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Chapter 2
Review of Directives, Regulations and Standards Related to Sustainable Product Design and Manufacture

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Abstract This chapter reviews the main directives, regulations and standards relevant to the design and manufacture of sustainable products. Product designers and manufacturers have to be aware of these, because some of these are mandatory in some countries (e.g. EU countries) and others can contribute significantly to reduce the environmental and social impact of products, thus making the products more sustainable. The chapter begins by providing a general introduction about regulations, directives and standards and their importance. It then continues with a description of the main directives, regulations and standards that are relevant to sustainable design and manufacturing. Finally it is explained how directives, regulations and standards are applied in design and development processes.

Keywords Regulations · Directives · Standards · Sustainability · Product design · Manufacture

2.1 Introduction

Some directives, regulations and standards can contribute to reduce the environmental and social impact of products, and hence contribute to make the products more sustainable. This chapter will review the existing directives, regulations and standards that, directly or indirectly, contribute to design and manufacture of products in a more sustainable manner.

Directives lay down certain results or targets (e.g. reduction of CO_2 levels per year) that must be achieved, but each country affected by these directives is free to

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decide how to transpose directives into national laws. In the case of sustainability-related directives, these targets are usually related with environmental indicators such as CO_2 levels or waste amount in some countries (USDA 2018).

Regulations have binding legal force, and enter into force on a set date in the countries where they apply (USDA 2018).

Standards are an agreed way of doing somethings. It could be about making a product, managing a process, delivering a service or supplying materials. Standards can cover a vast range of activities undertaken by organizations and used by their customers. The point of a standard is to provide a reliable basis for people to share the same expectations about a product or service. This helps to facilitate trade, provide a framework for achieving economies, efficiencies and interoperability and enhance consumer protection and confidence (BSI 2018).

Although directives do not have to be complied by law, they are usually translated into national laws, which have binding legal force, like regulations. However, the adoption and application of standards is voluntary, although they must to be followed to obtain some certifications or sustainable labels.

It is important that manufacturers, and product developers are aware of the regulations and directives applicable to the category of products they develop and produce in different geographical areas (i.e. country), so they can design and manufacture their products to comply with these to avoid fines as well as to reduce their environmental-social impact.

Although standards, unlike regulations and directives, are not compulsory, they are required to conduct tests to obtain certain certifications (i.e. eco-labels, quality labels), so they can, indirectly, contribute to reduce the environmental-social impact of products too.

In the following sections, the directives, regulations and standards which have been created to reduce the environmental and social impacts of products and the standards that can directly or indirectly contribute to reduce the environmental impact of products are discussed.

2.2 Directives

AQ2 Nine directives are reviewed in this section (Table 2.1), which are related to the areas of energy consumption, product development, waste, resources, recycle/reuse, restriction in use of hazardous, pollutant emissions and environmental impact assessment. Each directive's related key areas are listed in the Table 2.1, while more detailed information of the directives is presented after the table.

Table 2.1 List of directives

Directives	Related key areas
(1) Energy labelling directive 2010/30/EU (EC 2010b)	Energy consumption, product development
(2) Energy-related Products (ErP) Directive 2009/125/EC (EC, 2009a, b)	Energy consumption, product development
(3) Eco-design directive 2009/125/EC (EC 2009a, b)	Energy consumption, product development, waste, resources, recycle/reuse
(4) Waste Electrical and Electronic Equipment recycling (WEEE) directive 2012/19/EC (EC 2012a, b)	Waste, recycle/reuse of electronic products/equipment
(5) Waste Framework Directive 2008/98/EC (EC 2008)	Waste, recycle/reuse
(6) Restriction of Hazardous Substances (RoHS) directive 2011/65/EC (EC 2011)	Restriction to use hazardous in products
(7) Packaging and Packaging waste directive 94/62/EC (EC 1994)	Product packaging, recycle/reuse, waste
(8) Industrial Emissions Directive (IED) Directive 2010/75/EU (EC 2010a)	Regulating industrial pollutant emissions
(9) Environmental Impact Assessment (EIA) Directive 2014/52/EC (EC 1985)	Environmental impact assessment framework

2.2.1 Energy Labelling Directive 2010/30/EU (EC 2010b)

The Energy Labelling Directive (2010/30/EC) establishes a framework for labelling and consumer information regarding energy consumption. Initially established for household appliances, the scope of the Directive has been extended to energy-related products, which are likely to have a direct or indirect impact on the consumption of energy and potentially of other resources during use.

The Energy Labelling Directive is a framework directive that mandates the Commission to propose, by means of delegated acts, details relating to information to be provided on the label and in the fiche for each type of product. Products are ranked, according to their energy consumption, on an A to G scale with colours from dark green to red. The implementation of the Energy Labelling Directive is linked to the Eco-design Directive (2009/125/EC). Requirements and benchmarks defined for individual product group under the Eco-design Directive are used as references for setting the energy labelling classes.

449477_1_En_2_Chapter ☑ TYPESET ☐ DISK ☐ LE ☑ CP Disp.:30/3/2020 Pages: 38 Layout: T1-Standard

2.2.2 Energy-Related Products (ErP) Directive 2009/125/EC (EC 2009a, b)

The aim of this directive is to improve energy efficiency and environmental protection, it applies to products that affect energy consumption throughout their life cycle.

This directive does not introduce directly binding requirements for specific product categories, but rather outlines the conditions and criteria relating to environmental characteristics of products, such as energy and water waste, or lifespan, so they can be improved quickly and efficiently. It encourages manufacturers and/or importers to offer products designed to reduce their overall impact on the environment, including the resources consumed during manufacture and disposal.

It applies to energy-related products that meet the following criteria: Are sold in high quantities (over 200,000 units/year in the EU), have a significant environmental impact and have a potential for improvement.

2.2.3 Eco-design Directive 2009/125/EC (EC 2009a, b)

The aim of the Eco-design Directive is to reduce (at the design stage) the energy consumption and other negative environmental impacts of products. Although the primary aim is to reduce energy use, it is also aimed to consider other factors that may influence the environmental impact of the product such as: Materials use, water use, polluting emissions, waste issues and recyclability.

2.2.4 Waste Electrical and Electronic Equipment Recycling (WEEE) Directive 2012/19/EC (EC 2012a, b)

The WEEE directive require producers and distributors to finance the collection, treatment and recycling or reuse of Electrical and Electronic Equipment.

The aim of this directive is to address the environmental impacts of WEEE and to encourage its separate collection and subsequent treatment, reuse, recovery, recycling and environmentally sound disposal.

It affects any importer, re-brander or manufacturer of products that requires electricity for its main purpose. These will have to finance the cost of: Collecting, treating (i.e.: mercury in lamps, Printed Circuit Board (PCB) in ballasts, etc.), recovering and recycling products imported, re-branded or manufactured. For these purposes all these products should be marked.

449477_1_En_2_Chapter ☑ TYPESET ☐ DISK ☐ LE ☑ CP Disp.:30/3/2020 Pages: 38 Layout: T1-Standard

2.2.5 Waste Framework Directive 2008/98/EC (EC 2008)

It builds a legal framework for treating waste in the EU. It sets the basic concepts and definitions related to waste management, such as definitions of waste, recycling, recovery. It explains when waste ceases to be waste and becomes a secondary raw material (so called end-of-waste criteria), and how to distinguish between waste and by-products. The Directive lays down some basic waste management principles: it requires that waste be managed without endangering human health and harming the environment, and in particular without risk to water, air, soil, plants or animals, without causing a nuisance through noise or odours, and without adversely affecting the countryside or places of special interest. Waste legislation and policy of the EU Member States shall apply as a priority order the following waste management hierarchy: (1) Prevention (non-waste), (2) re-use of waste, (3) recycling of waste, (4) recovery of waste, and (5) disposal of waste.

This directive introduces the 'polluter pays principle' and the 'extended producer responsibility'. It incorporates provisions on hazardous waste and waste oils and includes two new recycling and recovery targets to be achieved by 2020: 50% preparing for re-use and recycling of certain waste materials from households and other origins similar to households, and 70% preparing for re-use, recycling and other recovery of construction and demolition waste. The Directive requires that Member States adopt waste management plans and waste prevention programmes.

2.2.6 Restriction of Hazardous Substances (RoHS) Directive 2011/65/EC (EC 2011)

This directive prevents all new electrical and electronic equipment placed on the market in the European Economic Area from containing lead, mercury, cadmium, hexavalent chromium, poly-brominated biphenyls (PBB) or polybrominated diphenyl ethers (PBDE), except in certain specific applications, in concentrations greater than the values decided by the European Commission. These values have been established as 0.01% by weight per homogeneous material for cadmium and 0.1% for the other five substances.

It draws its scope of application from that of the Waste Electrical and Electronic Equipment (WEEE) Directive, with a few exceptions. The WEEE Directive specifies ten broad product categories: (1) Large household appliances, (2) Small household appliances, (3) IT and telecommunications equipment, (4) Consumer equipment, (5) Lighting equipment, (6) Electrical and electronic tools (with the exception of large-scale stationary industrial tools), (7) Toys, leisure and sports equipment, (8) Medical devices (with the exception of all implanted and infected products), (9) Monitoring and control instruments, and (10) Automatic dispensers. Groups 8 and 9 were not within scope of the RoHS 1 but are being included within the scope of RoHS 2,

these will be phased in completely by 2019. Also 'Light bulbs and luminaries in households' have been included in the scope of the RoHS Directive, although they are not within the scope of the WEEE Directive.

2.2.7 *Packaging and Packaging Waste Directive 94/62/EC (EC 1994)*

This directive affects any type of product that uses any type (primary/secondary) of packaging. Its main objectives are: Reduce packaging material excess, eliminate/avoid specific hazardous substances/materials, inform the consumers about the content of product/packaging, reduce the amount of waste at end of life of the packaging, increase/promote the re-use and recycle of packaging waste and inform the producer/manufacturer about their responsibility to recuperate and recycle its packaging.

2.2.8 *Industrial Emissions Directive (IED) Directive 2010/75/EU (EC 2010a)*

This directive aims to achieve a high level of protection of human health and the environment taken as a whole by reducing harmful industrial emissions across the EU, in particular through better application of Best Available Techniques (BAT). It is the main EU instrument regulating pollutant emissions. IED is based on several pillars: (1) an integrated approach, (2) use of best available techniques, (3) flexibility, (4) inspections and (5) public participation.

(1) The integrated approach means that the permits must take into account the whole environmental performance of the plant, covering e.g. emissions to air, water and land, generation of waste, use of raw materials, energy efficiency, noise, prevention of accidents, and restoration of the site upon closure.
(2) The permit conditions including emission limit values must be based on the Best Available Techniques (BAT). In order to define BAT and the BAT-associated environmental performance at EU level, the Commission organises an exchange of information with experts from Member States, industry and environmental organisations. This work is co-ordinated by the European IPPC Bureau of the Institute for Prospective Technology Studies at the EU Joint Research Centre in Seville (Spain). This process results in BAT Reference Documents (BREFs); the BAT conclusions contained are adopted by the Commission as Implementing Decisions. The IED requires that these BAT conclusions are the reference for setting permit conditions.
(3) The IED allows competent authorities some flexibility to set less strict emission limit values. This is possible only in specific cases where an assessment shows

that achieving the emission levels associated with BAT described in the BAT conclusions would lead to disproportionately higher costs compared to the environmental benefits due to the geographical location or the local environmental conditions or the technical characteristics of the installation.

(4) The IED contains mandatory requirements on environmental inspections. Member States shall set up a system of environmental inspections and draw up inspection plans accordingly. The IED requires a site visit to take place at least every 1 to 3 years, using risk-based criteria.

(5) The IED ensures that the public has a right to participate in the decision-making process, and to be informed of its consequences, by having access to permit applications, permits and the results of the monitoring of releases.

2.2.9 Environmental Impact Assessment (EIA) Directive 2014/52/EC (EC 1985)

This directive is in force since 1985 and applies to a wide range of defined public and private projects, which are defined in Annexes I and II. Its objective is to simplify the procedures for assessing environmental impact, define timeframes for the different stages of environmental assessment, and improve the quality, transparency of EIA reports. All projects listed in Annex I are considered as having significant effects on the environment and require an EIA (e.g. long-distance railway lines, motorways and express roads, airports with a basic runway length $\geq$2100 m, installations for the disposal of hazardous waste, installations for the disposal of non-hazardous waste >100 tonnes/day, waste water treatment plants >150.000 p.e.), and therefore are considered as mandatory EIA.

For projects listed in Annex II, the national authorities have to decide whether an EIA is needed (i.e. the need of an EIA is decided at discretion of Member States). This is done by the 'screening procedure', which determines the effects of projects on the basis of thresholds/criteria or a case by case examination. However, the national authorities must take into account the criteria laid down in Annex III. The projects listed in Annex II are in general those not included in Annex I (i.e. railways, roads waste disposal installations, waste water treatment plants), but also other types such as urban development projects, flood-relief works.

2.3 Regulations

This section reviews two regulations, which are related to 'Eco-Management and Audit Scheme' and 'Eco-Labels'.

2.3.1 Eco-Management and Audit Scheme Regulation (EMAS) (EC) No 1221/2009 (EC 2009c)

It is a management instrument developed by the European Commission for companies and other organisations to evaluate, report, and improve their environmental performance. EMAS is open to every type of organisation eager to improve its environmental performance. It spans all economic and service sectors and is applicable worldwide.

EMAS supports organisations in finding the right tools to improve their environmental performance. The organisations that voluntarily participate, commit to, both evaluating and reducing, their environmental impact. Third party verification guarantees the external and independent nature of the EMAS registration process. Providing publicly available information on an organisation's environmental performance is an important aspect of EMAS. Organisations achieve greater transparency both externally, through the environmental statement, and internally through employees' active involvement.

EMAS can help to reduce the environmental impact of the company, strengthen legal compliance and employee involvement, and save resources and money. The key benefits of EMAS are: (1) Enhanced credibility, transparency and reputation, (2) Enhanced environmental risks and opportunities management, (3) Enhanced environmental and financial performance, and (4) Enhanced employee empowerment and motivation.

2.3.2 Eco-Label Regulation (EC) No 66/2010 (EC 2010c)

It concerns the European Union (EU) Ecolabel which is a voluntary environmental labelling scheme.

It enables consumers, by means of transparent ecological criteria, to make conscious choices without compromising on the quality of the products.

It may be awarded to products and services which have a lower environmental impact than other products in the same group. The label criteria were devised using scientific data on the whole of a product's life cycle, from product development to disposal. The label is awarded in consideration of European environmental and ethical objectives. It also promotes the EU's transition to a circular economy, supporting both sustainable production and consumption.

The label may be awarded to all goods or services distributed, consumed or used on the EU market whether in return for payment or free of charge, on condition that the ecological criteria have been clearly established. It does not apply to medicinal products for human or veterinary use, or to medical devices.

The system was introduced by Regulation (EEC) No 880/92 and amended by Regulation (EC) No 1980/2000. This Regulation (EC) No 66/2010 aims to improve the rules on the award, use and operation of the label.

2.4 Standards

Two types of standards, IEC and ISO, are reviewed in this section. The former is about design for electrical and electronic products, while the latter consists of 25 standards, including four standards regarding environmental management systems, five standards regarding environmental labels and declarations, 12 standards related to specific topics of environmental management, and four standards about greenhouse gases. The standards are listed in Table 2.2 and further reviewed in this section after the table.

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2.4.1 IEC 62430:2009 Standard of 'Environmentally Conscious Design for Electrical and Electronic Products' (IEC 2009)

It applies to all the electrical/electronic products. This international standard provides a set of requirements for the process of environmentally conscious design reflecting the contents of IEC Guide 114 and ISO/TR 14062. This International Standard is intended for use by all those involved in the design and development of electrical and electronic products. To ensure consistency throughout the electro-technical sector the use of this standard as a base reference is encouraged.

2.4.2 The ISO 14000 Family of 'Environmental Management' Related Standards

The standards of this family provide practical tools for companies and organizations of all kinds looking to manage their environmental responsibilities, facilitating sustainable product design and manufacturing. 25 standards are reviewed within in this family, which are grouped into four groups: four standards of Environmental management systems, five standards of environmental labels and declarations, 12 standards of environmental management specific topics, and four standards of greenhouse gases, as further detailed below.

2.4.2.1 Environmental Management Systems

This group of four standards cover the following aspects: Requirements with guidance for use, general guidelines on implementation, guidelines for the phased implementation of an environmental management system, and guidelines for incorporating eco-design, as with further information presented below:

Table 2.2 List of standards

2.4.1 IEC standard	
IEC 62430:2009	Environmentally conscious design for electrical and electronic products
2.4.2 ISO 14000 Standards 'Environmental Management'	
2.4.2.1 Environmental management systems	
ISO 14001:2015	Environmental management systems: Requirements with guidance for use
ISO 14004:2016	Environmental management systems: General guidelines on implementation
ISO 14005:2010	Environmental management systems: Guidelines for the phased implementation of an environmental management system, including the use of environmental performance evaluation
ISO 14006:2011	Environmental management systems: Guidelines for incorporating eco-design
2.4.2.2 Environmental labels and declarations	
ISO 14020:2000	Environmental labels and declarations: General principles
ISO 14021:2016	Environmental labels and declarations: Self-declared environmental claims (Type II environmental labelling)
ISO 14024:2018	Environmental labels and declarations: Type I environmental labelling: Principles and procedures
ISO 14025:2006	Environmental labels and declarations: Type III environmental declarations: Principles and procedures
ISO 14026:2017	Environmental labels and declarations: Principles, requirements and guidelines for communication of footprint information
2.4.2.3 Environmental management	
(1) Standards of miscellaneous topics related to environmental management	
ISO 14031:2013	Environmental management: Environmental performance evaluation: Guidelines
ISO/TS 4033:2012	Environmental management: Quantitative environmental information: Guidelines and examples
ISO 14034:2016	Environmental management: Environmental technology verification (ETV)
ISO 14063:2006	Environmental management: Environmental communication: Guidelines and examples
ISO 14045:2012	Environmental management: Eco-efficiency assessment of product systems: Principles, requirements and guidelines
(2) Water footprints	
ISO 14046:2014	Environmental management: Water footprint: Principles, requirements and guidelines
ISO/TR 14073:2017	Environmental management: Water footprint: Illustrative examples on how to apply ISO 14046

(continued)

Table 2.2 (continued)

(3) Life cycle assessment	
ISO 14044:2006	Environmental management: Life cycle assessment: Requirements and guidelines
ISO/TR 14047:2012	Environmental management: Life cycle assessment: Illustrative examples on how to apply ISO 14044 to impact assessment situations
ISO/TS 14048:2002	Environmental management: Life cycle assessment: Data documentation format
ISO/TR 14049:2012	Environmental management: Life cycle assessment: Illustrative examples on how to apply ISO 14044 to goal and scope definition and inventory analysis
ISO/TS 14072:2014	Environmental management: Life cycle assessment: Requirements and guidelines for organizational life cycle assessment
2.4.2.4 Greenhouse gases	
ISO 14064-1:2006	Greenhouse gases: Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals
ISO 14064-2:2006	Greenhouse gases: Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements
ISO/TS 14067:2013	Greenhouse gases: Carbon footprint of products: Requirements and guidelines for quantification and communication
ISO/TR 14069:2013	Greenhouse gases: Quantification and reporting of greenhouse gas emissions for organizations: Guidance for the application of ISO 14064-1

- *ISO 14001:2015—Environmental management systems: Requirements with guidance for use (ISO 2015):*

It specifies the requirements for an environmental management system that an organization can use to enhance its environmental performance. it is intended for use by an organization seeking to manage its environmental responsibilities in a systematic manner that contributes to the environmental pillar of sustainability. It helps an organization achieve the intended outcomes of its environmental management system, which provide value for the environment, the organization itself and interested parties. Consistent with the organization's environmental policy, the intended outcomes of an environmental management system include: (1) enhancement of environmental performance, (2) fulfilment of compliance obligations, and (3) achievement of environmental objectives.

This standard is applicable to any organization, regardless of size, type and nature, and applies to the environmental aspects of its activities, products and services that the organization determines it can either control or influence considering a life cycle perspective. However, this standard does not state specific environmental performance criteria. This standard can be used in whole or in part to systematically improve environmental management.

- *ISO 14004:2016—Environmental management systems: General guidelines on implementation (ISO 2016a):*

It provides guidance for an organization on the establishment, implementation, maintenance and improvement of a robust, credible and reliable environmental management system. The guidance provided is intended for an organization seeking to manage its environmental responsibilities in a systematic manner that contributes to the environmental pillar of sustainability. The guidance in this International Standard can help an organization to enhance its environmental performance and enables the elements of the environmental management system to be integrated into its core business process.

This standard is applicable to any organization, regardless of size, type and nature, and applies to the environmental aspects of its activities, products and services that the organization determines it can either control or influence, considering a life cycle perspective.

The guidance in this International Standard can be used in whole or in part to systematically improve environmental management. It serves to provide additional explanation of the concepts and requirements.

- *ISO 14005:2010—Environmental management systems: Guidelines for the phased implementation of an environmental management system, including the use of environmental performance evaluation (ISO 2010):*

It provides guidance for all organizations, but particularly small and medium-sized enterprises, on the phased development, implementation, maintenance and improvement of an environmental management system. It also includes advice on the integration and use of environmental performance evaluation techniques.

It is applicable to any organization, regardless of its level of development, the nature of the activities undertaken or the location at which they occur.

- *ISO 14006:2011—Environmental management systems: Guidelines for incorporating eco-design (ISO 2011):*

It provides guidelines to assist organizations in establishing, documenting, implementing, maintaining and continually improving their management of eco-design as part of an environmental management system (EMS). It is intended to be used by those organizations that have implemented an EMS in accordance with ISO 14001, but can help in integrating eco-design in other management systems. The guidelines are applicable to any organization regardless of its size or activity. It applies to those product-related environmental aspects that the organization can control and those it can influence. It does not establish by itself specific environmental performance criteria, and is not intended for certification purposes.

It is applicable to any organization, regardless of size, type and nature, and applies to the environmental aspects of its activities, products and services that the organization determines it can either control or influence considering a life cycle perspective. However, it does not state specific environmental performance criteria. It can be used in whole or in part to systematically improve environmental management. Claims

of conformity to ISO 14001:2015, however, are not acceptable unless all its requirements are incorporated into an organization's environmental management system and fulfilled without exclusion.

2.4.2.2 Environmental Labels and Declarations

This group of five standards cover the following aspects: General principles, Self-declared environmental claims (Type II environmental labelling), Types I and III environmental labelling (Principles and procedures), and Principles, requirements and guidelines for communication of footprint information, with further information presented below:

- *ISO 14020:2000—Environmental labels and declarations: General principles (ISO 2000):*

This International Standard establishes guiding principles for the development and use of environmental labels and declarations. It is intended that other applicable standards in the ISO 14020 series be used in conjunction with this International Standard. This International Standard is not intended for use as a specification for certification and registration purposes.

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

This standard specifies requirements for self-declared environmental claims (Type II environmental labels), including statements, symbols and graphics, regarding products. It further describes selected terms commonly used in environmental claims and gives qualifications for their use. It 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. It does not preclude, override, or in any way change, legally required environmental information, claims or labelling, or any other applicable legal requirements.

- *ISO 14024:2018—Environmental labels and declarations: Type I environmental labelling: Principles and procedures (ISO 2018):*

It establishes the principles and procedures for developing Type I environmental labelling programmes, including the selection of product categories, product environmental criteria and product function characteristics, and for assessing and demonstrating compliance. It also establishes the certification procedures for awarding the label.

- *ISO 14025:2006—Environmental labels and declarations: Type III environmental declarations: Principles and procedures (ISO 2006a):*

It establishes the principles and specifies the procedures for developing Type III environmental declaration programmes and Type III environmental declarations. It

specifically establishes the use of the ISO 14040 series of standards in the development of Type III environmental declaration programmes and Type III environmental declarations.

This standard establishes principles for the use of environmental information, in addition to those given in ISO 14020:2000.

Type III environmental declarations as described in this standard are primarily intended for use in business-to-business communication, but their use in business-to-consumer communication under certain conditions is not precluded.

- *ISO 14026:2017—Environmental labels and declarations: Principles, requirements and guidelines for communication of footprint information (ISO 2017a):*

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. It does not address the quantification of a footprint, nor does it address the communication of footprints that are not related to the environment, e.g. footprints addressing social or economic issues. In particular, footprint communications relating to the economic and social dimensions of sustainable development are outside the scope of this standard. Footprint communications relating to organizations are also outside the scope of this standard.

2.4.2.3 Environmental Management

This group of standards are reviewed in three sub-groups: (1) five standards of miscellaneous topics which cover 'Environmental performance evaluation: Guidelines', 'Quantitative environmental information: Guidelines and examples', 'Environmental technology verification', 'Environmental communication: Guidelines and examples', and 'Eco-efficiency assessment of product systems: Principles, requirements and guidelines'; (2) two standard about water footprint, including 'Illustrative examples on how to apply ISO 14046' and 'Principles, requirements and guidelines'; and (3) five standards of lifecycle assessment covering the following aspects: 'Principles and framework', 'Requirements and guidelines', 'Data documentation format', 'Illustrative examples on how to apply ISO 14044 to impact assessment situations', 'Illustrative examples on how to apply ISO 14044 to goal and scope definition and inventory analysis, and 'Requirements and guidelines for organizational life cycle assessment'. Further information of the standard is presented below.

(1) *Standards of miscellaneous topics related to environmental management*

- *ISO 14031:2013—Environmental management: Environmental performance evaluation: Guidelines (ISO 2013a):*

It gives guidance on the design and use of Environmental Performance Evaluation (EPE) within an organization. It is applicable to all organizations, regardless of type, size, location and complexity.

It does not establish environmental performance levels.

The guidance in this standard 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.

- *ISO/TS 14033:2012—Environmental management: Quantitative environmental information: Guidelines and examples (ISO 2012a):*

It supports the application of standards and reports on environmental management. It provides guidelines on how to acquire quantitative environmental information and data and implement methodology. It gives guidelines to organizations on general principles, policy, strategy 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 or products.

It addresses issues related to defining, collecting, processing, interpreting and presenting quantitative environmental information. It provides guidelines on how to establish accuracy, verifiability and reliability for the intended use. It utilizes proven and well-established approaches for the preparation of information adapted to the specific needs of environmental management. It is applicable to all organizations, regardless of their size, type, location, structure, activities, products, level of development and whether or not they have an environmental management system in place.

It supplements the contents of other International Standards on environmental management.

- *ISO 14034:2016—Environmental management: Environmental technology verification (ETV) (ISO 2016c):*

The objective of Environmental Technology Verification (ETV) is to provide credible, reliable and independent verification of the performance of environmental technologies. An environmental technology is a technology that either results in an environmental added value or measures parameters that indicate an environmental impact. Such technologies have an increasingly important role in addressing environmental challenges and achieving sustainable development.

ETV contributes to protection and conservation of the environment by promoting and facilitating market uptake of innovative environmental technologies, especially those that perform better than relevant alternatives. ETV is particularly applicable to those environmental technologies whose innovative features or performance cannot be fully assessed using existing standards. Through the provision of objective evidence, ETV provides an independent and impartial confirmation of the performance of an environmental technology based on reliable test data. ETV aims to strengthen the credibility of new, innovative technologies by supporting informed decision-making among interested parties.

- *ISO 14063:2006—Environmental management: Environmental communication: Guidelines and examples (ISO 2006b):*

It gives guidance to an organization on general principles, policy, strategy and activities relating to both internal and external environmental communication. It utilizes proven and well-established approaches for communication, adapted to the specific conditions that exist in environmental communication. It is applicable to all organizations regardless of their size, type, location, structure, activities, products and services, and whether or not they have an environmental management system in place.

It is not intended for use as a specification standard for certification or registration purposes or for the establishment of any other environmental management system conformity requirements. It can be used in combination with any of the ISO 14000 series of standards, or on its own.

- *ISO 14045:2012—Environmental management: Eco-efficiency assessment of product systems: Principles, requirements and guidelines (ISO 2012b):*

It describes the principles, requirements and guidelines for eco-efficiency assessment for product systems including: (1) the goal and scope definition of the eco-efficiency assessment, (2) the environmental assessment, (3) the product-system-value assessment, (4) the quantification of eco-efficiency, (5) interpretation (including quality assurance), (6) reporting, and (7) critical review of the eco-efficiency assessment.

Requirements, recommendations and guidelines for specific choices of categories of environmental impact and values are not included. The intended application of the eco-efficiency assessment is considered during the goal and scope definition phase, but the actual use of the results is outside the scope of this standard.

(2) *Water footprints*

- *ISO 14046:2014—Environmental management: Water footprint: Principles, requirements and guidelines (ISO 2014a):*

It specifies principles, requirements and guidelines related to water footprint assessment of products, processes and organizations based on LCA.

It provides principles, requirements and guidelines for conducting and reporting a water footprint assessment as a stand-alone assessment, or as part of a more comprehensive environmental assessment. Only air and soil emissions that impact water quality are included in the assessment, and not all air and soil emissions are included.

Whereas reporting is within the scope of this standard, communication of water footprint results, for example in the form of labels or declarations, is outside the scope of the standard.

- *ISO/TR 14073:2017—Environmental management: Water footprint: Illustrative examples on how to apply ISO 14046 (ISO 2017b):*

It provides illustrative examples of how to apply ISO 14046, in order to assess the water footprint of products, processes and organizations based on life cycle assessment.

The examples are presented to demonstrate particular aspects of the application of ISO 14046 and therefore do not present all of the details of an entire water footprint study report as required by ISO 14046.

(3) *Life cycle assessment*

- *ISO 14044:2006—Environmental management: Life cycle assessment: Requirements and guidelines (ISO 2006c):*

It specifies requirements and provides guidelines for 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, relationship between the LCA phases, and conditions for use of value choices and optional elements. It covers LCA studies and LCI studies.

- *ISO/TR 14047:2012—Environmental management: Life cycle assessment: Illustrative examples on how to apply ISO 14044 to impact assessment situations (ISO 2012c):*

The purpose of this standard is to provide examples to illustrate current practice of life cycle impact assessment according to ISO 14044:2006. These examples are only a sample of all possible examples that could satisfy the provisions of ISO 14044. They offer "a way" or "ways" rather than the "unique way" of applying ISO 14044. They reflect the key elements of the life cycle impact assessment (LCIA) phase of the LCA. The examples presented in this standard are not exclusive and other examples exist to illustrate the methodological issues described.

- *ISO/TS 14048:2002—Environmental management: Life cycle assessment: Data documentation format (ISO 2002):*

This Technical Specification provides the requirements and a structure for a data documentation format, to be used for transparent and unambiguous documentation and exchange of LCA and LCI data, thus permitting consistent documentation of data, reporting of data collection, data calculation and data quality, by specifying and structuring relevant information.

The data documentation format specifies requirements on division of data documentation into data fields, each with an explanatory description. The description of each data field is further specified by the structure of the data

documentation format. This Technical Specification is applicable to the specification and structuring of questionnaire forms and information systems. However, it can also be applied to other aspects of the management of environmental data. This Technical Specification does not include requirements on completeness of data documentation. The data documentation format is independent of any software or database platform for implementation.

This Technical Specification does not require any specific sequential, graphic or procedural solutions for the presentation or treatment of data, nor does it describe specific modelling methodologies for LCI and LCA data.

- *ISO/TR 14049:2012—Environmental management: Life cycle assessment: Illustrative examples on how to apply ISO 14044 to goal and scope definition and inventory analysis (ISO* 2012d*):*

It provides examples about practices in carrying out a LCI as a means of satisfying certain provisions of ISO 14044:2006. These examples are only a sample of the possible cases satisfying the provisions of ISO 14044. They offer "a way" or "ways" rather than the "unique way" for the application of ISO 14044. These examples reflect only portions of a complete LCI study.

- *ISO/TS 14072:2014—Environmental management: Life cycle assessment: Requirements and guidelines for organizational life cycle assessment (ISO* 2014b*):*

It provides additional requirements and guidelines for an effective application of ISO 14040 and ISO 14044 to organizations. It provides guidelines about: (1) the application of LCA principles and methodology to organizations, (2) the benefits that LCA can bring to organizations by using LCA methodology at organizational level, (3) the system boundary, (4) specific considerations when dealing with LCI, LCIA, and interpretation, and (5) the limitations regarding reporting, environmental declarations, and comparative assertions.

This standard applies to any organization that has interest in applying LCA. It specifically covers the goals of ISO 14040 and ISO 14044.

2.4.2.4 Greenhouse Gases

This group of standards cover the following aspects: 'Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals', 'Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements', 'Carbon footprint of products: Requirements and guidelines for quantification and communication', and 'Quantification and reporting of greenhouse gas emissions for organizations: Guidance for the application of ISO 14064-1', with further information presented below.

- *ISO 14064-1:2006—Greenhouse gases: Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals (ISO 2006e):*

It specifies principles and requirements at the organization level for 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 14064-2:2006 Greenhouse gases: Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements (ISO 2006e):*

It specifies principles and requirements and provides guidance at the project level for quantification, monitoring and reporting of activities intended to cause GHG emission reductions or removal enhancements. It includes requirements for planning a GHG project, identifying and selecting GHG sources, sinks and reservoirs relevant to the project and baseline scenario, monitoring, quantifying, documenting and reporting GHG project performance and managing data quality.

- *ISO/TS 14067:2013—Greenhouse gases: Carbon footprint of products: Requirements and guidelines for quantification and communication (ISO 2013b):*

It specifies principles, requirements and guidelines for the quantification and communication of the Carbon FootPrint of a product (CFP), based on International Standards on life cycle assessment (ISO 14040 and ISO 14044) for quantification and on environmental labels and declarations (ISO 14020, ISO 14024 and ISO 14025) for communication.

This standard is applicable to CFP studies and different options for CFP communication based on the results of such studies.

This standard also provides for the development of CFP-Product Category Rules (CFP-PCR), or the adoption of PCR that have been developed in accordance with ISO 14025 and that are consistent with ISO/TS 14067:2013. This standard only addresses one impact category: climate change.

- *ISO/TR 14069:2013—Greenhouse gases: Quantification and reporting of greenhouse gas emissions for organizations: Guidance for the application of ISO 14064-1 (ISO 2013c):*

It describes the principles, concepts and methods relating to the quantification and reporting of direct and indirect GHG emissions for an organization. It provides guidance for the application of ISO 14064-1 to greenhouse gas inventories at the organization level, for the quantification and reporting of direct emissions, energy indirect emissions and other indirect emissions.

It describes for all type of organizations, including local authorities, the steps for: (1) establishing organizational boundaries, in accordance with either a control approach (financial or operational) or an equity share approach, (2) establishing operational boundaries, by identifying direct emissions and energy indirect emissions

to be quantified and reported, as well as any other indirect emissions the organization chooses to quantify and report; for each category of emission, guidance is provided on specific boundaries and methodologies for the quantification of GHG emissions and removals, (3) GHG reporting: guidance is provided to promote transparency regarding the boundaries, the methodologies used for the quantification of direct and indirect GHG emissions and removals, and the uncertainty of the results.

2.5 Application of Directives, Regulations and Standards in Sustainable Product Design and Manufacture

Regulations, directives and standards can be applied in design and manufacturing processes to comply with environmental legislation and/or reduce the environmental and social impact of products. However, all these tools have different purposes and are applied differently during the design and manufacturing process.

Regulations and directives usually prescribe design recommendations which have to be taken into account during the design process. For example, the Energy-related Products (ErP) Directive 2009/125/EC (European Commission 2009a, b) provide general recommendations about how to improve the energy efficiency of energy-using products throughout their life cycle. These design guidelines/recommendations have to be included at the beginning of the design process, during the 'product design specifications' stage, so these design recommendations can be considered during the definition of the initial concept of the product. Another example is the Restriction of Hazardous Substances (RoHS) directive which ban the utilisation of specific amount of certain hazardous substances in products. This recommendation also has to be taken into account during the material selection stage of the design process.

The application of standards is not compulsory during the design and manufacturing processes. However, some tests and certifications oblige to follow certain standards to be valid and be recognised in industry. For example, standards provide the protocols and procedures used to carry out the tests which are necessary to improve the reliability of the product, to obtain a certification (e.g. CE mark, IP test), or to conduct a performance analysis/tests (e.g. energy consumption analysis).

2.6 Concluding Remarks

After giving brief definitions of the three terms 'directives', 'regulations' and 'standards' which are specially addressed in this chapter, the authors reviewed nine directives, two regulations and 26 standards related to the design and manufacture of sustainable products.

With the increasing demands for sustainable products, the product designers and manufacturers must comply with the sustainability related directives, regulation and

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standards. However, it is a challenge for the designers and manufacturers to find the related directives, regulations and standards for their particular product development tasks. The review presented in this chapter provides support for the product designers and manufacturers to overcome the challenge.

In addition, at the end of this chapter, it is presented how to apply the directives, regulations and standards in sustainable product design and manufacture. This is valuable guidelines for product designers and manufactures in their sustainable product development practice. As examples of successful applications, the guidelines have been applied in eco-lighting products (Casamayor and Su 2013) and implemented in the myEcoCost project supported by the European Commission FP7 programme (Geibler et al. 2015).

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Chapter 2

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