydrogen economy.

Impact of standards on the national economy

Hydrogen technology is becoming a strategic pillar of the clean energy transition, and Luxembourg is actively developing its hydrogen ecosystem.

This emerging sector offers opportunities for small and medium-sized enterprises (SMEs), including craft enterprises, to engage across the value chain - from production to distribution and end-use applications. National initiatives such as LuxHyVal, ECHO-WAVE, and HY4Link illustrate this national development willingness by promoting green hydrogen production, innovative storage and distribution solutions, and hydrogen-powered logistics hubs. In this context, standards play a key role in supporting this development by ensuring safety, interoperability, and infrastructure compatibility across the hydrogen value chain. They provide clear technical guidance and enable conformity assessment, which is essential for building trust and facilitating market uptake.

For industrial stakeholders in Luxembourg, such as gas providers, standards are key to streamlining operations, improving safety, and ensuring compliance. In hydrogen deployment, standards also help to manage risks, support infrastructure integration, and speed up the adoption of new solutions.

For craft enterprises in Luxembourg, this transition may create new opportunities in areas such as metalwork, system installation, component manufacturing, and maintenance services. Access to harmonized standards helps these businesses to reduce technical uncertainty and to align with evolving market and regulatory expectations.

As Luxembourg advances its hydrogen roadmap, particularly in mobility, logistics, and cross-border infrastructure, robust and standards will be essential to ensure safe, interoperable, and scalable deployment.

3.6 Sustainable mobility

3.6.1 Background

Sustainable mobility refers to the transformation of transport systems from an ecological perspective, aiming to minimize fuel consumption and emissions while maintaining safe, efficient, and accessible mobility [57] [58], it applies to all modes of transport and mobility services, placing people at the center of its implementation [59]. In today's context of the environmental and societal urgency, the mobility sector must strike a careful balance between the resource demands of all transport users and the planet's regenerative capacity [60]. More globally, the goal of sustainable activities are to develop transport solutions that not only satisfy growing mobility demands but also promote long-term environmental sustainability, social inclusiveness, and economic resilience through smarter use of resources and innovation in green mobility sectors [61].

To meet these ambitions, sustainable mobility incorporates a broad and interconnected set of sub-domains that leverage innovation, digitalization, and advanced technologies to reshape the transport landscape [62]. This transformation goes beyond ecological benefits, offering wider societal and economic gains, such as improved public safety, greater efficiency, and inclusive access to transportation [61]. Smart mobility emphasizes the use of digital tools, real-time data analytics, and intelligent infrastructure to optimize mobility services, reduce environmental footprints, and improve user experience [63].

Key areas driving this transition include Intelligent Transport Systems (ITS) and connected mobility [62], which integrate technologies like sensors, GPS, vehicle-to-everything (V2X) communication, and adaptive traffic control to streamline transport operations, reduce congestion, and increase safety and efficiency across networks. Autonomous driving is another transformative area, harnessing artificial intelligence, machine learning, and advanced sensor systems to develop self-driving vehicles that can enhance safety, reduce energy consumption, and offer flexible, on-demand mobility options, particularly in regions underserved by conventional transport networks. Meanwhile, electromobility (e-mobility) plays a vital role in decarbonizing transport by encouraging the uptake of electric vehicles (EVs) from private cars to buses and micromobility solutions, such as e-bikes and scooters, powered increasingly by renewable energy sources [64]. This transition contributes not only to lower emissions and quieter urban environments, but also to enhanced energy independence and improved air quality. Together, these innovations lay the foundation for a sustainable and smart mobility ecosystem [65], one that tackles the environmental and resource-related challenges of today's transport systems while enhancing quality of life, supporting green economic growth, and ensuring that mobility is inclusive, efficient, and future-proof [66].

3.6.2 Challenges of the sector

The current transport and mobility sector faces several critical challenges that affect the environment, economy, and society [67]. Addressing these issues demands innovative solutions, including decarbonization strategies, technological advancements, and policy reforms, to create a sustainable and efficient mobility future [68] [69].

Transport Emissions and Environmental Pollution

Road transport remains one of the largest contributors to CO_2 emissions, with passenger cars and vans accounting for more than half of the sector's total output. These emissions not only accelerate global climate change but also degrade urban air quality, leading to respiratory and cardiovascular illnesses and imposing a significant burden on public health systems [70].

Road Congestion Increasing

Traffic congestion across urban and interurban networks results in lost productivity due to extended travel times and unpredictable journey durations. It also contributes to excessive fuel consumption, higher GHG emissions, and noise pollution [71]. The resulting delays and stress affect the quality of life for individuals and generate considerable economic costs for businesses and public services.

Inefficient Use of Resources and Infrastructure

Enhancing the efficiency and coordination of transport systems, by improving public transportation utilization, optimizing road network planning, and expanding access to mobility services, can significantly reduce energy waste, lower operational costs, and improve overall mobility effectiveness [61]. Addressing current imbalances offers an opportunity to strengthen the sustainability, inclusiveness, and resilience of transport infrastructure [72].

Safety and Security

Despite technological advancements, ensuring the safety and security of transport systems remains a persistent challenge. High accident rates, especially in road traffic, continue to cause injuries and fatalities [73]. Moreover, the rise of connected and smart mobility introduces new vulnerabilities, such as cyber threats targeting vehicle systems or digital infrastructure, which can compromise both passenger safety and logistics reliability [74].

3.6.3 Policies and strategies

European level

➜ **The European Sustainable and Smart Mobility Strategy**

The European Sustainable and Smart Mobility Strategy together with an action plan of several initiatives, sets out a roadmap to make Europe's transport system greener, smarter, and more resilient. It aims for a 90% reduction in transport-related greenhouse gas emissions by 2050, while boosting digitalization, intermodality, and the use of clean vehicles and fuels. The strategy includes 82 actions structured around key milestones for 2030, 2035, and 2050, supporting the broader goals of the European Green Deal. The strategy focuses on three main pillars:

- Sustainable mobility aims to reduce emissions by increasing the use of clean vehicles, alternative fuels, and public transport. It also promotes shifting passengers and freight to rail and inland waterways and improving urban mobility through active modes like walking and cycling.
- Smart mobility emphasizes the role of digitalization, automation, and data sharing. It supports the development of Mobility-as-a-Service (MaaS) platforms, connected and automated transport systems, and the use of AI and data to enhance logistics and traffic management.
- Resilient mobility focuses on strengthening transport systems to withstand crises, improving multimodal networks and supply chain reliability, and ensuring fair working conditions and social sustainability within the sector.

➜ The EU Urban Mobility Framework

The EU Urban Mobility Framework sets out a comprehensive approach to help cities to tackle urban transport challenges and transition toward more sustainable, efficient, and inclusive mobility systems. It promotes active modes of transport such as walking and cycling, encourages the development of shared mobility services, and supports the integration of digital solutions. The overarching goal is to improve quality of life by addressing air pollution, congestion, accessibility gaps, and road safety issues.

A key measure is the prioritization of public and active transport, including reallocation of road space and improved infrastructure. The framework supports the shift to zero-emission urban logistics, through incentives for electric delivery vehicles, optimized last-mile delivery, and urban consolidation centers. Cities are encouraged to adopt Sustainable Urban Mobility Plans (SUMPs) that align with EU climate and digitalization goals. Improved multimodality is another focus, promoting seamless connections between transport modes through Mobility-as-a-Service (MaaS) platforms and integrated ticketing. The framework emphasizes digital innovation, including smart traffic management and real-time data use to enhance efficiency and reduce emissions. To enhance safety and inclusion, the framework supports the Vision Zero approach and calls for improved access for persons with disabilities. Decarbonizing urban fleets, such as buses, taxis, and ride-hailing services, is also a priority, alongside the introduction of low- and zero-emission zones. These coordinated measures aim to increase the share of sustainable transport modes while fostering a climate-neutral, people-centered urban mobility system.

➜ Trans-European Transport Network (TEN-T)

The Trans-European Transport Network (TEN-T) is the EU's flagship initiative to develop a comprehensive, integrated, and multimodal transport infrastructure across Europe. Its objective is to connect all EU Member States, both centrally and peripherally, through a seamless network of railways, roads, inland waterways, ports, airports, and logistics terminals. It is structured around two layers: the Core Network, to be completed by 2030, and the Comprehensive Network, by 2050. These layers aim to ensure efficient, safe, and sustainable movement of goods and people across the EU.

The initiative promotes modal shift from road to rail and waterways, cross-border connectivity, and interoperability between national networks. It also integrates sustainability goals, supporting low-emission mobility, alternative fuels infrastructure, and digital transport services. TEN-T plays a central role in economic cohesion, climate action, and strengthening the EU single market through improved accessibility and connectivity.

National level

➜ The National Mobility Plan 2035 of Luxembourg

The national mobility plan 2035 Luxembourg aligns closely with the European Sustainable and Smart Mobility Strategy, contributing to the broader European goals of decarbonizing transport, reducing emissions, and improving efficiency of the transport system. This comprehensive strategy addresses current and future mobility needs in Luxembourg while ensuring that the country remains on track to meet its climate and sustainability objectives. The plan builds on Luxembourg's Modu 2.0 strategy for sustainable mobility, which proactively anticipates future mobility needs to ensure long-term, forward-thinking solutions — moving beyond simply reacting to present-day challenges. The goal of the plan is to create a sustainable, efficient, and smart transport system that benefits both Luxembourg and the broader European mobility landscape, making it easier for people to travel while reducing environmental impacts and improving overall quality of life. Key elements of Luxembourg's National Mobility Plan 2035 include:

- **Anticipating future mobility needs:** By moving from a reactive approach to a proactive one, the plan involves forecasting the number of people who will need to travel to specific locations and adapting transport modes to meet these demands. This forward-looking approach ensures that the mobility system can handle increasing numbers of trips and adapt to changing needs over time.
- **Engaging stakeholders:** The plan involves the collaboration of four main stakeholders: the State, municipalities, employers, and citizens. This multi-stakeholder approach ensures that all parties are involved in the process of designing, implementing, and evaluating the mobility system, promoting shared responsibility for its success.
- **Decarbonization and energy savings:** One of the central goals of the mobility plan is to reduce the carbon footprint of the transport sector, focusing on decarbonization through the adoption of electric vehicles (EVs), hydrogen, and other alternative fuels. The plan aims to achieve significant reductions in transport-related emissions while enhancing energy efficiency.
- **Improving quality of life in urban areas:** With a focus on enhancing mobility in urban areas, the plan addresses issues such as traffic congestion, pollution, and public transport access, promoting more sustainable, efficient, and accessible transport solutions that improve the quality of life for citizens.
- **Cost efficiency and modal share:** The plan emphasizes increasing the modal share of public transport, cycling, and walking, reducing the reliance on private cars. This aligns with Luxembourg's broader objectives of enhancing fiscal efficiency by promoting solutions that provide transport services of comparable quality at lower cost, alongside tools that increase transparency of mobility-related costs and benefits.

In addition to these priorities, Luxembourg's National Mobility Plan 2035 supports the wider European initiative of smart and connected mobility, digitalization, and the integration of emerging technologies. It promotes a sustainable, integrated transport network that can efficiently handle future challenges while contributing to Europe's transition to a greener, more connected mobility ecosystem.

3.6.4 Legal frameworks

European level

Several directives and regulations focus on making the transport sector more sustainable within the EU. These aim to reduce emissions, improve efficiency, and promote green technologies. Several of these ones are listed here below:

➜ **Directive (RED II) (EU) No 2018/2001 on renewable energy**

This directive promotes the use of renewable energy in transport, aiming for a greener, low-carbon transport sector by increasing the share of renewable fuels like biofuels, renewable electricity, and hydrogen. The directive sets a binding target of at least 14% renewable energy in the transport sector by 2030, encouraging innovation, investment, and the decarbonization of mobility systems. It also supports the development of advanced biofuels and renewable fuels of non-biological origin (RFNBOs) such as green hydrogen, aligning with the EU's broader climate neutrality objectives.

➜ **Directive (EU) No 2019/1161 on clean vehicles**

This directive sets requirements for public procurement to prioritize the purchase of clean, energy-efficient vehicles, with a particular focus on electric and hydrogen-powered models. By encouraging public authorities to lead by example, it supports the decarbonization of public transport fleets across Europe, fosters market demand for sustainable vehicle technologies, and contributes to the EU's broader climate and air quality objectives.

➜ **COM (2021) 563 final - Proposal for a COUNCIL DIRECTIVE restructuring the Union framework for the taxation of energy products and electricity**

This proposal of directive aims to revise the EU's tax framework and to promote the use of clean and renewable fuels by imposing higher taxes on fossil fuels. It incentivizes the adoption of sustainable energy sources in transport, including biofuels and electricity, helping to reduce greenhouse gas emissions and support the transition to a low-carbon mobility system aligned with the EU's climate goals.

➜ **Regulation (EU) No 2019/1242 on CO_2 emission standards for heavy-duty vehicles**

This regulation sets binding CO_2 emission reduction targets for new heavy-duty vehicles (HDVs) in the EU, aiming to reduce the climate impact of freight and commercial transport. It requires a 15% emissions cut by 2025 and 30% by 2030 compared to 2019/2020 levels, with incentives for zero- and low-emission vehicles (ZLEVs). The regulation applies to large trucks over 16 tonnes and uses the VECTO tool for monitoring emissions and fuel consumption. Manufacturers would face financial penalties for non-compliance. In 2024, the regulation was revised to introduce stricter targets up to 2040 and a zero-emission mandate for urban buses by 2035. It supports the EU's goal of climate neutrality by 2050.

➜ **Regulation (EU) No 2020/852 on taxonomy**

This regulation establishes a comprehensive classification system to define what qualifies as environmentally sustainable economic activities. It guides public and private investments towards low-carbon transport solutions, including electric and hydrogen vehicles, by providing clear criteria for sustainability. It helps channel funding into projects that significantly contribute to climate mitigation and adaptation, fostering transparency and encouraging a shift toward greener transport technologies and infrastructure across the EU.

➜ **Regulation (EU) No 2019/631 on CO_2 emission standards for cars and vans**

This regulation sets mandatory CO_2 emission limits for new passenger cars and vans sold within the EU, promoting the shift towards electric, hybrid, and other low-emission vehicles. Its objective is to significantly reduce the carbon footprint of the automotive industry by encouraging manufacturers to develop cleaner technologies and accelerate the transition to zero- and low-emission mobility, contributing to the EU's climate and air quality goals.

➜ **Regulation (EU) No 2023/1804 on deployment of alternative fuels infrastructure**

This regulation aims to significantly expand and enhance the network of infrastructure for electric and hydrogen vehicles across Europe. By improving the availability and accessibility of charging and refueling stations, it accelerates the adoption of alternative fuels, supports the transition to sustainable mobility, and helps ensure the EU meets its ambitious climate and energy targets.

➜ **Regulation (EU) No 2021/1119 on European Climate**

This regulation establishes a legally binding target for the European Union to achieve climate neutrality by 2050. It directly impacts the transport sector by requiring the accelerated adoption of low-emission vehicles and the increased use of sustainable fuels. It drives policy and regulatory measures aimed at decarbonizing transport, fostering innovation in clean mobility technologies, and supporting the transition to a climate-resilient and environmentally sustainable transport system across the EU.

National level

Currently, there is no specific regulation in this area at national level.

3.6.5 Standardization activities

Relevant technical committees and standards

➜ **ISO/TC 268/SC 2 Sustainable Cities and Communities — Sustainable Mobility and Transportation**

Scope: Standardization in the field of sustainable mobility and transportation to promote and support a multi-sectorial integrated approach of sustainable cities and communities with a long-term vision based on the purposes of sustainability defined in ISO 37101. It covers organizational issues, infrastructures and services in the mobility and transportation options for cities and communities, including those related to new technologies (i.e. electric, hydrogen, autonomous driving). This committee aims at providing: requirements, frameworks, guidance and supporting techniques and tools for cities and territories, as well as all mobility and transportation stakeholders to plan, develop, operate, maintain and manage sustainable mobility and transportation systems and services with a long-term vision.

➜ **ISO/TC 204 Intelligent transport systems**

Scope: Standardization of information, communication and control systems in the field of urban and rural surface transportation, including intermodal and multimodal aspects thereof, traveller information, traffic management, public transport, commercial transport, emergency services and commercial services in the intelligent transport systems (ITS) field.

➜ **ISO/TC 22/SC 37 Electrically propelled vehicles**

Scope: Specific aspects of electrically propelled road vehicles, trailers using voltage class B, electric propulsion systems, related components, body builder equipment and their vehicle integration.

➜ **CEN/TC 278 Intelligent Transport Systems**

Scope: Standardization in the field of intelligent transport systems, encompassing services and techniques to achieve road safety, environmental sustainability and traffic efficiency, and to improve the travel experience applying information and communication technologies between vehicles, infrastructure or other road users. The following topics are considered: Aspects of cooperation (C-ITS); Inter-modality and multimodality; traffic, public transport and parking management; mobility- information, integration and as a service; systems and services for vulnerable road users; ITS services for automated vehicles; user fee collection; etc.

➜ **ETSI/TC ITS Intelligent Transport Systems**

Scope: Standardization to support the development and implementation of Intelligent Transport Systems (ITS) service provision across the network, for transport networks, vehicles and transport users, including interface aspects, multiple modes of transport and interoperability between systems:

- communication media, and associated physical layer, transport layer, network layer, security, lawful intercept, and the provision of generic web services;
- development of conformance test specifications which are crucial for the commercial deployment of the technology and are closely involved in radio spectrum requirements for ITS.

Relevant technical standards supporting sector challenges

This section is intended to present examples of both published and ongoing standards that respond to the issues raised in section 3.6.2.

Environmental oriented and alternative energy source

➜ **ISO 37182:2022 Smart community infrastructures — Smart transportation for fuel efficiency and pollution emission reduction in bus transportation services**

Abstract: This standard describes criteria to organize smart transportation to save fuel in bus transportation services where the reduction of energy consumption is intended. Smart transportation aims not only at fuel efficiency, but at pollutant emission reduction for engine driven buses, as well as the financial stabilization of bus transportation services for citizens and city visitors

➜ **CEN/TS 17378:2019 Intelligent transport systems — Urban ITS — Air quality management in urban areas**
This standard has been developed in the frame of standardization request M/546. It supports the European directive 2008/50/EC and directive 2010/40/EU.

Abstract: This standard provides information, guidance and specifications of requirements and options on how to set up an air quality (emissions) management policy, and how to deploy reliable and scalable technologies to monitor air quality on a continuous or regular basis, and to react with adequate measures. This provides a means to measure the air quality required by relevant EU directives.

➜ **ISO 37162:2023 Smart community infrastructures — Smart transportation for newly developing areas**

Abstract: This standard specifies a procedure to arrange smart transportation for newly developing areas, including transportation services between the developing area and existing city centres.

➜ **ISO/TR 16497-1:2024 Sustainable mobility and transportation — Sustainable mobility services — Part 1: Use cases**

Abstract: This technical report compiles use cases for the implementation of sustainable mobility services. The collected data will be analysed to identify issues for international standardization. It focuses on use cases that aim to implement sustainable transport services. The use cases considered are at the city scale or metropolitan scale, aligned with the scope of smart cities and communities. The use cases encompass land transport, water transport, and air transport for both passengers and freight. Ideas related to connection and integration, including demand-side, supply-side, and policy framework aspects, are included.

Efficient use of resources and infrastructure related

➜ **ISO 37181:2022 Smart community infrastructures — Smart transportation by autonomous vehicles on public roads**

Abstract: This standard describes the concept and goals of smart transportation by autonomous vehicles on public roads. It provides guidelines for the successful introduction and organization of autonomous vehicles, with the aim of enhancing the safety of public road transportation and addressing the challenges to cities such as an aging population and diverse travel demands.

➜ **ISO/TR 4445:2021 Intelligent transport systems — Mobility integration — Role model of ITS service application in smart cities**

Abstract: This technical report describes a basic role model of smart city intelligent transport systems (ITS) service applications as a common platform for smart city instantiation, directly communicating via secure ITS interfaces.

➜ **ISO 37168:2022 Smart community infrastructures — Guidance on smart transportation by Electric, Connected and Autonomous Vehicles (eCAVs) and its application to on-demand responsive passenger services with shared vehicles**

Abstract: This standard provides guidance on the staged implementation of Electric, Connected and Autonomous Vehicle (eCAV) passenger and delivery services, with a special focus on on-demand responsive passenger services with shared vehicles. This document aims to accelerate innovation and deliver smart transportation by eCAV, in and between cities.

➜ **ISO/TS 4398:2022 Intelligent transport systems — Guided transportation service planning data exchange**

Abstract: This technical specification specifies an open, XML-based data format which enables an efficient and unambiguous exchange of static information concerning the operational functionality of the infrastructure, rolling stock and timetable of a track-bound transportation system. The main objective is to enable heterogeneous applications to communicate with each other.

Safety and Security related

➜ **ETSI TS 102 941 (2022-11) Intelligent Transport Systems (ITS); Security; Trust and Privacy Management**

Abstract: This technical specification specifies the trust and privacy management for Intelligent Transport Systems (ITS) communications. Based upon the security services defined in ETSI TS 102 731 and the security architecture defined in ETSI TS 102 940, it identifies the trust establishment and privacy management required to support security in an ITS environment and the relationships that exist between the entities themselves and the elements of the ITS reference architecture defined in ETSI EN 302 665.

➜ **ISO 6469-1:2019 Electrically propelled road vehicles — Safety specifications — Part 1: Rechargeable energy storage system (RESS)**

Abstract: This standard specifies safety requirements for rechargeable energy storage systems (RESS) of electrically propelled road vehicles for the protection of persons.

➜ **ISO TS 5616:2024 Intelligent transport systems — Secure interfaces governance**

Abstract: This technical specification specifies the minimum governance procedure requirements for ITS data management and access using secure interfaces (particularly, secure vehicle interfaces) in order to meet objectives in accordance with the principles of ISO/TC 204 policy documents concerning ITS data governance policy.

National involvement/activities on identified technical committees

Luxembourg is highly engaged in sustainable related standardization efforts by participating in key international and European technical committees. As of the writing of this report, 3 national experts from Luxembourg are registered as delegates in ISO/TC 268/SC 2 subcommitee and its parent technical committee, ISO/TC 268, ensuring the country's representation in shaping international sustainable mobility standards.

At the European level, in CEN/TC 278 Intelligent Transport, which develops standards supporting the road safety, environmental sustainability and traffic efficiency, no national delegate is currently registered, at the time of writing this report.

Impact of standards on the national economy

Sustainable mobility is expected to reshape how Luxembourg's SMEs operate, particularly in transport and logistic sectors. While the upfront cost of electric or hydrogen vehicles remains high, long-term savings and government incentives, such as the Klimabonus, co-financing schemes, and SME Sustainability Packages, support the transition. As national and EU infrastructure for charging and hydrogen expands, new business opportunities emerge in eco-logistics, smart transport services, and fleet management.

Standards are essential to this transition, ensuring safety, efficiency, and interoperability across transport systems. They provide a common framework for deploying electric vehicles, intelligent transport systems (ITS), and charging infrastructure, enabling smoother traffic flow and cleaner urban environments. National initiatives like Chargy and SuperChargy benefit from European standards that ensure cross-border compatibility of charging systems.

In public transport, standards for ITS and telematics, such as those applied in the GloTel upgrade, enhance service reliability and integration across operators. Harmonized standards also support compliance with EU CO_2 regulations by enabling transparent and comparable performance data. For communes and bus companies in Luxembourg, these standards create opportunities to improve fleet management, optimize route planning, and deliver real-time passenger information. For craft enterprises and SMEs in Luxembourg, this evolving mobility landscape offers opportunities in vehicle retrofitting, charging station installation, electrical works, and maintenance services. Access to clear and harmonized standards helps these businesses align with market needs, reduce technical barriers, and contribute to a more sustainable transport ecosystem.

3.7 Green ICT

3.7.1 Background

The accelerating adoption of digital technologies is reshaping every aspect of modern life, driving higher expectations for speed, performance, and service quality. This evolution, while driving technological progress, also contributes to rising energy consumption, increasing demand for natural resources, and a growing volume of electronic waste [75]. In this context, Green ICT (Information and Communication Technology) refers to the environmentally responsible design, use, and end-of-life management of digital technologies. Its main objective is to reduce the ecological footprint of ICT systems throughout their lifecycle, from production and operation to reuse, recycling, or environmentally sound disposal, while supporting, innovation, and economic resilience [76].

To achieve this, Green ICT relies on a combination of technical practices, which directly reduce environmental impacts, and strategic enablers, which support the widespread and effective adoption of these practices.

At the technical level, several key areas contribute to the sustainability of ICT systems [77]:

- **Energy-efficient hardware and infrastructure:** Sustainable ICT begins with hardware that delivers high performance using less energy. Eco-design principles applied early in product development reduce raw material use and minimize electronic waste.
- **Software optimization:** Efficient software significantly reduces energy consumption. Poorly optimized applications can increase CPU load and data usage. In contrast, well-designed software uses fewer resources and improves hardware efficiency.
- **Cloud computing and virtualization:** Moving to cloud environments enables better use of physical infrastructure. Virtualization and resource pooling allow dynamic scaling, minimize idle capacity, and reduce energy consumption while maintaining service quality.
- **Circular economy and lifecycle management:** Green ICT promotes repair, reuse, and recycling of equipment instead of disposal. Lifecycle assessments help evaluate environmental impact at each stage and guide the design of more sustainable products.

However, technical developments alone are not sufficient [78]. Their success relies on a broader enabling ecosystem that includes public policies, technical standards, legal frameworks, and innovation initiatives, as further discussed in sections 3.7.3, 3.7.4 and 3.7.5 of this report. These enablers play a crucial role in defining sustainability goals, providing financial and regulatory incentives, and ensuring consistent implementation across sectors.

At the same time, putting Green ICT principles into practice remains a complex task shaped by a combination of technical, financial, and organizational challenges. These are outlined in the following section.

3.7.2 Challenges of the sector

While Green ICT offers a promising pathway toward environmental sustainability in the digital domain, its implementation is not without obstacles. Several technical, financial, and organizational challenges continue to limit its widespread adoption:

- **Complexity of ICT infrastructure design**: Building energy-efficient infrastructures requires managing many interdependent components. This includes power distribution, cooling systems, server design, and physical layout. Such integration demands specialized expertise and planning [79].
- **Growing energy demands from technology**: Technological progress increases energy use. New telecommunication networks and the rapid expansion of connected devices such as those in the Internet of Things contribute to the sector's growing energy footprint [80].
- **Resource optimization challenges**: Maximizing hardware utilization, particularly in data centers, is challenging. Efficient use of servers must be complemented by well-optimized software to avoid wasting resources [81].
- **E-waste and lifecycle management:** Short device lifespans and fast technological turnover generate large volumes of electronic waste. Effective management requires better durability, repair options, recycling systems, and supportive regulation [82].

3.7.3 Policies and strategies

Efforts related to Green ICT at both the European and national levels are supported by a set of strategic roadmaps, policy programmes, voluntary industry commitments, and financial instruments. While these initiatives are not legally binding, they play a crucial role in shaping the direction of digital sustainability efforts and creating a favorable environment for regulatory implementation and innovation.

European level

➜ **EU Digital Decade Policy Programme 2030**

The EU Digital Decade Policy Programme 2030, adopted in 2022, sets out the European Union's shared vision for the digital transformation of Europe by the year 2030. It defines concrete objectives in four key areas: digital skills, digital infrastructure, digitalisation of businesses, and digitalisation of public services. Sustainability is not treated as a separate pillar but is embedded as a cross-cutting priority throughout all dimensions of the digital transition. This approach reflects the EU's broader commitment to align its digital strategy with the goals of the European Green Deal and achieving climate neutrality by 2050.

The programme promotes climate-neutral and energy-efficient digital infrastructures, especially in data centers and cloud services. It encourages green ICT innovation, environmentally responsible hardware sourcing and recycling, and the deployment of digital solutions that reduce emissions in various sectors, such as smart mobility, agriculture, and energy management.

Member States are required to integrate environmental considerations into national digital strategies. Investments must align with circular economy principles and Sustainable Development Goals. Progress is tracked through Digital Decade Country Reports, providing a governance tool for performance monitoring and coordination across the EU.

➜ **Circular Economy Action Plan 2020**

Part of the European Green Deal, the Circular Economy Action Plan (CEAP) sets a long-term strategy to reduce resource use and waste generation. Electronics and ICT are key target sectors due to their short product lifespans and high e-waste impact.

CEAP introduces measures such as Digital Product Passports, which provide standardized environmental information to support repair, reuse, and recycling. The plan also promotes the "right to repair" by ensuring access to spare parts and repair information. These efforts aim to reduce e-waste, enhance material efficiency, and support a circular digital economy.
More details about the Circular Economy Action Plan 2020 are presented in the section Circular Economy (section 3.3).

National level

Luxembourg has actively integrated environmental sustainability into its digital development agenda, aligning closely with the objectives of the European Digital Decade Programme 2030. The country's strategic vision for Green ICT is reflected in a series of public frameworks and innovation programmes aimed at reducing the ecological footprint of digital infrastructures while supporting broader climate and energy goals.

➜ **Luxembourg Digital Decade Strategic Roadmap**

A key component of this approach is the Luxembourg Digital Decade Strategic Roadmap, which sets out national priorities and commitments in line with the EU's 2030 Digital Compass. While sustainability is treated as a cross-cutting enabler, the roadmap includes concrete measures that support environmentally responsible digital transformation. In the area of digital infrastructure, the roadmap promotes the deployment of energy-efficient data centers and cloud services, aiming to reduce the environmental impact of growing data demands.

These actions show Luxembourg's commitment to ensuring that its digital transformation contributes not only to innovation and competitiveness but also to climate goals and responsible resource use.

3.7.4 Legal frameworks

European level

➜ **Commission Regulation (EU) 2019/424 on laying down ecodesign requirements for servers and data storage products**

Adopted on 15 March 2019, the Commission Regulation (EU) 2019/424 establishes ecodesign requirements for servers and online data storage products placed on the EU market. The goal of this regulation is to reduce energy and resource consumption by requiring compliance with energy performance thresholds and transparency obligations.

The regulation applies to a wide range of servers and storage equipment, excluding categories such as large, fault-tolerant, and embedded servers. It sets technical specifications for energy efficiency, including minimum power supply unit (PSU) efficiency and limits on energy use.

Beyond energy, it supports material efficiency by requiring easier product disassembly and disclosure of critical raw materials in components. Manufacturers must also provide detailed technical documentation covering energy use, material composition, maintenance, and end-of-life instructions. This regulation is one of the first EU instruments addressing ICT infrastructure sustainability and supports the goals of the Circular Economy Action Plan and the European Green Deal.

➜ **Commission Regulation (EU) 2024/1781 on the Ecodesign for Sustainable Products (ESPR)**

The ESPR creates a broad legal framework to improve the environmental performance of most physical goods in the EU, including ICT products such as smartphones, laptops, tablets, and servers. It introduces binding requirements for durability, reparability, upgradability, energy efficiency, and circularity. For ICT, this marks a shift toward lifecycle-based design and circular principles. More details about the regulation are provided in the Circular Economy section.

➜ **Directive (EU) 2023/1791 on energy efficiency**

Adopted on 13 September 2023, Directive (EU) 2023/1791 is the revised version of the EU Energy Efficiency Directive, and forms a key pillar of the European Union's "Fit for 55" package and REPowerEU plan. It sets a legally binding target to reduce EU energy consumption by 11.7% by 2030, compared to projections made in 2020.

It reinforces the "energy efficiency first" principle and includes digital infrastructure, especially data centers, in its scope. Under Article 12, operators of data centers with IT loads above 500 kW must report annually on key energy performance indicators (such as total energy use, power usage effectiveness, energy reuse, and cooling performance) to an EU database, ensuring transparency and benchmarking.

The directive also mandates a 1.9% annual energy consumption reduction in the public sector, compulsory renovations of public buildings, extended industrial audits, and targeted actions against energy poverty. Including data centers aligns digital infrastructure with the EU's decarbonization and efficiency goals.

National level

Currently, there is no specific regulation in this area at national level.

3.7.5 Standardization activities

In the context of Green ICT, standardization plays a crucial role in ensuring consistency, interoperability, and enhanced environmental performance across the digital ecosystem. By establishing common technical specifications, measurement methods, and sustainability criteria, standards enable manufacturers, service providers, and policymakers to align their practices with climate objectives and the principles of circular economy. These standards are developed at international, European, and national levels by organizations such as ISO, IEC, CEN, CENELEC, ITU, and ETSI.

Standardization supports the implementation of ecodesign principles, energy efficiency measures, and responsible resource use throughout the ICT lifecycle from product development and deployment to end-of-life management. Moreover, it facilitates compliance with evolving regulatory frameworks while promoting innovation and transparency. This section highlights key standardization efforts that contribute to the greening of ICT infrastructure and services, with a focus on data centers, electronic devices, and energy-efficient digital systems.

Relevant technical committees and standards

Many international and European standardization organization are proposing initiatives to address green ICT challenges. The corresponding technical committees and standards on energy management and energy savings are listed in the Energy efficiency section. (section 3.2)

➜ **ISO/IEC JTC 1/ SC 39 Sustainability, IT and data centres**

Scope: Responsible for standardization of assessment methods, design practices, operation and management aspects to support resource efficiency, resilience and environmental sustainability for and by information technology, data centres and other facilities and infrastructure necessary for service provisioning.

➜ **IEC/TC 100/TA 19 Environmental and energy aspects for multimedia systems and equipment**

Scope: To develop standards for power consumption, energy efficiency and environmental conscious design (ECD) aspects of audio, video, multimedia systems, personal computing systems, and related equipment. The scope includes specifying methods of measurement and software for testing (for example audio and video recordings).

➜ **ITU-T/SG 5 Environment, EMF & circular economy**

Scope: ITU-T Study Group 5 (SG5) is responsible for studies on methodologies for evaluating ICT effects on climate change and publishing guidelines for using ICTs in an eco-friendly way. Under its environmental mandate SG5 is also responsible for studying design methodologies to reduce ICTs and e-waste's adverse environmental effects, for example, through recycling of ICT facilities and equipment.

➜ **CENELEC/TC 215 Electrotechnical aspects of telecommunication equipment**

Scope: This committee addresses standardization in the field of electrotechnical aspects of telecommunication equipment and associated infrastructures. It prepares harmonized standards (EN, TS, or TR) covering both generic and application-specific telecommunications cabling (e.g. ISDN, LAN) across all types of premises. Its documents also include requirements and recommendations for building infrastructure to support effective installation and operation of telecommunications systems. By enabling efficient and future-ready cabling systems, the work of TC 215 contributes to reducing energy losses and supporting sustainable ICT infrastructure deployment.

➜ **ISO/IEC JTC 1/SC 7 Software and systems engineering**

Scope: ISO/IEC JTC 1/SC 7 addresses standardization of processes, supporting tools and supporting technologies for the engineering of software products and systems. Currently, within this subcommittee, Ad hoc Group 10 (AhG 10) is dedicated to green software, exploring how software engineering standards can support environmental sustainability. The group focuses on identifying standardization needs related to energy efficiency, carbon awareness, and sustainable software development practices.

Relevant technical standards supporting sector challenges

This non-exhaustive list presents key international and European standards that, while not always explicitly labeled as "green," support the development of environmentally responsible ICT infrastructures through better design, energy efficiency, resource optimization, and circular economy practices.

Complexity of ICT infrastructure design

➜ **EN 50174 series Cabling Installation Standards**
Although not sustainability standards, these contribute indirectly to environmental goals by promoting high-quality, durable, and efficient installations.

➜ **EN 50174-1:2018 Information technology — Cabling installation — Part 1: Installation specification and quality assurance**

Abstract: Outlines general requirements for installation specification and quality assurance, applicable to all types of premises.

➜ **EN 50174-2:2018 Information technology — Cabling installation — Part 2: Planning and installation practices inside buildings**

Abstract: focuses on planning and installation practices inside buildings, addressing aspects such as safety, electromagnetic compatibility (EMC), and coordination with other building systems.

➜ **EN 50174-3:2013/A1:20217 Information technology — Cabling installation — Part 3: Planning and installation outside buildings**

Abstract: covers installation practices outside buildings, including external ducts, buried cables, and campus environments, with a strong emphasis on environmental protection.

➜ **EN 50600 series Data Centre Facilities and Infrastructure**
These standards promote energy-efficient design, optimized resource use, and long-term operational sustainability in data centres.

➜ **EN 50600-2-1:2021 Information technology — Data centre facilities and infrastructures — Part 2-1: Building construction**

Abstract: addresses the building construction aspects, including site selection, structural desgn, and space allocation.

➜ **EN 50600-2-2:2019 Information technology — Data centre facilities and infrastructures — Part 2-2: Power supply and distribution**

Abstract: focuses on power supply and distribution, ensuring reliability and redundancy in energy systems.

➜ **EN 50600-2-3:2019 Information technology — Data centre facilities and infrastructures — Part 2-3: Environmental control**

Abstract: Covers environmental control, such as cooling, ventilation, and humidity regulation.

➜ **EN 50600-2-4:2023 Information technology — Data centre facilities and infrastructures — Part 2-4: Telecommunications cabling infrastructure**

Abstract: specifies the telecommunications cabling infrastructure.

➜ **EN 50600-2-5:2021 Information technology — Data centre facilities and infrastructures — Part 2-5: Physical security**

Abstract: sets requirements for physical security of critical ICT assets.

➜ **EN 50600-3-1:2016 Information technology — Data centre facilities and infrastructures — Part 3-1: Management and operational information**

Abstract: outlines the necessary management and operational information to support effective monitoring and maintenance.

Increased energy consumption from technological growth

➜ **ITU-T L.1320 Energy efficiency metrics and measurement for power and cooling for telecommunications and data centres**

Abstract: contains the general definition of metrics, test procedures, methodologies and measurement profiles required to assess the energy efficiency of power and cooling equipment for telecommunications and data centres.

➜ **ETSI TS 105 174 (2020-01) Broadband Deployment and Lifecycle Resource Management — Part 2: ICT sites: Implementation of energy and lifecycle management practices**

Abstract: Provides guidance for implementing energy and lifecycle management practices at ICT sites, such as data centres and telecom facilities. It supports operators in reducing energy consumption, improving resource efficiency, and applying sustainable practices throughout the equipment lifecycle.

➜ **ISO/IEC TR 30132-1:2016 Information technology sustainability — Energy efficient computing models — Part 1: Guidelines for energy effectiveness evaluation**

Abstract: The document establishes guidelines for improving the energy effectiveness for computing models. It provides

- a reference computing model for evaluating end-to-end energy effectiveness,
- a holistic framework for evaluating the applicability of energy effectiveness improving technologies, and
- guidelines for evaluating energy effectiveness.

Resource Optimization

➜ **ISO/IEC TR 30133:2023 Data centres — Practices for resource-efficient data centres**

Abstract: Describes generally applicable practices for improving the resource efficiency of data centres, regardless of their application. It emphasizes continuous improvement processes, designs, and guidelines focused on resource efficiency. The practices are technology-neutral and location-independent, covering planning, management, cooling, power, ICT, and cost aspects.

➜ **ITU-T L.1305 Data centre infrastructure management system based on big data and artificial intelligence technology**

Abstract: Specifies technical requirements for a data centre infrastructure management (DCIM) system using big data and AI. It covers principles, management objects, system schemes, data collection, energy saving, capacity management, intelligent control, maintenance, early alarms, and cost-reduction strategies for efficient and sustainable operations.

➜ **ISO/IEC 23544:2021 Data centres — Application Platform Energy Effectiveness (APEE)**

Abstract: Introduces the APEE Key Performance Indicator to evaluate the energy effectiveness of an application platform (IT equipment, OS, middleware) before deployment. Provides formulas, component definitions, and reporting requirements, helping organizations select energy-efficient IT stacks and reduce energy use in data centres.

➜ **CLC/TS 50600-5-1 Information technology — Data centre facilities and infrastructures — Part 5-1: Maturity Model for Energy Management and Environmental Sustainability**
This standard has been developed in the frame of standardization request M/462

Abstract: Offers a maturity model addressing energy management and environmental sustainability of data centre facilities and ICT equipment. Focuses on environmental viability through design, procurement, operation, and end-of-life. Implementation is based on practices from related CENELEC technical reports.

Lifecycle management

➜ **ETSI ES 203 199 (2025-01) Methodology for environmental Life Cycle Assessment (LCA) of Information and Communication Technology (ICT) goods, networks and services**

Abstract: Provides a methodology for conducting LCAs of ICT goods, networks, and services. Based on ISO 14040/14044, it includes ICT-specific requirements to ensure consistent and high-quality assessments across all life cycle stages, enabling objective evaluations of environmental impact.

➜ **ETSI TR 104 080 (2024-07) Environmental Engineering (EE) - Example of a Life Cycle Assessment (LCA) of a Mobile Phone**

Abstract: Demonstrates the application of ETSI ES 203 199 to a mobile phone. Assesses environmental impacts across the product's full life cycle, focusing on categories such as climate change and resource use. Serves as a practical guide for LCA implementation in the ICT sector.

➜ **ITU-T L.1000 Universal power adapter and charger solution for mobile terminals and other hand-held ICT devices**

Abstract: Specifies a universal charger solution for mobile phones and other handheld ICT devices. Covers interface compatibility, energy efficiency, safety, EMC, and environmental requirements to reduce charger waste.

➜ **ITU-T L.1010 Green battery solutions for mobile phones and other hand-held information and communication technology devices**

Abstract: Establishes ecodesign criteria for batteries used in mobile phones and handheld ICT devices to promote environmental friendliness and align with SG 5 initiatives.

➜ **ITU-T L.1020 Guide for operators and suppliers on approaches to migrate towards circular ICT goods and networks**

Abstract: Guides operators and suppliers in adopting circular economy principles such as: remanufacturing, recycling, and enhancing resource efficiency in ICT goods and networks.

➜ **ITU-T L.1022 Circular economy: definitions and concepts for material efficiency for information and communication technology**

Abstract: Establishes definitions, concepts, parameters, and material-efficiency metrics for ICT circularity, complementing L.1020.

➜ **ITU-T L.1023 Assessment method for circular scoring**

Abstract: Provides a quantitative method for evaluating ICT products' circular performance, enabling benchmarking against circular economy criteria.

National involvement/ activities on identified technical committees

In Luxembourg, national representation in technical committees covering green ICT remains limited, with seven national delegates involved. Participation includes the following committees:

- **ISO/IEC JTC 1/SC 39** Sustainability, IT and data centres
- **CENELEC/TC 215** Electrotechnical aspects of telecommunication equipment
- **ISO/IEC JTC 1/SC 7** Software and systems engineering

While participation is limited, these contributions are valuable for representing Luxembourg's interests and aligning with broader European and international goals on sustainable digitalization.

Impact of standards on the national economy

Luxembourg's digital economy, though supported by a limited number of data centres, is dynamic, particularly in software development, digital services, and innovation. Enterprises of all sizes contribute to the green transition by integrating digital tools into their processes. As digitalization advances, sustainability principles are increasingly embedded in the design and operation of digital systems, aligning with national environmental and digital goals.

Large enterprises, including data centre operators, use standards to monitor and improve their environmental performance in areas such as energy, water, resources, and end-of-life management. SMEs benefit from the same frameworks to improve efficiency, enhance competitiveness through alignment with international best practices, and access international markets. Craft enterprises gain indirect advantages through eco-design, responsible sourcing, and digital tools, and those active in the ICT value chain, such as cabling installers and electricians, apply standards to deliver safer and more efficient services.

In practice, all enterprises, from the smallest craft businesses to the largest data centre operators, benefit directly by adopting relevant standards and indirectly through digital tools that increasingly embed sustainability requirements. This combined impact strengthens environmental responsibility, economic performance, and the competitiveness of Luxembourg's digital economy.

3.8 E-waste

3.8.1 Background

E-waste, or electronic waste, refers to discarded electrical or electronic devices. This waste stream includes a wide range of products such as household appliances, office equipment, entertainment devices, lighting equipment, and more [83]. E-waste is one of the fastest-growing waste streams globally, driven by rapid technological advancements and shorter product lifespans [84].

E-waste contains both valuable and hazardous materials. Valuable materials include metals like gold, silver, and copper, which can be recovered and recycled. However, e-waste also contains hazardous substances such as mercury, lead, cadmium, etc. Improper disposal of e-waste can lead to severe environmental pollution and health risks. For instance, toxic substances can leach into soil and groundwater, posing risks to human health and ecosystems [85] [86].

The global generation of e-waste is substantial. In 2019, the world produced 53.6 million tonnes of e-waste, with only about 20% being recycled through proper channels. The improper handling and disposal of e-waste, including dumping and open burning, exacerbate environmental and health issues [86].

Effective e-waste management involves several key practices: decontamination, dismantling, recycling, and recovery of valuable materials [86]. The European Union (EU) has implemented regulations to improve the collection, treatment, and recycling of e-waste. Specifically, the Waste Electrical and Electronic Equipment (WEEE) Directive aims to enhance resource efficiency and support the circular economy by ensuring proper handling of e-waste [87]. Actions to help reduce the e-waste can be summarized like in Figure 8.

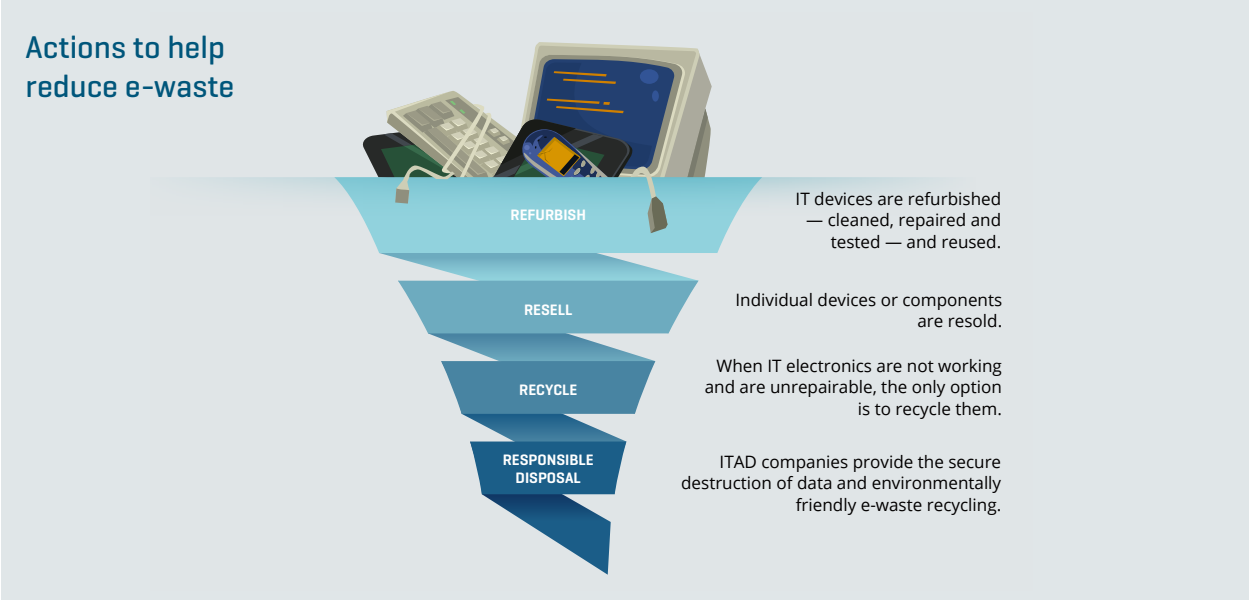

Figure 8 - Waste reduction activities

Sustainable e-waste management practices include the development of business models that focus on recovery and recycling. Innovations in technology and best practices can help reduce greenhouse gas emissions and prevent hazards to health and the environment. The concept of a circular economy is central to sustainable e-waste management, emphasizing the reuse, refurbishment, and recycling of electronic products [84] [88].

3.8.2 Challenges of the sector

Main challenges related to e-waste are as follows:

- **Presence of toxic substances**: E-waste contains hazardous materials such as lead, mercury, and cadmium. The toxic substances can leach into the environment, causing soil and water contamination [89] [90] [91].
- **Resource recovery:** E-waste contains a combination of valuable and hazardous materials making the recycling process complex and costly. Efficient recovery of valuable materials from e-waste is challenging, yet essential for economic value and environmental health [90] [91].
- **Health impacts**: Improper recycling practices, especially in informal sectors, expose workers and nearby communities to harmful chemicals. Children and pregnant women are particularly vulnerable to these toxic exposures [89].
- **Lack of infrastructure**: Many regions lack the necessary infrastructure for efficient e-waste recycling, leading to improper disposal, for example using unsafe methods like open burning and acid baths, and environmental contamination [89] [90]. Moreover, the recycling process can be expensive due to the need for specialized equipment and facilities to safely handle hazardous materials [90]. Another challenge is to integrate informal e-waste processors with formal recycling systems to ensure safe and efficient recycling practices [91].
- **Global e-waste generation**: The rapid increase in e-waste generation, with millions of tonnes produced yearly [89].
- **Awareness and education:** There is a general lack of awareness and education about the importance of proper e-waste recycling, contributing to the throw-away mentality [90].
- **Illegal trade**: A significant portion of e-waste is illegally traded or dumped, particularly in developing countries where it is not managed in an environmentally sound manner [91].

3.8.3 Policies and strategies

European level

➜ **Circular Economy Action Plan**

The Circular Economy Action Plan (CEAP), adopted in March 2020, is a key component of the European Green Deal. It aims to reduce pressure on natural resources and create sustainable growth and jobs. The plan includes measures to ensure that products are designed for durability, repairability, and recyclability, which directly impacts e-waste management. Specific actions target sectors with high potential for circularity, such as electronics and ICT. This includes promoting circular economy processes and sustainable consumption to keep resources in the EU economy for as long as possible.

➜ **Zero Waste Europe**

Zero Waste Europe (ZWE) is an initiative dedicated to promoting sustainable waste management practices across Europe, advocating for a circular economy where resources are reused, recycled, and kept in use for as long as possible. ZWE works through policy advocacy, community engagement, and innovation to drive systemic change, supporting local governments, businesses, and citizens in adopting zero waste strategies. These strategies emphasize reducing waste at the source, improving recycling rates, and fostering sustainable consumption patterns, which notably addresses the challenges posed by e-waste. By promoting the design of durable, repairable, and recyclable electronic products, ZWE helps mitigate the environmental and health

impacts of e-waste, ensuring valuable materials are recovered and reused, thus supporting the circular economy principles. The initiative also collaborates with other EU platforms to share best practices, develop guidelines, and influence policy-making to achieve a zero waste future.

➜ **WEEELABEX**

The WEEE Forum is a non-profit association representing e-waste producer responsibility organizations across the globe, mainly in Europe. It aims to enhance the efficiency and effectiveness of e-waste management through collaboration, knowledge sharing, and best practices. The forum supports its members in meeting their legal obligations under the Waste Electrical and Electronic Equipment (WEEE) Directive and other related regulations. By promoting sustainable e-waste management practices, the WEEE Forum helps to ensure that valuable materials are recovered and hazardous substances are safely disposed of, thereby reducing the environmental impact of e-waste.

National level

➜ ***Plan national de gestion des déchets et des ressources* (PNGDR)**

Plan national de gestion des déchets et des ressources (PNGDR) aims to protect the environment, cultural heritage, and human health by preventing and reducing the harmful effects of waste. It sets long-term goals for resource conservation, climate protection, and impacts on future generations. The plan promotes a transition to a circular economy, emphasizing responsible consumption of natural resources and optimizing the lifecycle of materials through reuse, repurposing, or recycling.

The PNGDR's objectives are achieved through strategic measures, such as guidelines for planning, management, control, and authorization levels, and operational measures, which set deadlines or reduction targets.

➜ **Ecotrel**

Ecotrel is a non-profit organization in Luxembourg dedicated to managing and recycling waste electrical and electronic equipment (WEEE). It operates under the principle of extended producer responsibility, ensuring that producers finance the collection, treatment, and recycling of e-waste. Ecotrel collaborates with various stakeholders, including manufacturers, importers, and retailers, to promote sustainable e-waste management practices. The organization aims to reduce the environmental impact of e-waste by facilitating efficient recycling processes and encouraging the reuse of valuable materials.

3.8.4 Legal frameworks

➜ **Directive 2012/19/EU on Waste Electrical and Electronic Equipment (WEEE Directive)**

The Directive 2012/19/EU on Waste Electrical and Electronic Equipment (WEEE Directive) aims at reducing the environmental impact of e-waste by promoting its proper collection, recycling, and recovery. It establishes the principle of extended producer responsibility, requiring manufacturers to finance the management of e-waste. The directive sets specific targets for the collection and recycling of various types of electrical and electronic equipment, ensuring that valuable materials are recovered and hazardous substances are safely disposed of. By encouraging sustainable product design, in line with the Ecodesign Directive (Directive 2009/125/EC), and responsible disposal practices, the WEEE Directive supports the transition to a circular economy, where resources are reused and recycled efficiently, minimizing waste and environmental harm.

The publication of the WEEE Directive was followed by a number of implementing acts:

- Implementing Regulation (EU) 2017/699 establishing a common methodology for the calculation of the weight of electrical and electronic equipment (EEE) placed on the market of each Member State and a common methodology for the calculation of the quantity of waste electrical and electronic equipment (WEEE) generated by weight in each Member State,
- Implementing Regulation (EU) 2019/290 establishing the format for registration and reporting of producers of electrical and electronic equipment to the register,
- Implementing Decision (EU) 2019/2193 laying down rules for the calculation, verification and reporting of data and establishing data formats for the purposes of WEEE Directive.

Among EU Zero Pollution Dashboards there exist one dedicated to e-waste collection monitoring.

➜ **Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS Directive)**

The Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS Directive) aims to reduce the environmental and health risks associated with hazardous substances in electrical and electronic equipment. It restricts the use of specific hazardous materials, such as lead, mercury, cadmium, hexavalent chromium, and certain flame retardants (PBB and PBDE), in the manufacturing of electronic products. By limiting these substances, the RoHS Directive promotes safer recycling and disposal processes, reduces environmental pollution, and encourages the development of greener electronics.

➜ **Regulation (EU) 2023/1542 concerning batteries and waste batteries (New Batteries Regulation)**

The Regulation (EU) 2023/1542 concerning batteries and waste batteries aims to ensure that batteries placed on the EU market are sustainable, high-performing, and safe throughout their lifecycle. It sets requirements for the entire battery value chain, including production, use, and recycling, to minimize environmental impact and promote circular economy principles. The regulation emphasizes the use of recycled materials, responsible sourcing of raw materials, and the reduction of hazardous substances in batteries. This regulation directly impacts e-waste management by ensuring that batteries, a significant component of electronic waste, are designed for durability, repairability, and recyclability.

3.8.5 Standardization activities

Relevant technical committees

➜ **IEC/TC 111 Environmental standardization for electrical and electronic products and systems**

Scope: IEC/TC 111 prepares documents in the area of environmental sustainability. Documents include consideration for environmentally conscious design (ECD), environmental impact assessment, chemical substance management, material and environmental declarations, substance testing, and implementing a circular economy - including the use of recycled, reused, and renewable materials; extending the lifetime of products; and the recovery of products, components and materials at the end-of-life to close material loops. The documents cover aspects that help to mitigate environmental impacts such as climate change, resource depletion and biodiversity loss.

➜ **CLC/TC 111X Environment**

Scope: Deal with environmental aspects for electrical and electronic products and systems.

➜ **CEN-CLC JTC 10 Energy-related products — Material Efficiency Aspects for products in scope of Ecodesign**

Scope: Material efficiency aspects for products in scope of the Ecodesign Directive 2009/125/EC and its future revisions. Producing generic and horizontal CEN-CENELEC publications covering aspects such as assessment methods, design rules, dematerialization, digitalization and transfer of information on a variety of material efficiency topics, in particular (but not limited to):

- Extending product lifetime
- Ability to reuse components or recycle materials from products at End-of-Life
- Use of reused components and/or recycled materials in products

➜ **CLC/TC 21X Secondary cells and batteries**

Scope: CLC/TC 21X executes the following standardization activities for secondary cells and batteries:

- implement IEC/TC 21/SC 21A documents into CENELEC standards;
- to prepare Product Standards, general requirements and methods of testing included;
- to prepare Safety Standards and associated Codes of Practice;
- to consider Environmental Requirements (EC Rules) for the products.

TC 21X and its international counterpart, IEC/TC 21, will contribute to the Circular Economy objectives by standardizing technical performances, associated qualification tests of cells, modules, batteries and safety risk consideration for their “second life” after Electric Vehicle.

➜ **ITU-T/SG 5 Environment, climate change and circular economy**

Scope: ITU-T Study Group 5 (SG5) is responsible for studies on methodologies for evaluating ICT effects on climate change and publishing guidelines for using ICTs in an eco-friendly way. Under its environmental mandate SG5 is also responsible for studying design methodologies to reduce ICTs and e-waste’s adverse environmental effects, for example, through recycling of ICT facilities and equipment. The committee is thus operating at the intersection between circular economy (section 3.3) and green ICT (section 3.7).

➜ **ETSI TC EE Environmental Engineering**

The committee is responsible for defining the equipment engineering, the bonding and grounding, the power supply interface, the eco-design and environmental aspects for telecommunication infrastructures and equipment, including equipment installed in subscriber premises and mobile phones.

ETSI TC EE various engineering aspects of telecommunication equipment in different types of installations. These include:

- environmental conditions (climatic, thermal, active substances, acoustic, etc.),
- equipment practice (the physical requirements of racks, sub-racks and cabinets including thermal matters),
- power supply and grounding (power interface specifications, power and grounding distributions),
- eco-environmental matters (energy efficiency, environmental impact analysis, alternative energy sources),
- environmental matters associated with mobile Information and Communications Technologies (ICT) devices.

Relevant technical standards supporting sector challenges

Standards related to the extraction of toxic substances

➜ **IEC 62321 series on Determination of certain substances in electrotechnical products**
Multiple standards from this series have been adopted at European level and support the European directive 2011/65/EU.

Abstract: While the first part of the IEC 62321 series refers to the sampling of products and provides guidance on the disassembly procedure employed for obtaining a sample, other parts provide more specific information on the screening analysis and test methods for determination of certain substances (such as lead, mercury, phthalates, etc.)

➜ **IEC TR 62476:2010 Ed. 1.0 Guidance for evaluation of product with respect to substance-use restrictions in electrical and electronic products**

Abstract: IEC/TR 62476:2010 provides a framework for the use of internationally accepted standards, tools and practices to evaluate electrical and electronic products with respect to restricted substances. It can also be applied to declarable substances which are not restricted in electrical and electronic products. It provides guidance on how technical documentation and relevant evaluation and control methods should be selected and applied for restricted or declarable substances of any producer's product.

Standards related to infrastructure and processes related to e-waste recycling and resource recovery

➜ **IEC 62474:2018 Ed. 2.0 Material declaration for products of and for the electrotechnical industry (Amended in 2020)**
This standard has been adopted at European level.

Abstract: This document specifies the procedure, content, and form relating to material declarations for products and accessories of organizations operating in and supplying to the electrotechnical industry. The main intended use of this document is to provide data up and down the supply chain that: - allows organizations to assess products against substance compliance requirements, - allows organizations to use this information in their environmentally conscious design process and across all product life cycle phases. This document

specifies mandatory declaration requirements and also provides optional declaration requirements. This document is intended to allow reporting based on engineering judgement, supplier material declarations, and/or sampling and testing.

➜ **EN 50625-1:2014 Collection, logistics & Treatment requirements for WEEE — Part 1: General treatment requirements**

This standard has been developed in the frame of standardization request M/518 and supports the European directive 2012/19/EU.

Abstract: This European Standard is applicable to the treatment of waste electrical and electronic equipment (WEEE). This standard will be supplemented, for example by standards covering specific equipment. NOTE: This European Standard is intended to cover WEEE arising from electrical and electronic equipment as listed in Annex I and Annex III of Directive 2012/19/EU. This standard applies to the treatment of WEEE until end-of-waste status is fulfilled, or until the WEEE is prepared for re-use, recycled, recovered, or disposed of. This standard addresses all operators involved in the treatment including related handling, sorting, and storage of WEEE.

➜ **CLC/TS 50625-3-1:2015 Collection, logistics & treatment requirements for WEEE — Part 3-1: Specification for de-pollution — General**

This standard has been developed in the frame of standardization request M/518 and supports the European directive 2012/19/EU.

Abstract: In order to support the European Standard EN 50625-1 which covers treatment of WEEE, it is necessary to include normative requirements, such as target and limit values for the analysis, into a document that may be revised to take into account both practical experience and changes in treatment technologies.

➜ **CLC/TS 50625-5:2017 Collection, logistics & Treatment requirements for WEEE — Part 5: Specification for the final treatment of WEEE fractions — Copper and precious metals**

This standard has been developed in the frame of standardization request M/518 and supports the European directive 2012/19/EU.

Abstract: This Technical Specification addresses the processes regarding the recycling of copper and/or precious metals contained in WEEE and fractions of WEEE. NOTE 1: For the treatment of WEEE EN 50625-1 applies. This Technical Specification relates to the chemical and metallurgical processes used for the recycling of copper and/or precious metals contained in WEEE and fractions of WEEE, thereby differentiating it from manual/mechanical processing. All chemical and metallurgical processes are included up and until the output materials will be used for their original purpose or for other purposes or will be finally disposed of.

➜ **CLC/TR 50625-6:2018 Collection, logistics & treatment requirements for WEEE — Part 6: Report on the alignment between Directive 2012/19/EU and EN 50625 series standards and EN 50614**

This standard has been developed in the frame of standardization request M/518 and supports the European directive 2012/19/EU.

Abstract: This Technical Report provides information on the alignment between directive 2012/19/EU and EN 50625 series standards and EN 50614.

➜ **EN 50419:2022 Marking of electrical and electronic equipment (EEE) in respect to separate collection of waste EEE (WEEE)**

This standard has been developed in the frame of standardization request M/336 and supports the European directive 2012/19/EU.

Abstract: This document specifies a marking — of electrical and electronic equipment (EEE) with a view to minimizing the disposal of waste EEE (WEEE) as unsorted waste and to facilitating its separate collection.

➜ **IEC 63333:2023 Ed. 1.0 General method for assessing the proportion of reused components in products**

Abstract: IEC 63333:2023 deals with the assessment of the proportion of reused components in products on a horizontal level, which can be applied at any point in the life of the product. This document applies to electrical and electronic products. It can also be applied to other product types. This document is intended to be used in the assessment of the proportion of reused components in products.

➜ **EN 45556:2019 General method for assessing the proportion of reused components in energy-related products**
This standard has been developed in the frame of the standardization request M/543 in support of European legislation.

Abstract: This document deals with the assessment of the proportion of re-used components in energy-related products on a generic level. All energy-related products are in the scope of this standard.

➜ **EN 45558:2019 General method to declare the use of critical raw materials in energy-related products**
This standard has been developed in the frame of the standardization request M/543 in support of European legislation.

Abstract: In accordance with standardization request M/543 it is necessary to consider the "Use and recyclability of Critical Raw Materials to the EU, listed by the European Commission". This standard facilitates this requirement by describing appropriate information on critical materials.

➜ **ITU-T L.1021 Extended producer responsibility — Guidelines for sustainable e-waste management**

Abstract: This Recommendation offers a description of the extended producer responsibility (EPR) system in dealing with e-waste. It expands on the different existing forms of EPR globally, not only in theoretical terms, but also with a practical view on their feasibility, challenges and pre-requisites. It presents the definition of the EPR system, in addition to the roles and responsibilities of the different stakeholders, the different types of EPR as well as how and why they could be used in certain contexts and not in others. The funding mechanism behind every mode and the organizational structure expected to be in place are also presented. The Recommendation concludes with many best practices from the international arena including developed, developing and emerging economies, as well as the challenges faced in some cases.

➜ **ITU-T L.1027 Assessment of material efficiency of ICT network infrastructure goods (circular economy) — Server and data storage product disassembly and disassembly instruction**

Recommendation ITU-T L.1027 contains methods to assess the ability to disassemble certain key components of servers and data storage products, and the provision of information on these disassembly operations. It places a special emphasis on aspects relevant to the circular economy, such as fostering durability and reparability, in particular by third parties.

➜ **ITU-T L.1030 E-waste management framework for countries**

Abstract: Recommendation ITU-T L.1030 provides a management framework for e-waste to countries. It summarizes the different steps that countries need to adopt in order to put in place an e-waste management system. The different steps of the e-waste management system described in this Recommendation will be further elaborated in future Recommendations. In addition, the Recommendation provides highlights concerning the environmental impact of improper handling of e-waste as well as the economic opportunities that could emerge from the sustainable management of e-waste.

➜ **ITU-T L.1035 Sustainable management of batteries**

Abstract: Recommendation ITU-T L.1035 provides guidance on the sustainable management of used batteries from information and communication technology (ICT) equipment and their environmentally responsible management, including waste prevention, minimization, recycling, recovery and final disposal. This Recommendation also provides information on best practices in recycling batteries for dissemination.

Batteries are crucial for the functioning of ICTs. Improving their design, prolonging their lifespan, improving their recyclability and preventing the dumping of waste batteries can lower their overall energy consumption, reduce exposure of humans and the environment to hazardous substances, as well as reducing global greenhouse gas emissions.

Standards related to the reduction of global e-waste generation and ecodesign

➜ **EN 45552:2020 General method for the assessment of the durability of energy-related products**
This standard has been developed in the frame of the standardization request M/543 in support of European legislation.

Abstract: The standard will cover a set of parameters for assessing durability of energy-related products (ErP) and a general method to describe and assess the durability of ErP, i.e. both electrotechnical and non-electro technical products, respectively it shall be applicable to all energy-related products, that is, all products covered by the Ecodesign Directive 2009/125/EC.

➜ **EN 45553:2020 General method for the assessment of the ability to remanufacture energy-related products**
This standard has been developed in the frame of the standardization request M/543 in support of European legislation.

Abstract: This European Standard (EN) will provide a general methodology for the assessment of the ability to re-manufacture energy related products. This EN will elaborate the assessment and process of re-manufacturability in a horizontal, cross-product way. However, a correct assessment can only be done in a product-specific way, taking into account specific parameters of a specific energy related product.

➜ **EN 45554:2020 General methods for the assessment of the ability to repair, reuse and upgrade energy-related products**
This standard has been developed in the frame of the standardization request M/543 in support of European legislation.

Abstract: This standard will fulfil requirements in Standardization request M/543 by defining parameters and methods relevant for assessing the ability to repair and reuse products; the ability to upgrade products, excluding remanufacturing; the ability to access or remove certain components, consumables or assemblies from products to facilitate repair, reuse or upgrade and lastly by defining reusability indexes or criteria

➜ **EN 45555:2019 General methods for assessing the recyclability and recoverability of energy-related products.**
This standard has been developed in the frame of the standardization request M/543 in support of European legislation.

Abstract: This European standard (EN) provides a general methodology for:

- Assessing the recyclability of energy related products
- Assessing the recoverability of energy related products
- Assessing the ability to access or remove certain components or assemblies from energy related products to facilitate their potential for recycling or other recovery operations.
- Assessing the recyclability of critical raw materials from energy related products.

This EN will elaborate on recyclability and recoverability in a horizontal, cross-product way. However, a correct assessment can only be done in a product-specific way, taking into account specific parameters of a specific product group. This standard will define a series of parameters which may be considered to calculate product specific recycling and recoverability rates.

➜ **IEC 62430:2019 Environmentally conscious design (ECD) — Principles, requirements and guidance.**
This standard has been adopted at European level.

Abstract: IEC 62430:2019 describes principles, specifies requirements and provides guidance for organizations intending to integrate environmental aspects into the design and development in order to minimize the adverse environmental impacts of their products. This document applies to processes on how ECD (environmentally conscious design) are integrated into the design and development. This document applies to any organization, regardless of its size, type or sector. This document does not provide requirements for assessing the conformity of individual products.

➜ **IEC/TS 63428:2024 Guidance on material circulation considerations in environmentally conscious design**

Abstract: IEC/TS 63428:2024 describes principles and provides guidance on how to embed material circularity aspects into the design and development of products. This includes making efficient use of materials and closing material flows in design and production, extending the lifetime of products through increased durability and enabling parts and materials to be reused or recycled at end-of-life.

➜ **ITU-T L.1040 Effects of information and communication technology-enabled autonomy on vehicles longevity and waste creation**

Abstract: Recommendation ITU-T L.1040 establishes guidelines and requirements for information and communication technology original equipment manufacturer vendors providing equipment to autonomous vehicles aiming to reduce the amount of future e-waste. Recommendation ITU-T L.1040 analyses the e-waste risks and other sustainability indicators of autonomous vehicles and proposes how these potential challenges can be mitigated.

➜ **ITU-T L.1010 Green battery solutions for mobile phones and other hand-held information and communication technology devices**

Abstract: Recommendation ITU-T L.1010 defines a minimum set of parameters necessary to identify green battery solutions that should be considered by developers/manufacturers to reduce the future environmental impact of battery use. The provision of so-called green batteries is to extend the lifetime of handsets, reduce global resources consumption and preserve the environment.

The compliance in terms of supporting green information and communication technology (ICT) efforts will be considered including the use of scarce resources, recycling and reuse. The existing environmental schemes available in different regions and international standards will be considered.

Standards related to awareness and education about e-waste

➜ **ITU-T L.1024 The potential impact of selling services instead of equipment on waste creation and the environment — Effects on global information and communication technology**

Abstract: Recommendation ITU-T L.1024 utilizes information compiled from stakeholders that provides insights into cases in the information and communication technology (ICT) ecosystem, in which ICT goods are sold as services or subscriptions rather than products.

➜ **IEC 62542:2013 Environmental standardization for electrical and electronic products and systems — Glossary of terms**
This standard has been adopted at European level. The document is currently being revised.

Abstact: IEC 62542:2013 specifies generic terms and definitions that are related to environmental standardization within the IEC. It serves as a glossary of terminology to be considered for environmental aspects of relevant work in IEC. The terms cover environmental issues that are relevant for electrotechnical products across all product life cycle stages.

➜ **ETSI ES 204 082 (2025-01) Environmental Engineering (EE) — An information model for digital product information on sustainability and circularity**

Abstract: The present document relates to, builds on, and complements Recommendation ITU-T L.1070 [i.43] and ETSI TS 103 881 [3] standards, which define opportunities for a global digital sustainable product passport to achieve a circular economy. The present document defines an information model to describe environmental sustainability and circularity information details about ICT goods (products) in a digital form to be part of a digital product passport as environmental information that can be compared with information requirements in relevant environmental sustainability and circularity standards. The information details can represent products at any time of their circular lifespan: design, manufacturing, use, hardware changes, and final recycling as e-waste. The aim is to complement and contribute to regional (European digital product passport) and global (UNECE B2B digital product passport) standards.

➜ **ETSI TS 103 881 (2025-01) Environmental Engineering (EE) — Global digital sustainable product passport opportunities to achieve a circular economy**

Abstract: The present document provides an overview of global and common opportunities to represent sustainability, mainly environmental-related, details about digital technology products, either collective ICT product models, batches or individual ICT product items. These product details are intended to be represented in digital format instead of paper-based. The details can represent design-related information, products at the time of manufacturing, including relevant information for product transparency and a potential for a circular lifecycle, such as details related to the origin of materials composition, design, manufacturing, energy consumption, maintenance, repair, preparation for reuse, final recycling, and may include links to related documentation. Product details can include or relate to details that change over the lifespan of a product as a result of reconfiguration events, including repair, upgrade, usage, sale, and final recycling. The details should exclude any personal or business-sensitive information.

National involvement/ activities on identified technical committees

The national community following the development of standards related to e-waste is rather small, containing only 4 persons.

Impact of standards on the national economy

In Luxembourg, SMEs can significantly contribute to e-waste management by adopting sustainable standardized practices, such as partnering with certified recyclers like Ecotrel, promoting product designs that are durable and recyclable, and educating employees on proper e-waste disposal. These efforts help reduce environmental impact and support the circular economy. However, SMEs also face challenges, including compliance with strict e-waste regulations, which can incur additional costs.

Artisans in Luxembourg have several opportunities related to e-waste management. They can engage in the repair and refurbishment of electronic devices, extending their lifespan, and create unique products from recycled electronic components, reducing waste. Collaborating with e-waste recycling organizations like Ecotrel can provide artisans with access to materials and support for their initiatives.

Standards can help SMEs and artisans with building new services around e-waste recycling, based on materials extraction, information provision and eco-friendly design. Moreover, standard that are linked to European legislation can support the compliance.

4

How to use and access standards

4 How to use and access standards

Using standards provides multiple benefits such as improving the quality of products, enhancing trust in services provided or ensuring the interoperability of systems. Several studies have demonstrated their economic value [16] [92]. Therefore, to support national stakeholders, ILNAS provides several solutions designed to facilitate access to standards. The ILNAS e-Shop allows anyone to purchase digital version of standards at competitive prices. Currently, the catalogue contains more than 200.000 standards, originating from recognized standardization organizations — ISO, IEC, CEN, CENELEC and ETSI — as well as from national standardization organizations, such as ILNAS and DIN. Complementary to the e-Shop, ILNAS offers the possibility to consult standards from the ILNAS e-Shop catalogue free-of-charge via the reading stations available at various locations throughout Luxembourg. The up-to-date list of locations is available on portail-qualite website.

PORTAIL-QUALITE.LU
QUALITE·SECURITE·CONFORMITE
UNE INITIATIVE DE L'ILNAS

ILNAS e-shop

5

Why and how to contribute to standardization in sustainable development

5 Why and how to contribute to standardization in sustainable development

5.1 Benefits to participate in standardization

Participation in standardization offers a wide range of benefits to individuals and organizations. These advantages span technical, strategic, business, and environmental dimensions.

Technical benefits

- Access to draft standards and influence their content based on your technical expertise.
- Stay up to date with the state of the art in standardization relevant to your core business.
- Propose new standardization projects that reflect emerging technologies and needs.
- Anticipate future developments and best practices in your sector through early access to evolving standards.

Strategic and business benefits

- Expand your strategic network by connecting with a broad pool of national, European, and international experts.
- Gain insights into partners' and competitors' positions and strategies through participation in technical meetings.
- Collaborate to defend shared interests within your industry or professional community.
- Shape standards to reflect your organization's values, needs, and know-how, enhancing the visibility and impact of your expertise.
- Gain early access to future specifications, allowing your organization to proactively adapt to market trends and regulatory changes.

Environmental benefits

- Support climate change mitigation and environmental protection by sharing knowledge and experience for developing environmentally focused standards.
- Encourage inclusiveness and diversity in the standardization process, helping define robust and widely applicable environmental requirements.
- Improve environmental performance across sectors through the implementation of well-designed standards.

5.2 How to participate in standardization

Founding principles followed by the standards developing organizations, include a participation based on openness, inclusiveness and consensus (see section 2.1.1). The implementation of these key principles is defined by each recognized standardization organization via internal directives and policies, such as ISO/IEC directives and CEN/CENELEC internal regulations. To preserve the key principles along the full standard development process, each national standards body has to comply with the European and international requirements, notably by integrating them into their national procedures. At ILNAS, ILNAS/OLN/P001 document provides the policy on participation in technical standards committees for national stakeholders.

While specific requirements for participants may differ between standardization organization, the overall opportunities for involvement remain broadly similar. Participation can be categorized into three levels, ranging from minimal to full engagement:

- **Public commenting:** providing feedback on standard's draft during the public enquiry phase. While this type of involvement does not require any prior registration, it typically has limited impact, as it occurs at a late stage in the standards' development process.
- **Delegate role:** participation in technical committee discussions and contributing to the review and refinement of draft standards. Delegates can help steer the content of standards.
- **Expert role:** actively shaping the content of standards from the early stages, based on specialized knowledge and experience. Experts have the most significant influence, with the opportunity to define the structure and requirements of standards from the outset, while also advocating for their organization's interests.

Figure 9 illustrates the standards' development process showing how opportunities to influence the content of a future standard decrease over time, while its content stability progressively increases.

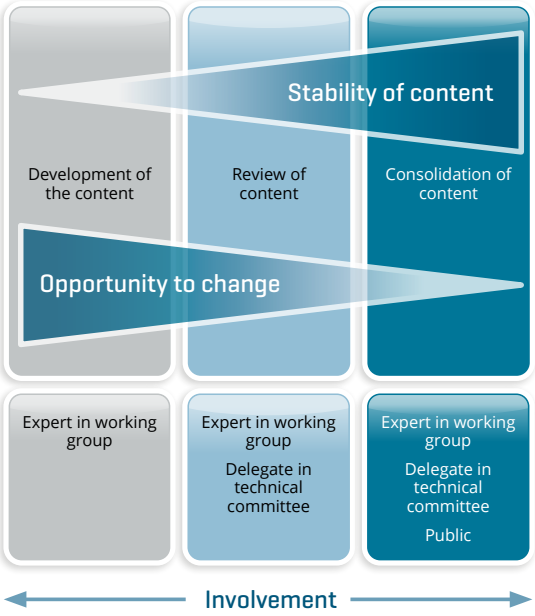

Figure 9 - Opportunity to change standards content versus development phase

5.2.1 Comment standards during the public enquiry phase

Occurring at a late stage in the standard's development process, public enquiry remains the easiest way to contribute to standardization. Commenting standard at this stage does not require any specific registration and is open to any stakeholder. Concretely, this task can be done via the ILNAS e-Shop, by selecting "Draft standards in public enquiry". During the enquiry phase, drafts of standards are made freely available on ILNAS e-Shop and any stakeholder can contribute to standardization by providing comments. Once sent back to ILNAS, the comments will be considered when submitting the national position to the responsible technical committee. It is brought to the attention of the interested parties that the possibility to modify a draft standard during the public enquiry phase is limited, as this stage occurs late in the standard development process.

Figure 10 - Example of standard under public enquiry

5.2.2 Participation in technical committees

Participation in national, European or international technical committee's activities is the most common way to contribute actively to standardization. This level of involvement offers an optimal balance between time investment and obtained benefits. Participants are invited to comment on drafts prepared by the working groups at each stage of the development process, leaving them with significant opportunities to influence the final content.

Depending on the technical committee level (national, European or international), the goals are different: while at national level the different participants would defend only their organization's interest, at European and international levels, all involved parties will have to agree on one consensual position to represent the interests of their country. To ensure effective coordination between national stakeholders, national mirror committees are set-up by ILNAS. These committees serve to incorporate the perspectives of all interested parties and to define a unified national position.

To have more opportunities to change standard content, early participation is recommended.

5.2.3 Participation in working groups

Participation in drafting activities within working groups requires the highest level of commitment. Experts in these groups are primarily responsible for developing the standard: they produce the initial draft that serves as a basis for discussions and comments, and they also manage the comments resolution and update the subsequent versions of the document. The *modus operandi* of the working groups is based on consensus, overseen by a convenor who ensures balanced and inclusive collaboration.

Unlike individuals registered in technical committees, experts involved in drafting activities participate in a personal capacity rather than as representative of their country. They contribute based on their professional knowledge and experience, focusing on technical elements of the standard.

6

ILNAS support to national stakeholders

6 ILNAS support to national stakeholders

6.1 Registration in standardization committees or working groups through ILNAS

ILNAS offers the possibility for nationally established organizations to register delegates or experts within ISO, IEC, CEN, and CENELEC technical committees and related working groups free-of-charge.

To register into a technical committee, candidates have to complete the ILNAS/OLN/F001a form and to send it back to ILNAS. The application will be submitted to evaluation by ILNAS during its standardization steering board meeting. Assessment criteria are mainly based on the relevance of education and professional experience of applicants in regards to the scope of the technical committees for which the registration is requested. Once approved, the applicant is granted access to the documentation of the technical committees and working groups in which he/she requested registration.

6.2 Unique point of contact for standardization information

ILNAS, as Luxembourg's national standards body, is the unique point of contact for all questions related to standardization, wether they concern standards availability or general inquiries about participation in the standard development process.

6.3 Awareness sessions and trainings on standardization

ILNAS and ANEC EIG propose every year several standardization-related awareness sessions and trainings related to the growth sectors (ICT, Construction and Space) and relevant domains (Conformity and sustainable development) identified in the national standardization strategy. The list of available trainings can be found on portail-qualite.public.lu website.

6.4 Dedicated standards watch service

Recognizing that each organization has unique needs, ANEC EIG proposes a competitive fee-based service for tailored standards watch. This on-demand solution provides companies with a list of standards relevant to a specific domain or topic, helping them save time and focus on strategic priorities.

Conclusion

Since its definition in 1987, the concept of sustainable development has been progressively integrated into international, European, and national strategies, particularly as a means to mitigate the risks posed by accelerating climate change. While numerous actions have been undertaken at the international level, effective response to this global challenge requires coordination at all governance levels.

At the national level, the Grand Duchy of Luxembourg has been for a long time committed to sustainability, implementing projects that address its three dimensions – environmental, social and economic. In this frame, Luxembourg already contributes to a comprehensive movement that requires a global, coordinated and collaborative engagement from the international community. In this frame, standards play an important role, while defining, for example, common specifications that can be used to measure concretely how different initiatives can contribute to the Sustainable Development Goals (SDGs) of the United Nations.

With this report, ILNAS with the support of ANEC EIG, provides an overview of standardization developments for different sustainability related topics of particular interest to the national economy. It aims at helping Luxembourg's organizations in the identification and implementation of standards relevant to their sectors, to maximize potential benefits from a sustainability perspective. It also highlights the opportunities for the national stakeholders to take part in the drafting of standards, offering them the possibility to engage in the development of future standards and guide the market towards a more sustainable journey.

In Luxembourg, standardization efforts in the field of sustainable development field remain primarily centered on the application of existing standards. As an example, there were 152 valid certificates for ISO 14001:2015 Environmental management systems — Requirements with guidance for use in Luxembourg in 2024[4]. This figure demonstrates the engagement of many national organizations to progress toward sustainable development goals and the creation of environmentally responsible products and services, but a step forward would be to actively engage in the elaboration of these standards.

In summary, the objective of this report is twofold. On the one hand, it aims to support national stakeholders in the use of standards for launching innovative projects and identifying new opportunities, notably the development of markets that encompass all three dimensions of sustainable development. On the other hand, the report intends to stimulate the interest of the national market for an active participation in the standardization process that allows the integration of more national expertise in shaping the European and international good practices for sustainable development.

Within this framework, ILNAS, with the support of ANEC EIG, remains available to support national stakeholders in advancing towards a sustainable future through the strategic use of standardization.

4 According to the ISO Survey 2024 (https://www.iso.org/the-iso-survey.html)

References

[1] U. N. G. Assembly, "Report of the World Commission on Environment and Development: Our Common Future," 1987.

[2] European Commission - Mobility and Transport, "Hydrogen and fuels cells for transport," [Online]. Available: https://transport.ec.europa.eu/transport-themes/clean-transport/clean-and-energy-efficient-vehicles/green-propulsion-transport/hydrogen-and-fuels-cells-transport_en.

[3] GTM - What Exactly Is Green Hydrogen?, [Online]. Available: https://www.greentechmedia.com/articles/read/green-hydrogen-explained.

[4] "Renewable energy source," [Online]. Available: https://www.reuters.com/business/sustainable-business/eu-reaches-deal-more-ambitious-renewable-energy-targets-2030-2023-03-30.

[5] "EU renewable energy target," [Online]. Available: https://energy.ec.europa.eu/topics/renewable-energy/renewable-energy-directive-targets-and-rules/renewable-energy-targets_en.

[6] "Luxembourg's integrated national energy and climate plan for the period 2021-2030 (PNEC)," [Online]. Available: Luxembourg's integrated national energy and climate plan for the period 2021-2030 (PNEC).

[7] "Luxembourg's hydrogen artery: first law on a transport network for green hydrogen adopted," 2025. [Online]. Available: https://luxtoday.lu/en/technology-innovation-energy/luxembourgs-hydrogen-artery-first-law-on-a-transport-network-for-green-hydrogen-adopted.

[8] PNEC Luxembourg. Available: https://gouvernement.lu/en/dossiers/2023/2023-pnec.html.

[9] "Ministry of Mobility and Public Works - PNM 2035 - Luxembourg," [Online]. Available: https://mmtp.gouvernement.lu/en/dossiers.gouvernement%2Ben%2Bdossiers%2B2022%2Bpnm2035.html.

[10] "Modu2.0," [Online]. Available: https://transports.public.lu/dam-assets/publications/contexte/strategie/modu2-de-brochure.pdf.

[11] "PNEC," [Online]. Available: https://gouvernement.lu/en/dossiers/2023/2023-pnec.html.

[12] W. T. Organization, "Principles for the Development of International Standards, Guides and Recommendations," WTO, [Online]. Available: https://www.wto.org/english/tratop_e/tbt_e/principles_standards_tbt_e.htm. [Accessed 08 2024].

[13] UIC, "Standardization: the UIC role," [Online]. Available: https://uic.org/standardisation/. [Accessed August 2025].

[14] ITU, "Historical Highlights: ITU and Standardization," ITU, [Online]. Available: https://www.itu.int/en/history/Pages/FocusOnStandardization.aspx. [Accessed August 2025].

[15] ASME, "The American Society of Mechanical Engineers," [Online]. Available: https://www.asme.org/about-asme/engineering-history/landmarks/234-the-united-states-standard-screw-threads. [Accessed August 2025].

[16] A. J. A. M. Knut Blind, The Economic Benefits of Standardization - an update of the study carried out by DIN in 2000, Berlin: DIN German Institude for Standardization, 2012.

[17] ISO, "Environmental sustainability," ISO, [Online]. Available: https://www.iso.org/sectors/environment. [Accessed August 2025].

[18] ISO, "ISO - Strategy 2030," [Online]. Available: https://www.iso.org/strategy2030.html#vision. [Accessed July 2025].

[19] IEC, "IEC Strategic Plan," [Online]. Available: https://www.iec.ch/strategic-plan#fostering.

[20] G. Zahedi, A. A. Bazmi and A. W. Bhutto, "The environmental impacts: in "Industrialization: economic, environmental and health impacts," "Advances in environmental research, vol. 20, pp. 147-162, 2012.

[21] United Nations Environment Programme, "We are all in this together - Annual Report 2024," 2025. [Online]. Available: https://wedocs.unep.org/20.500.11822/47082. [Accessed 08 05 2025].

[22] United Nations - Climate Action, "What Is Climate Change?," [Online]. Available: https://www.un.org/en/climatechange/what-is-climate-change. [Accessed 17 09 2025].

[23] IPCC, "Sections. In: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]," Geneva, 2023.

[24] UNEP, "Global Waste Management Outlook," 2024. [Online].
Available: https://www.unep.org/ietc/resources/report/global-waste-management-outlook-2024. [Accessed 09 05 2025].

[25] UNEP, "Why does environment, health and pollution matter?," 2025. [Online].
Available: https://www.unep.org/topics/chemicals-and-pollution-action/pollution-and-health/why-does-environment-health-and. [Accessed 09 05 2025].

[26] European Environment Agency, "The benefits to biodiversity of a strong circular economy.," 2023. [Online].
Available: https://www.eea.europa.eu/publications/the-benefits-to-biodiversity. [Accessed 09 05 2025].

[27] UNECE, "Ecosystem Services," [Online]. Available: https://unece.org/ecosystem-services-0. [Accessed 17 09 2025].

[28] P. Cervini, E. Farri and G. Rosani, "How Sustainability Efforts Fall Apart," Harvard Business Review, 2022. [Online].
Available: https://hbr.org/2022/09/how-sustainability-efforts-fall-apart. [Accessed 12 05 2025].

[29] K. Mutua, J. Powell-Turner, M. Spiers and J. Callaghan, "An In-Depth Analysis of Barriers to Corporate Sustainability.," Administrative Sciences, 15(5), 161, 2025. [Online].
Available: https://www.mdpi.com/2076-3387/15/5/161. [Accessed 17 09 2025].

[30] A. Bozic Mazzi, A. Vikström, C. Gruß, M. Cuellar, P. Catchlove, S. Santamarta and T. Seppä, "The Challenges of a Sustainability Transformation," BCG, 2022. [Online].
Available: https://www.bcg.com/publications/2022/the-challenges-of-a-sustainability-transformation.
[Accessed 12 05 2025].

[31] European Environment Agency, "Energy Efficiency," 2024. [Online].
Available: https://www.eea.europa.eu/en/topics/in-depth/energy-efficiency. [Accessed 27 05 2025].

[32] International Energy Agency, "Energy Efficiency," 2024. [Online].
Available: https://www.iea.org/energy-system/energy-efficiency-and-demand/energy-efficiency.
[Accessed 27 05 2025].

[33] V. Rizos, K. Tuokko and A. Behrens, "The Circular Economy: A review of definitions, processes and impacts," Centre for European Policy Studies (CEPS), Brussels, 2017.

[34] Ellen McArthur Foundation, "What is a circular economy?," [Online].
Available: https://www.ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview.
[Accessed May 2025].

[35] "Challenges on the way to a circular economy from the perspective of the Austrian manufacturing industry," Frontiers, [Online]. Available: https://www.frontiersin.org/journals/sustainability/articles/10.3389/frsus.2023.1243374/full.

[36] INDEED, "The Circular Economy: Challenges and Opportunities in Implementation," [Online].
Available: https://www.indeed-innovation.com/the-mensch/the-circular-economy-challenges-and-opportunities-in-implementation/.

[37] ICC and EY, "Circular economy: Challenges and opportunities for businesses and policymakers," International chamber of Commerce, [Online].
Available: https://iccwbo.org/global-insights/sustainability-and-climate-action/circular-economy-challenges-and-opportunities-for-businesses-and-policymakers/.

[38] Statistiques - Luxembourg, « Le Portail des Statistiques, » 2024. [En ligne].
Available: https://statistiques.public.lu/fr/publications/series/analyses/2024/analyses-02-24.html.

[39] K. Ntakana and A. Ahmi, "Blueprints for Sustainability: An In-Depth Study of Construction," in Globalization and Sustainability - Ecological, Social and Cultural Perspectives, InTechOpen, 2024.

[40] S. Hegelbach, "Was bedeutet nachhaltiges Bauen?," n.a.. [Online].
Available: https://www.baunetzwissen.de/nachhaltig-bauen/fachwissen/einfuehrung/was-bedeutet-nachhaltiges-bauen-7560079.

[41] C. Jackson, "https://www.construction21.org/articles/h/what-is-sustainable-construction.html," 2021. [Online].
Available: https://www.construction21.org/articles/h/what-is-sustainable-construction.html.

[42] M. Zacharia, "What you need to know about new changes to the EU's product EPD regulations," 03 09 2024. [Online].
Available: https://oneclicklca.com/en/resources/articles/eu-product-epd-regulations.

[43] P. Hild, "The Circular Economy and Circular Building Practices in Luxembourg," Circular Economy and Sustainability, pp. 1963-1988, 2023.

[44] Ordre des Architectes et des Ingénieurs-Conseils, "6 revendications phares OAI pour l'accord de coalition du nouveau Gouvernement," 22 09 2023. [Online].
Available: https://www.oai.lu/files/Avis/2023/6_revendications_phares_OAI_ad_accord_de_coalition_20230922.pdf.

[45] "International Energy Agency (IEA)," [Online]. Available: https://www.iea.org/reports/the-future-of-hydrogen.

[46] IERNA, "Hydrogen," https://www.irena.org/Energy-Transition/Technology/Hydrogen, 2024.

[47] "Hydrogen Council," [Online]. Available: https://hydrogencouncil.com/en/hydrogen-insights-2023/.

[48] "European Commission - Energy," [Online]. Available: https://energy.ec.europa.eu/topics/eus-energy-system/hydrogen_en.

[49] IEA, "Global Hydrogen Review 2025," 2025.

[50] M. A. e. al., "Challenges and Future Perspectives on Production, Storage Technologies, and Transportation of Hydrogen: A Review," https://doi.org/10.1002/ente.202300997, vol. 12, no. 4, 2024.

[51] Hydrogen Europe, "Hydrogen Infrastructure: The recipe for the Hydrogen Grid Plan," 2024.

[52] European Commission - JRC, "Hydrogen Storage: State-of-the-Art and Future Perspectives," 2001.

[53] M. Calabrese, M. Portarapillo, A. Di Nardo, V. Venezia, M. Turco, G. Luciani and A. Di Benedetto, "Hydrogen Safety Challenges: A Comprehensive Review on Production, Storage, Transport, Utilization, and CFD-Based Consequence and Risk Assessment.," Energies , vol. 1350, no. 6, p. 17, 2024.

[54] "Hydrogen Certification 101," Hydrogen Council, [Online].
Available: https://hydrogencouncil.com/wp-content/uploads/2023/08/Hydrogen-Certification-101.pdf.

[55] ELECTRA, Certification of the electricity used to produce hydrogen, p. June 2025, June 2025.

[56] European Commission, 2050 long-term strategy.

[57] "European Environmental Agency (EEA)," 2025. [Online].
Available: https://www.eea.europa.eu/en/about/contact-us/faqs/why-do-we-need-a-sustainable-mobility-system.

[58] Transformingtransporteu - What is Transforming Transport?, 2024. [Online]. Available: https://transformingtransport.eu/.

[59] Euopean Commission, "Report on the new EU urban mobility framework," 2023.

[60] European Commission - Mobility Strategy, 2021. [Online].
Available: https://transport.ec.europa.eu/transport-themes/mobility-strategy_en.

[61] European Commission - Sustainable and smart mobility, 2019. [Online].
Available: https://transport.ec.europa.eu/transport-themes/eu-mobility-transport-achievements-2019-2024/sustainable-smart-mobility_en.

[62] Intertraffic - Smart mobility: from data to information to insight to action, 2024. [Online].
Available: https://www.intertraffic.com/news/smart-mobility-from-data-to-information.

[63] European Commission - Shaping Europe's digital future, "Digitalising transport - towards smart and sustainable mobility," 2025. [Online]. Available: https://digital-strategy.ec.europa.eu/en/policies/digitalisation-mobility.

[64] European Commission, "Electric vehicles," [Online].
Available: https://transport.ec.europa.eu/transport-themes/clean-transport/clean-and-energy-efficient-vehicles/green-propulsion-transport/electric-vehicles_en.

[65] M. M. Mariano Gallo, "Sustainable Mobility: A Review of Possible Actions and Policies," Sustainability , vol. 12(18), no. 7499, 2020.

[66] European Commission , "Common transport policy: Overview," [Online].
Available: https://www.europarl.europa.eu/factsheets/en/sheet/123/common-transport-policy-overview.

[67] "IEA," [Online]. Available: https://www.iea.org/energy-system/transport.

[68] IEA - transport- cars and vans, 2025. [Online].
Available: https://www.iea.org/energy-system/transport/cars-and-vans?utm_source.

[69] McKinsey & Company - Declining bus ridership: Improving the efficiency of transit networks, 2019. [Online].
Available: https://www.mckinsey.com/industries/infrastructure/our-insights/declining-bus-ridership-improving-the-efficiency-of-transit-networks.

[70] European Commission, “Light-duty vehicles,” [Online]. Available: https://climate.ec.europa.eu/eu-action/transport-decarbonisation/road-transport/light-duty-vehicles_en?prefLang=it.

[71] European Enviromental Agency, “Transport and mobility,” 2025.

[72] European Commission, “Strategic forecast report,” 2023.

[73] World Health Organization, “Road traffic injuries,” 2023. [Online]. Available: https://www.who.int/news-room/fact-sheets/detail/road-traffic-injuries.

[74] “Cyber Security and Resilience of smart cars,” ENISA, 2017.

[75] A. Goel, “An Overview of Digital Transformation and Environmental Sustainability: Threats, Opportunities, and Solutions,” nvironmental Sustainability and Applications, p. 36, 2024.

[76] C. A. D. Pahalson, “Green Information and Communication Technology,” "International Journal of Engineering Research & Technology (IJERT)," vol. 12, no. 11, 2023.

[77] S. Effenberger, “docusnap,” 14 March 2025. [Online]. Available: https://www.docusnap.com/en/it-documentation/sustainability-in-it. [Accessed july 2025].

[78] T. J. V. Saldanha, S. Mithas, J. Khuntia, J. Whitaker and N. P. Melville, “How Green Information Technology Standards and Strategies Influence Performance: Role of Environment, Cost and Dual Focus,” MIS Quarterly, vol. 46, no. 4, 22.

[79] “Submer,” [Online]. Available: https://submer.com/blog/data-center-sustainability-the-lifecycle-of-a-green-data-center/#:~:text=Designing%20a%20green%20data%20center,energy%20and%20data%20center%20operations. [Accessed 2025].

[80] M. G. T. J. I. R. H. L. J. S. L. Vitor Castro, “Digital data demand and renewable energy limits: Forecasting the impacts on global electricity supply and sustainability,” Energy Policy, 2024.

[81] X. Sun, N. Ansari and R. Wang, “Optimizing Resource Utilization of a Data Center,” "IEEE Communications Surveys & Tutorials," vol. 184, 2016.

[82] I. a. T. W. Bank, “Green data centers: towards a sustainable digital transformation,” 2023. [Online]. Available: https://www.itu.int/en/ITU-D/Environment/Documents/Publications/2025/ITU-World%20Bank%20Green%20data%20centers_2023.pdf. [Accessed 2025].

[83] Gartner, “Gartner Glossary - Electronic Waste (e-Waste),” [Online]. Available: https://www.gartner.com/en/information-technology/glossary/electronic-e-waste. [Accessed June 2025].

[84] United Nations Environment Programme, “Sustainable Future of E-waste,” [Online]. Available: https://www.unep.org/ietc/news/story/sustainable-future-e-waste. [Accessed May 2025].

[85] United Nations Environment Programme, “E-Waste,” 2005. [Online]. Available: https://wedocs.unep.org/bitstream/handle/20.500.11822/40949/E-Waste_Eng.pdf. [Accessed May 2025].

[86] UNDRR - United Nations Office for Disaster Risk Reduction, “Electronic Waste (E-Waste),” [Online]. Available: https://www.undrr.org/understanding-disaster-risk/terminology/hips/tl0041. [Accessed May 2025].

[87] European Commission, “Waste from Electrical and Electronic Equipment (WEEE),” [Online]. Available: https://environment.ec.europa.eu/topics/waste-and-recycling/waste-electrical-and-electronic-equipment-weee_en. [Accessed May 2025].

[88] Gartner, “IT Is Improving the Circular Economy: Q&A with Annette Zimmermann,” June 2023. [Online]. Available: https://www.gartner.com/en/newsroom/press-releases/2023-06-28-it-is-improving-the-circular-economy. [Accessed June 2025].

[89] WHO - World Health Organization, “Electronic waste (e-waste),” October 2024. [Online]. Available: https://www.who.int/news-room/fact-sheets/detail/electronic-waste-(e-waste). [Accessed June 2025].

[90] Recycle Technologies, “Disadvantages of Recycling: An In-depth Overview of E-Waste Recycling Challenges,” April 2024. [Online]. Available: https://www.recycletechnologies.com/disadvantages-of-recycling-an-in-depth-overview-of-e-waste-recycling-challenges/. [Accessed May 2025].

[91] Geneva Environment Network, “The Growing Environmental Risks of E-Waste,” October 2024. [Online]. Available: https://www.genevaenvironmentnetwork.org/resources/updates/the-growing-environmental-risks-of-e-waste/. [Accessed May 2025].

[92] ISO, Economic benefits of standards - Volume 2, Geneva: International Organization for Standardization, 2012.

[94] European Framework - new EU urban mobility framework, 2021. [Online].
Available: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12916-Sustainable-transport-new-urban-mobility-framework_en.

[95] European Commission - Trans-European Transport Network (TEN-T), 2024. [Online].
Available: https://transport.ec.europa.eu/transport-themes/infrastructure-and-investment/trans-european-transport-network-ten-t_en.

[96] Ministry of Mobility and Public Works - PNM 2035 - National mobility plan, [Online].
Available: https://gouvernement.lu/en/dossiers/2022/pnm2035.html.

[97] Minister for Mobility - Modu 2.0 strategy, 2020. [Online].
Available: https://transports.public.lu/dam-assets/publications/contexte/strategie/Modu20-EN-final.pdf.

[98] IPCC, " Sections. In: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]," Geneva, 2023.

[99] UNEP, "Global Waste Management Outlook," 2024. [Online].
Available: https://www.unep.org/ietc/resources/report/global-waste-management-outlook-2024. [Accessed 09 05 2025].

[100] UNEP, "Why does environment, health and pollution matter?," 2025. [Online].
Available: https://www.unep.org/topics/chemicals-and-pollution-action/pollution-and-health/why-does-environment-health-and. [Accessed 09 05 2025].

[101] A. Bozic Mazzi, A. Vikström, C. Gruß, M. Cuellar, P. Catchlove, S. Santamarta and T. Seppä, "The Challenges of a Sustainability Transformation," BCG, 2022. [Online].
Available: https://www.bcg.com/publications/2022/the-challenges-of-a-sus. [Accessed 12 05 2025].


H2
CO2

STANDARDIZATION ANALYSIS · SUSTAINABLE DEVELOPMENT · VERSION 1.0 · October 2025 · © ILNAS/ANEC · ISBN 978 99987 734 7 9

ILNAS
Institut Luxembourgeois de la Normalisation, de l'Accréditation, de la Sécurité et qualité des produits et services

ANEC
Agence pour la Normalisation et l'Economie de la Connaissance

Southlane Tower I · 1, avenue du Swing · L-4367 Belvaux · Tel.: (+352) 24 77 43 -40 · E-mail: normalisation@ilnas.etat.lu

www.portail-qualite.lu