



Learner Centric Advanced Manufacturing Platform



ENERGY EFFICIENCY & LIFE CYCLE

WPN° 3 Observatory



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GLOSSARY AND/OR ACRONYMS

AI - Artificial Intelligence

AM - Advanced Manufacturing

Cedefop - European Centre for the Development of Vocational Training

CoVE - Centres of Vocational Excellence

EAfA - European Alliance for Apprenticeships

EC - European Commission

ECVET - European Credit System for Vocational Education and Training

EntreComp - The Entrepreneurship Competence Framework

EQAVET - European Quality Assurance in Vocational Education and Training

EQF - European Qualifications Framework

ESCO - European Skills, Competences and Occupations

ETF - European Training Foundation

EU - European Union

HE - Higher Education

HVET - Higher Vocational Education and Training

I4.0 - Industry 4.0

KET - Key Enabling Technology

OECD - Organisation for Economic Cooperation and Development

SME - Small and Medium Enterprises

SWOT - Strengths, Weaknesses, Opportunities, Threats

TVET - Technical and Vocational Education and Training

VET - Vocational Education and Training

WBL - Work Based Learning



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EXECUTIVE SUMMARY

Advanced Manufacturing (AM) and Higher Vocational Education and Training (HVET) need to update training, implement new technologies, and get quick access to data.

The causes behind these needs are technological factors (Industry 4.0), factors conditioned by education systems and education methodologies, social factors and environmental factors (the European Green Deal with its emphasis on the greening industry).

Under the CoVE initiative, the LCAMP project aims to support regional skill ecosystems and various stakeholders in providing new skills and implementing new or updated technologies in VET centres. LCAMP will tackle this by incorporating a permanent European Platform of Vocational Excellence for Advanced Manufacturing.

By collaborating across borders, LCAMP's goal is to support and empower regional Advanced Manufacturing CoVEs to become more resilient, innovative, and better equipped to train, upskill, and reskill young and adult students, to successfully face the digital and green transitions. We will help European regions and countries grow and be more competitive through their VET systems.

Therefore, the LCAMP OBSERVATORY is one of the services in the LCAMP platform. The observatory is led by the French cluster *Mecanic Vallée* and the French VET provider *Campus des Métiers et des Qualifications d'Excellence Industrie du Futur*.

This present document details the first results of the LCAMP Observatory, through the methodology that the LCAMP consortium used to set up and run the Observatory. We had set up a process cycle for the observation consisting of 5 stages:

- Stage 1: Diagnosis and priority
- Stage 2: Search and information gathering
- Stage 3: Information Analysis
- Stage 4: Creating value. Elaboration of LCAMP reports
- Stage 5: Dissemination and communication.

1. INTRODUCTION

The LCAMP observatory is one of the services of the LCAMP platform.

The LCAMP Observatory must be a reliable and easily accessible source of information and data for trainers, VET teachers, and professionals, updated on Digital / Advanced Manufacturing / Smart Industry, delivered through a multimedia and interactive platform - LCAMP platform-, that can be customized according to individual interests (Work in progress in WP8).

This observatory must feed other Work packages (WP), for instance, WP 5 on Learner Centric Training, or Open innovation Community in the WP4.

In a first document about methodology, are set up a process cycle for the observation consisting in 5 stages:

- Stage 1: Diagnosis and priority
- Stage 2: Search and information gathering
- Stage 3: Information Analysis
- Stage 4: Create value. Elaboration of LCAMP reports
- Stage 5: Disseminate-communicate.

Following this process cycle, are detailed the main aspects of the observation methodology:

- Identify reliable sources that we can find in Europe about Advanced Manufacturing.
- Classify and filter data gathered from different sources.
- Present several ways to collect data and to analyse them.
- Define the methods for the creation of annual reports.
- Validate process for those reports.

The observatory will publish periodical reports for VET and HMET target audiences about technology trends, labour market changes, skill needs, and occupations in Advanced Manufacturing. It is expected that SMEs, industry clusters and other associations will also find valuable information in the observatory.

The publication of a yearly report is planned.

- Report 1: June 2023,
- Report 2: June 2024,
- Report 3: June 2025.



This first annual report is gathering sub-reports written by around twenty different writers, from the main partners involved in the LCAMP project. 39 Topics were determined, and 22 TOPICS were analysed and worked on during this first period.



2. TOPICS

The purpose of this chapter is to present some of the development areas related to AM.

These are topics that concern all or some of the stakeholders

- CoVEs and VETs: teachers, trainers and heads of VET schools;
- Learners: students, active workers, job seekers;
- Companies;
- Policy makers and other stakeholders

2.1 ENERGY EFFICIENCY & LIFE CYCLE

2.1.1 Main used Sources

Table 1 : Presentation and brief description of main sources

Source				Scope	
Identification [1]	type of source	links	description	Geographical scope.	Sectorial scope
PUBLIC SOURCES					
EFFRA	website	https://www.effra.eu/	The European Factories of the Future Research Association (EFFRA) is a non-for-profit, industry-driven association promoting the development of new and innovative production technologies. EFFRA has been representing the private side of	Europe	Multisector



Source				Scope	
Identification [1]	type of source	links	description	Geographical scope.	Sectorial scope
			the manufacturing partnership with the EU Commission. Named under Horizon 2020, Factories of the Future to become Made in Europe nowadays under Horizon Europe		
Groupe AFNOR	website	www.afnor.fr	French national agency for standardization	International	Multisector
CORDIS		https://cordis.europa.eu/search/fr?q=%27advanced%27%20AND%20%27manuf acturing%27%20AND%20%27trends%27&p=1&num=10&srt=Relevance:decreasing	European Website about European Projects	Europe	
TRAINING SOURCES					
MINALOGIC	website	https://www.minalogic.com/	European competitiveness cluster on mechanics	EU & Regional France	Aerospace
CETIM	website	www.cetim.fr https://www.cetim-engineering.com/	French national agency for all mechanics subjects & Ind 4.0		Multisector
FRANCE COMPETENCES	website	https://www.francecompetences.fr/	French National Center for technical learning	France	Industry and I 4.0
EFVET	website	https://www.efvet.org/who-we-are/	EFVET is the European Forum of Technical and Vocational Education and Training	Europe	
industrial SOURCES					
BPi	website & News letter	https://www.bpifrance-universite.fr/formation/e-parcours-industrie-du-futur/	French National Public Bank for development	France	Industry and I 4.0
Usine Nouvelle	website & Newspaper	https://www.usinenouvelle.com/	French national Newspaper for Industry	France	Multisector



2.1.2 Main Data

Table 2 : Presentation and brief description of data

Source	Topic Analysis	
Identification	Topic name	Internet links
PUBLIC SOURCES		
EFFRA	Pathways to Energy Efficient Manufacturing workshop at Sustainable Places 2021	https://www.effra.eu/events/pathways-energy-efficient-manufacturing-workshop-sustainable-places-2021
Groupe AFNOR	Efficacité énergétique dans l'industrie : AFNOR Energies forme	https://www.afnor.org/actualites/efficacite-energetique-dans-lindustrie-afnor-energies-forme-et-conseille/
	Audit énergétique : faites-le avec la NF EN 16247 version 2022	https://www.afnor.org/actualites/audit-energetique-nf-en-16247-version-2022/
CORDIS	Assessing the intangibles: the socioeconomic benefits of improving energy efficiency	https://cordis.europa.eu/project/id/649619
CORDIS	NEW TRENDS IN ENERGY DEMAND MODELING	https://cordis.europa.eu/project/id/893311
CORDIS	CReating Innovative Sustainability Pathways	https://cordis.europa.eu/project/id/265310/reporting
TRAINING SOURCES		
FRANCE COMPETENCES	Speed up your ecological and energy transition	https://www.cetim-engineering.com/speed-up-your-ecological-and-energy-transition/
industrial SOURCES		
BPi	Formation : Réalisez des économies vertueuses grâce à l'efficacité énergétique	https://www.bpifrance-universite.fr/formation/realisez-des-economies-vertueuses-grace-a-lefficacite-energetique/
	Efficacité énergétique : comment consommer moins d'énergie et de ressources naturelles et réduire son empreinte environnementale ?	https://www.bpifrance-universite.fr/formation/efficacite-energetique-comment-consommer-moins-denergie-et-de-ressources-naturelles-et-reduire-son-empreinte-environnementale/
Usine Nouvelle	Décarboner la production : les leviers de l'accélération	https://www.usinenouvelle.com/article/dossier-production-decarboner-s-impose.N2099161



2.1.3 Context and presentation

This document provides the analysis of different approaches to foster and compare industrial 4.0 impacts on supply chain, from cradle to grave, to assess the state-of-the-art situation.

Starting from an overview on policy initiatives and instruments, which define the basic framework and requirements for the development of a potential approach for industrial 4.0 impact on supply chain, the present approaches related to all part of life product from cradle to grave, and for main industry 4.0 technologies.

This includes energy management systems, energy audits, environmental management systems, voluntary agreements, LCA (, life cycle assessment), LCC (life cycle costing), Industry 4.0 impact on supply chain, links between Industry 4.0 technologies on supply chain, and other sustainability management systems.

Based on this, an analysis of the existing approaches towards Industry 4.0 impact on supply chain is performed and clear criteria Industry 4.0 impacts on supply chain are derived.

2.1.4 Summary and Synthesis

Various policy initiatives and instruments define the basic framework and the requirements for developing a potential approach for Industry 4.0 impact on supply chain.

Next, there are principle problems with present approaches related to the subject; none of these approaches is actually enabling a comparison of performances of companies as proposed by Europe for manufactured products:

- Energy management certificates confirm that a company is working to improve its energy efficiency according to a given management standard (ISO 50001). However, this gives no information on the actual energy efficiency achieved in its operations.
- Industry 4.0 benchmarks only provide reasonable information if the industrial operations of different companies are sufficiently similar to allow for comparison.
- Life cycle analysis also is performed on a product, not for a company, and hence would needs to be done at least for every class of products of a company to generate results at company level. Comparison between companies would still be possible only for the same class of products produced in the different companies.
- There are very few research studies available that explains Industry 4.0 technologies' impact on manufacturing companies' supply chain and Industry 4.0 technologies' role in achieving supply chain sustainability as explained by Naseem, and Yang (August 2021) ²: only 57 documents published.

Most of the supply chain models include only the traditional procurement-production-distribution sub-processes used for converting raw materials to final products and deliver them to the wholesalers, retailers or directly to end users. In our case, study is showed a complex green supply chain model in which sophisticated operation research heuristics has to be used to find the optimal solution in order to minimize the costs on all the supply chain.

The introduction of this approach generates new technological and non-technological needs. The change in ownership and material management concepts, both at a consumer and at business level, generates a need for upscaling and acceleration of business concepts such as:



products as a service, sharing platforms, peer-to-peer interactions, and industrial symbiosis. Industrial symbiosis approach focuses on the hidden value of waste resources within an industrial network which can be exploited through the cooperation.¹

As suggested by Wuppertal Institute, the diversity of policy instruments can be distinguished according to strength of strategic measures and determining factors as shown in the matrix below. With regard to the scope of the present analysis, this differentiation provides already a first intuitive view on the relevance of a potential scheme for energy characterisation of companies in relation to such policy instruments.

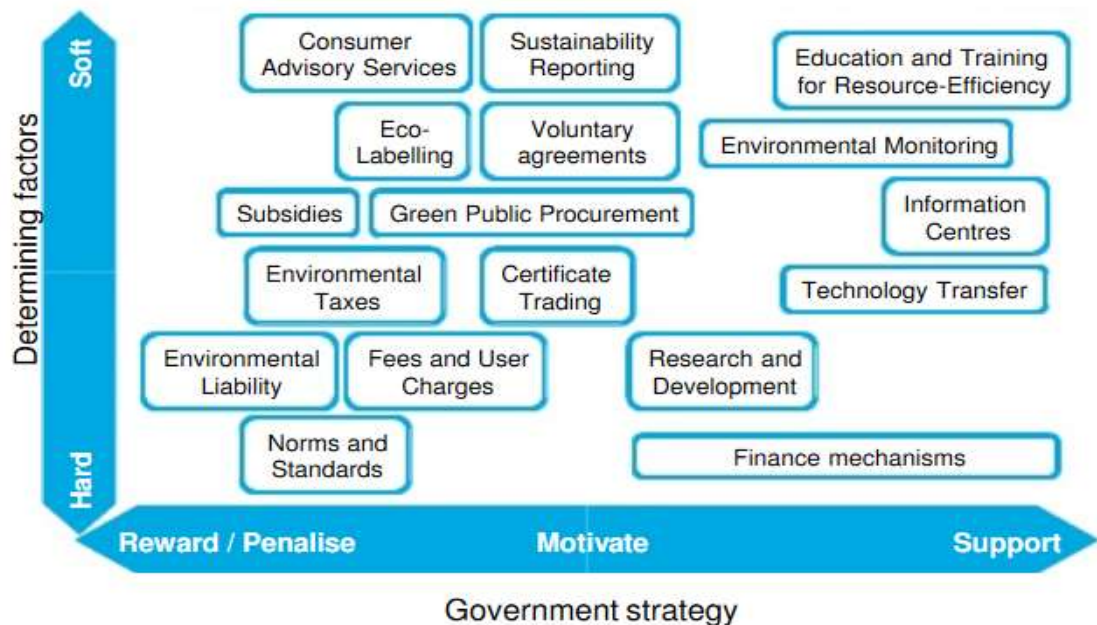


Figure 1 Resource efficiency policy matrix

In the following review, the above policy instruments have been grouped under the following five main themes:

- Regulatory Instruments (norms and standards, liability and control)
- Economic Instruments (taxes, fees and charges, certificate trading, and environmental financing, procurement and subsidies)
- Research & Educational Instruments
- Cooperation Instruments (technology transfer, voluntary agreements)
- Informational Instruments (eco labels, reporting, information centres)

Any meaningful characterisation of companies must provide relevant information with regard to such policy instruments. In particular, the requirement is to develop an approach that would be coherent with the EU Eco-design directive.

¹ Muhammad Hamza Naseem et Jiaqi Yang, « Role of Industry 4.0 in Supply Chains Sustainability: A Systematic Literature Review », *Sustainability* 13, n° 17 (janvier 2021): 9544, <https://doi.org/10.3390/su13179544>.



2.2 DATA ANALYSIS

2.2.1 Introduction

None of these approaches about energy efficiency is actually enabling a comparison of performances of companies as proposed by Europe for manufactured products:²

- Energy management certificates confirm that a company is working to improve its energy efficiency according to a given management standard (ISO 50001). However, this gives no information on the actual energy efficiency achieved in its operations.
- Industry 4.0 benchmarks only provide reasonable information, if the industrial operations of different companies are sufficiently similar to allow comparisons.
- Life cycle analysis also is performed on a product, not for a company, and hence would need to be done at least for every class of products of a company to generate results at company level. Comparison between companies would still be possible only for the same class of products produced in the different companies.
- There are very few research studies available that explain Industry 4.0 technologies' impact on manufacturing companies' supply chain, life cycle and Industry 4.0 technologies' role in achieving supply chain sustainability.

2.2.2 Contextualisation

So, we need to review most of approaches to determine best trends in this subject, and thereafter, best trends in training and new courses.

2.2.3 Objectives / Problem statement

Objectives

To get best trends in this subject, and thereafter, best trends in training and new courses.

Problem statement

So, we can study present norms and standards, and the so few analysis methods on energy efficiency and Life cycles.

² Anbesh Jamwal et al., « Industry 4.0 Technologies for Manufacturing Sustainability: A Systematic Review and Future Research Directions », *Applied Sciences* 11, n° 12 (janvier 2021): 5725, <https://doi.org/10.3390/app11125725>.



Norms and Standards

Norms and standards include laws, directives and technical guidance documents as far as these are legally binding.³

- Emission standards for maximum level of permitted emissions
Ambience standards for minimum level of air, water or soil quality
- Technology standards that describe what kind of technology must be used
- Management and process standards
- Product standards for certain product characteristics.

Energy Efficiency Directive

In Europe, since 2015, companies that are not SME (≥ 250 people, ≥ 50 Million turnover) are obliged to improve their energy efficiency and to have an energy audit performed. Article 8 of the European Energy Efficiency Directive describes the obligation for companies to perform an accredited energy audit at least every 4 years, with minimum demands prescribed (Annex VI of the Directive). Excluded are companies that hold a certificate of a management system, which includes an energy management system.

The most important systems are:

- ISO 50001 with a specific focus on Energy Management Systems
- EN 16247 on Energy Audits
- ISO 14001 as long as it includes an energy audit.

ISO 50 001 Energy Management System

Using energy efficiently helps organizations save money as well as helping to conserve resources and tackle climate change. ISO 50001 supports organizations in all sectors to use energy more efficiently, through the development of an energy management system (EnMS).

ISO 50001 is based on the management system model of continual improvement also used for other well-known standards such as ISO 9001 or ISO 14001. This makes it easier for organizations to integrate energy management into their overall efforts to improve quality and environmental management.

ISO 50001 describes the requirements for an energy management system. The standard is intended to help organisations with the development of systems and processes for improvement of energy-efficiency. ISO 50001 provides guidelines for both small and large organizations:

- To improve energy management systematically
- Set up an energy management system, implement, improve and / or maintain
- Ensure that the energy system is up to date

³ Bundesumweltministeriums, « Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection », Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection, consulté le 12 mai 2023, <https://www.bmuv.de/WS1-1>.



- Assess and evaluate their energy management on the basis of the standard
Demonstrate this to customers and stakeholders

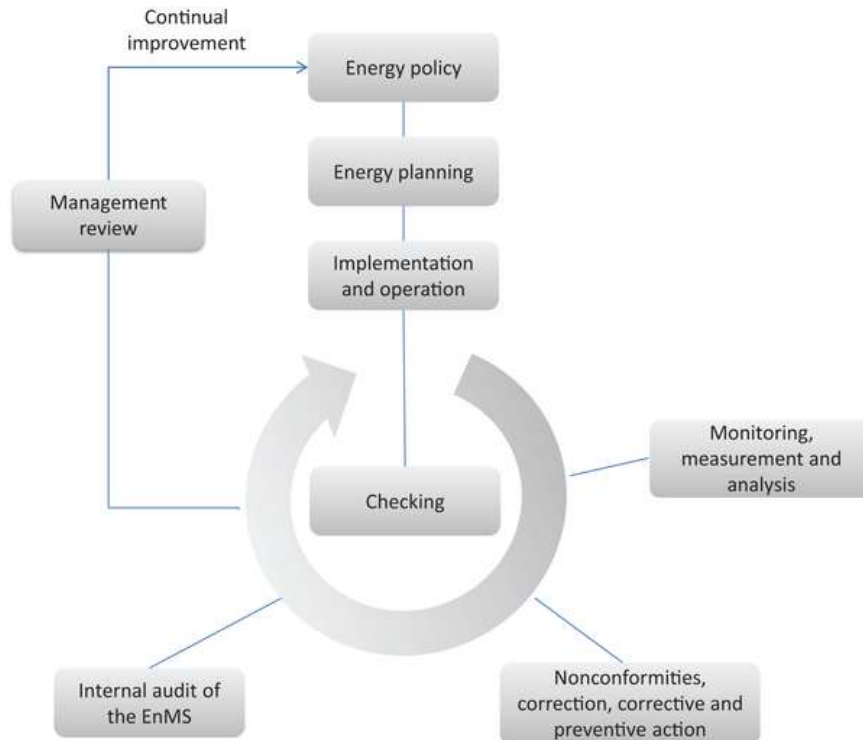


Figure 2 Graphic: Energy management system model for ISO 50001

This International Standard is based on the 'Plan - Do - Check – Act' (PDCA) continual improvement framework and incorporates energy management into everyday organizational practices, as illustrated in the following figure. In addition, ISO/TC 242, has developed additional standards regarding energy.

ISO 14001 Environmental Management System

The 14001 pays only limited attention to energy related topics, so the additional module ISO 14051 is needed to qualify for exemption. Therefore, an ISO 14001 certificate only exempts an organisation from the obligation to perform an energy audit if the MFCA, described in the ISO 14051 module, is included.

Environmental Liability

Environmental liability holds a polluter responsible for any environmental impact he has caused. First, liability serves to compensate parties who have suffered injury or damage, which can include both individuals and 'society'. Second, as liability creates a cost for causing harm, it



provides a direct incentive not to pollute and to reduce corporate environmental risks (Comm.2000, GTZ 1995, von Seth/Ott 2000)⁴⁵.

Environmental Control and Enforcement

Environmental control and enforcement include activities to inspect companies whether they comply with regulations, standards and laws. They therefore include

- Permissions by authorities
- Inspection of companies
- Checking of emissions and environmental impacts
- Control information submitted to the private sector
- Control of environmental self-control of companies.

2.2.4 Economic Instruments

Environmental Taxes

Environmental taxes (eco-taxes) however put into early positive environmental impact. They are collected from business, consumers or any other organisation. Environmental taxes can be applied on different ways, on emissions, on product tax, on natural resources.^{6 7}

Fees and User-Charges

Fees and user charges are provided by services where the revenue is used for a specific purpose. They can be collected from business or from private consumers. Fees depend on the individual benefit; general government bodies outside can apply them⁸:

Certificate Trading

In certificate trading systems, authorities allow certificate holders and maximum quantity of emissions to the environment or the use of environmental records up to a defined maximum. Certificates can be treated among firms. The maximum quantity of emissions to the environment is fixed. Procedures and rules for treating difficulties need to be set. Emissions need to be measured and reported.⁹

⁴ EU Environmental Liability Directive <https://ec.europa.eu/environment/liability/index.html>

⁵ Techniques for environmental economic valuation <https://www.epa.qld.gov.au/publications?id=710>

⁶ « To Be Assisted in the Ecodesign of Your Products | Ecosystem », Ecosystem, s. d., <https://www.ecosystem.eco/en/category/ecodesign-approach>.

⁷ « Soörüz rewarded for its innovative and eco-responsible approach - EuroSIMA », <https://www.eurosima.com/> (blog), s. d., <https://www.eurosima.com/sooruz-recompense-pour-sa-demarche-innovante-et-eco-responsable/>.

⁸ Waste Water Charge Germany <http://www.umweltbundesamt.de/water/themen/gwr.htm>

⁹ « Home IETA », consulté le 12 mai 2023, <https://www.ieta.org/>.



Environmental Financing

Environmental financing is an instrument used for promoting environmentally beneficial measures through financial institutions or independent funds. Loans and/or grants are provided to fully or partially finance measures beneficial to the environment on more favourable terms than those in the prevailing market. Such measures are usually initiated through programmes of governments or credit lines of donor agencies with the necessary resources to provide the financial resources for such a scheme.¹⁰¹¹

Green Public Procurement

Green public procurement usually means that the acquisition of goods or services by the public sector considers environmental elements. Aim of Green public procurement is to encourage the market to produce and sell more environmentally sound products and services and thus to reduce their prices through economies of scale.¹²¹³

2.2.5 Findings

Energy and Environment management systems aim at providing guidance to companies on how to improve their energy use continuously. They are not undertaking to provide solutions for a characterisation of a company directly. Accordingly, the audits and certifications provided only concern the energy management of the companies.¹⁴

CSR performance ladder

The CSR (Corporate Social Responsibility) performance ladder is an internationally renowned certification scheme for companies that demonstrate their social responsibility. The system is based on the ISO 26 000 standard, which in itself is not a management system standard and is not intended for certification purposes. The CSR performance ladder is certifiable. Its origin lies in the Netherlands, but more and more is it internationally accepted as proof of social responsibility related to people, planet and profit, starting with Belgium and Norway.

In order to assess the performance of companies, the Global Reporting Initiative (GRI) has been set up. A set of indicators allows comparing the performance in the field of sustainability of various companies worldwide.¹⁵

¹⁰ « Home ADEME - the French Agency for Ecological Transition », The French Agency for Ecological Transition, s. d., <https://www.ademe.fr/en/frontpage/>.

¹¹ KfW - Environmental Programme Promotion with preferential credit terms, Germany

¹² Systemadmin_Umwelt, « Umweltfreundliche Beschaffung », Text, Umweltbundesamt (Umweltbundesamt, 22 août 2013), <https://www.umweltbundesamt.de/themen/wirtschaft-konsum/umweltfreundliche-beschaffung>.

¹³ UNEP Sustainable Procurement Website: <http://www.unep.fr/pc/sustain/policies/green-proc.htm>

¹⁴ « ISO - ISO 50001 — Energy Management », ISO, 20 octobre 2021, <https://www.iso.org/iso-50001-energy-management.html>.

¹⁵ « GRI - Standards », consulté le 12 mai 2023, <https://www.globalreporting.org/standards/>.



According to the website, the standard offers a structural approach in strategic steps for sustainable business performance by taking new levels of the CSR Performance Ladder:

- The CSR Performance Ladder has proven its value since June 2010
- 194 certificates were issued in the Netherlands and Belgium in 3 last years (which is more than OHSAS in the first years in the Netherlands)
- The standard is appreciated by the Dutch government in quotations and specifications
- The standard is already transformed to the High level Structure from the Annex SL/2012 -Guide 83 - (same will apply to ISO 9001, ISO 14001, ISO 18001 coming in 2015)
- Acceptance for accreditation for the standard is offered to the Dutch accreditation body (RvA), which does confirm that certification of a CSR management system is possible.

CO2 performance ladder

The purpose of the CO2-performance ladder is to let companies know their CO2 emissions and of their suppliers, to seek possibilities to reduce the emissions, and to work together with various actors for this purpose. Its origin was at the Dutch railroad maintenance company ProRail who used the scheme as a way to stimulate tender contestants to act sustainably and actively work on reduction of greenhouse gas emissions. Currently it is available for all companies.

An important aspect of the tool is the reduction of energy use.¹⁶

The CO₂ performance ladder has five levels, rising from 1 to 5. Each level has set requirements to the company's CO₂ performance. These requirements stem from four perspectives: understanding, reducing emissions, transparency, participation.

The level of a company is determined by the highest level at which it meets all the requirements.

EU Eco-design directive

The Eco-design Directive provides consistent EU wide rules for improving the environmental performance of products. The directive sets out the minimum mandatory requirements for the energy efficiency of these products. A stakeholder consultation forum is guiding the implementation of the directive. The consultation forum includes representatives from EU countries, industry and civil society.

The ultimate aim of the Eco-design Directive is that at the design stage, manufacturers of energy-using products will be obliged to reduce the energy consumption and other negative environmental impacts of products. While the Directive's primary aim is to reduce energy use, it is also aimed at enforcing other environmental considerations including: materials use; water use; polluting emissions; waste issues and recyclability.

¹⁶ « Home CO2 emissiefactoren », CO2 emissiefactoren, s. d., <https://www.co2emissiefactoren.nl/>.



The Eco-design Directive is a framework directive, meaning that it does not directly set minimum ecological requirements. These are adopted through specific implementing measures for each group of products in the scope of the Directive. The implementing measures are adopted through the so-called comitology procedure. Implementing measures are based on EU internal market rules governing which products may be placed on the market. Manufacturers who begin marketing an energy-using product covered by an implementing measure in the EU area have to ensure that it conforms to the energy and environmental standards set out by the measure.

Eco-design has proven to be a highly politically feasible instrument that is accepted by a wide range of stakeholders. Evidence suggests that the Directive has contributed not only to improve environmental performance of products but has also yielded positive effects on competitiveness of EU industry. This is obviously the reason for the requirement to propose an energy characterisation for companies coherent with the EU eco-design provisions.

Technically, the Eco-Design Directive is based on the Methodology for the Eco-design of Energy-using Products (MEEuP) and its successor, the Methodology for the Eco-design of Energy-related Products (MEErP) which extends the first methodology (MEEuP) from energy-using to energy-related products. MEErP is developed to investigate eco-design requirements appropriate for the products that are covered under the Eco-Design Directive such as heating equipment, cooking equipment (i.e. ovens and furnaces), machine tools, refrigerating and freezing equipment, sound and imaging equipment, transformers, and ventilation systems.

Energy Labelling Directive

The EU Energy Labelling Directive complements the requirements of the Eco-Design Directive with mandatory labelling requirements. The Directive¹⁷ establishes a framework for the harmonisation of national measures on end-user information, particularly by means of labelling and standard product information, on the consumption of energy and where relevant of other essential resources during use, and supplementary information concerning energy-related products, thereby allowing end-users to choose more efficient products.

The energy efficiency of the appliance is rated in terms of a set of energy efficiency classes from A to G on the label, A being the most energy efficient, G the least efficient. The labels also give other useful information to the customer as they choose between various models. The information should also be given in catalogues and included by internet retailers on their websites.

This statement could well be taken as an indication of a possible position of this industry, which is a major part of the metal mechanical manufacturing industry in Europe, towards any potential, obligatory energy characterisation of companies, since the latter would be even more challenging than labelling professional equipment.

The latter would strongly point towards implementation of any such approach under a voluntary scheme. Besides the basic criteria of such energy characterisation scheme, hence

¹⁷Directive 2010/30/EU of the European Parliament and of the Council of 19 May 2010



the potential implementation modalities will also be an issue for further clarification through stakeholder consultation.

EU Ecolabel

Other than the Energy Label, the EU Ecolabel¹⁸ is a voluntary scheme, aiming to identify products and services that have a reduced environmental impact throughout their life cycle, from the extraction of raw material through to production, use and disposal. Voluntary means that producers, importers and retailers can choose to apply for the label for their products. The EU Ecolabel scheme is hence a commitment to environmental sustainability; it can be used as a promotional instrument for more environmentally sustainable products. The criteria have been developed and agreed upon by scientists, NGOs and stakeholders to create a credible and reliable way to make environmentally responsible choices.

2.2.6 Life Cycle Assessment and Life Cycle Costing

Life Cycle Thinking (LCT) is about going beyond the traditional focus and production site and manufacturing processes to include environmental, social and economic impacts of a product over its entire life cycle. The main goals of LCT are to reduce a products resource use and emissions to the environment as well as improve its socio-economic performance through its life cycle. This may facilitate links between the economic, social and environmental dimensions within an organization and through its entire value chain.

Looking at the industrial sector, taking LCT as an approach means going beyond the narrower traditional focus on a company's production facility. A product life cycle can begin with the extraction of raw materials from natural resources in the ground and the energy generation. Materials and energy are then part of production, packaging, distribution, use, maintenance, and eventually recycling, reuse, recovery or final disposal.

¹⁸ <http://www.ec.europa.eu/environment/ecolabel>



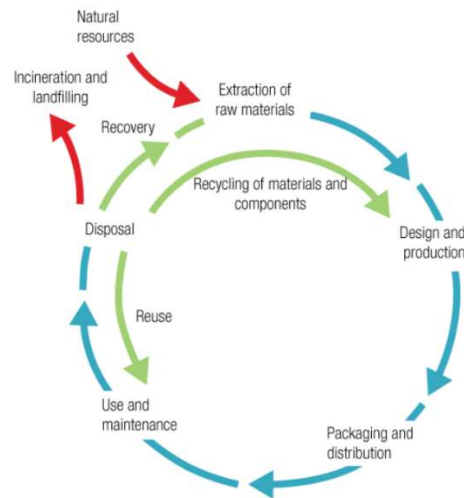


Figure 3 : Life cycle

In each life cycle stage, there is the potential to reduce resource consumption and improve the performance of products.

Life Cycle Assessment (LCA)

The concepts that later became (environmental) LCA first emerged in the 1960s (Baumann et al., 2004). Until the early 1990s, studies that undertook an assessment of the material, energy and waste flows of a product's life cycle were conducted under a variety of names – including the resource and environmental profile analysis (REPA), Eco balance, integral environmental analyses and environmental profiles. In 1990, SETAC hosted workshops with the aim of developing a standardized method of (environmental) LCA, which was to serve as the basis for the ISO 14040 series.

ISO 14000 Life Cycle Analysis Standard

LCA standards ISO 14040 and 14044 belong to the ISO 14000 family concerning various aspects of environmental management. On a national level, only two standardisation organisations have developed their own LCA standards before ISO 14040 was enacted: AFNOR (Association Francaise de Normalisation, France) and CSA (Canadian Standards Association, Canada).

To date, a singular internationally accepted standardisation is aimed at promoting international communication, and this is why France and Canada have stepped into the ISO process.



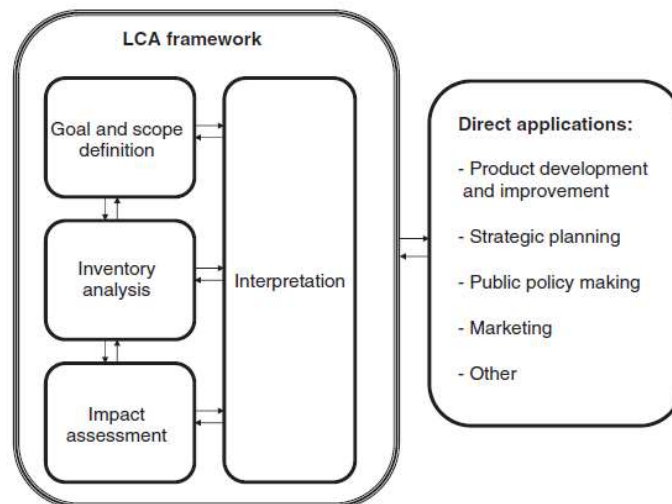


Figure 4: LCA phases according to ISO 14040:1997/2006.

Life Cycle Costing (LCC)

Life cycle costing (LCC) is the oldest of the three life cycle techniques. Developed originally from a strict financial cost accounting perspective, in recent years LCC has gained importance. The origins of LCC go back to 1933, when the United States of America General Accounting Office (GAO) requested an assessment of the costs of tractors that considered a life cycle perspective in a Request for Tender.

Social Life Cycle Assessment

A social life cycle assessment (S-LCA) is described as 'a social impact (and potential impact) assessment technique that aims to assess the social and socio-economic aspects of products and their potential positive and negative impacts along their life cycle' (UNEP/SETAC, 2009a). These aspects assessed in S-LCA are those that may, directly or indirectly, affect stakeholders. The impacts may be linked to the behaviours of companies, to socio-economic processes, or to impacts on social capital.

Life Cycle Inventory Analysis (LCI)

In the second phase, all emissions released into the environment and resources extracted from the environment along the whole life cycle of a product are grouped in an inventory. The inventory is a list of elementary flows as shown in Fig. 1.



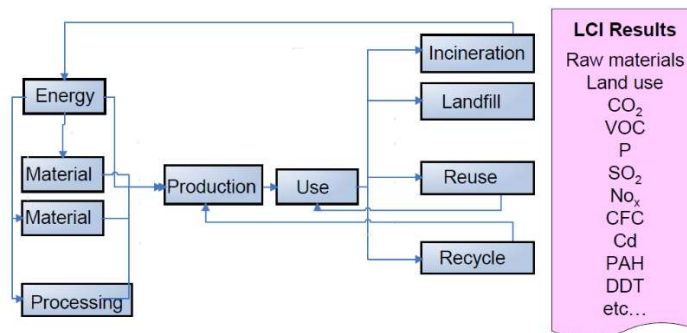


Figure 5: Flows of information needed for a cycle inventory.

Life Cycle Impact Assessment (LCIA)

In the third phase – life cycle impact assessment (LCIA) – the LCI results or indicators of environmental interventions are translated, with the help of an impact assessment method, into environmental impacts. Impacts may be assessed at the midpoint or endpoint level (see Fig. 2). In a ‘classification’ step, elementary flows⁴ are assigned to midpoint impact categories such as ‘climate change’ or ‘human toxicity’, thereby organizing the information to allow for a further processing and meaningful interpretation (see Fig. 2 below). In this ISO 14040-termed ‘characterization’ step, all elementary flows within the same category are converted to a common unit of assigned elementary flows. This step is accomplished by using characterization factors (see Glossary). At the endpoint, environmental LCIA aims to link emissions and resource demands with damages to human health, ecosystem quality and the resource base. Several characterization models can be used to link the inventory results with the midpoint and endpoint categories of impact: the choice of model depends on the goal and scope of the study and on the stakeholders affected by the outcome.

Normalization, aggregation and weighting are optional LCIA steps, according to ISO 14040 (2006) and ISO 14044 (2006). While the first provides the contribution of each impact category in comparison to a reference by converting differing units into a common and dimensionless format, aggregation and weighting allow the conversion (using numerical factors based on value-choices) and the possible aggregation of indicator results across impact categories.

Life Cycle Interpretation

A life cycle interpretation is carried out in the last phase. This is necessary for identifying, quantifying, checking and evaluating information from the results of the LCI and/or the LCIA. This interpretation phase should generate a set of conclusions and recommendations. It should also (according to ISO 14040) raise significant environmental issues, including an evaluation of the study considering completeness, sensitivity and consistency checks, and limitations.



Life Cycle Sustainability Assessment (LCSA)

Life cycle sustainability assessment (LCSA) refers to the evaluation of all environmental, social and economic negative impacts and benefits in decision-making processes towards more sustainable products throughout their life cycle.

$LCSA = (\text{environmental}) LCA + LCC + S-LCA$

Life Cycle Management (LCM)

Life cycle management (LCM) is a product management system aimed at minimizing the environmental and socio-economic burdens associated with an organization's product or product portfolio during its entire life cycle and value chain. LCM supports the business assimilation of product policies adopted by governments. This is done by making life cycle approaches operational and through the continuous improvement of product systems (UNEP/SETAC, 2007).



3. CONCLUSIONS

Life Cycle Assessment is a useful theoretical and practical framework for selecting and evaluating indicators for green industry and products. Its growing application is promising to bring greater clarity to the concept of “green industry”. It is in this context that the EED requires building energy audits, whenever possible, on life-cycle cost analysis (LCCA) instead of Simple Payback Periods (SPP) in order to take account of long-term savings, residual values of long-term investments and discount rates.

Principle problems with the approach relate for instance to decisions that have to be taken without scientific basis, such as whether three tonnes of emitted sulphur is more or less harmful than the emission of just a few pounds of a more toxic pollutant, which are necessarily subjective.

Other examples are

- How can one compare heavy energy demand with heavy water use: which imposes greater environmental burden?
- How should the use of non-renewable mineral resources like oil or gas (the ingredients of plastics) be compared with the production of softwoods for paper?
- How should the combined impacts of the landfilling of wastes (air and groundwater pollution, transport impacts etc.) be compared with those produced by the burning of wastes for energy production (predominantly emissions to air)?

Another principle drawback to the application of life cycle based instruments is the extensive data gathering and expensive analysis requirements, which have hampered a wider use particularly in SMEs. In addressing this issue, for instance the ERDF funded project LiCEA developed a Life Cycle based Energy Audit (LiCEA) aiming especially at SMEs. The LiCEA tool calculates only three environmental indicators according to the LCA approach:

- Global warming potential - GWP (in kg CO₂, according to IPCC 2007, 100a);
- Cumulative energy demand –CED (in MJ, incl. non-renewable and renewable energy);
- Blue virtual water (in m³).

Such simplified approaches could provide a practical solution to energy characterisation, under the provision that they really allow meaningful comparisons. This has to be further analysed in subsequent work.

®Ecosystem¹⁹ guides companies to prevent the impacts of a product's end of life as from the development and supply phases. This approach is an important lever for waste prevention, natural resources conservation and the reduction of recycling's environmental impact.

Their ecodesign approach of a product involves manufacturing it with the aim of improving its environmental performance throughout its whole life cycle. ecosystem assists companies in addressing all issues related to a stage or the end of life, in order to anticipate materials,

¹⁹ « To Be Assisted in the Ecodesign of Your Products | Ecosystem ».



substances and assembly choices when designing a product, and thus improve the quality of recycling. Integrating material from recycled equipment into new products is part of this virtuous approach.

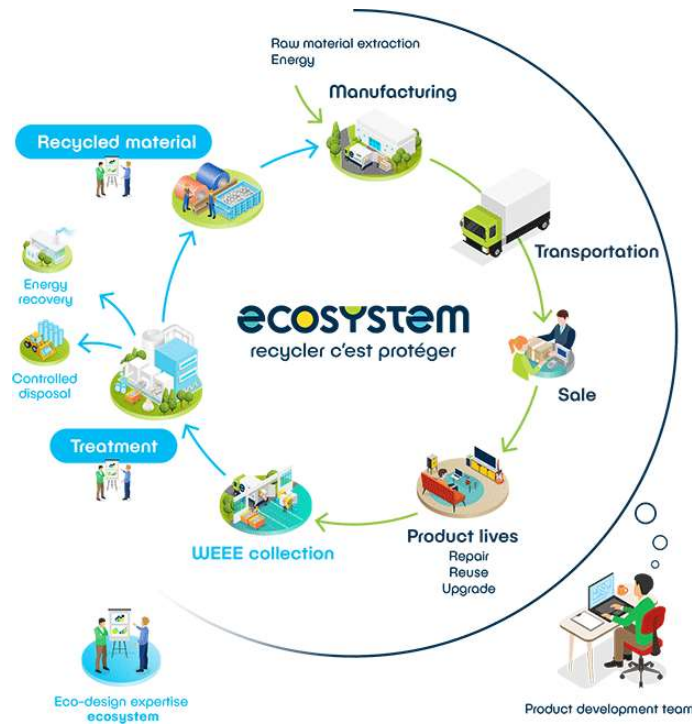


Figure 6: Ecosystem.

- Ecosystem has developed two databases, that allow to quantify the environmental impacts and benefits of:
- The end-of-life management of your electrical and electronic equipment
- The production of plastics recycled from waste electrical and electronic equipment (WEEE).

To ensure good data representativity, ecosystem has modelled the overall process of equipment's end-of-life based on field data collected from more than 50 WEEE decontamination and treatment facilities and took into account about fifteen disposal or recovery sectors.

ecosystem has also developed REEECYC'LAB²⁰, an educational simulator developed specifically by ecosystem for its members in order to understand, assess and improve the recyclability of new products.

For (advanced) manufacturing, MEMAN²¹ approach was developed inside a H2020 European project from 2015 to 2018.

This MEMAN project aims to maximise resource saving potentials of the metal mechanical sector through integral material and energy flow management. MEMAN addresses the complete manufacturing value chain, from casting and machining to surface finishing – for which it

²⁰ « REEECYC'LAB by Ecosystem », Ecosystem, s. d., <https://reeecyclab.ecosystem.eco/?locale=en>.

²¹ « MEMAN - Home », MEMAN, s. d., <http://www.meman.eu/>.



develops tools for practical decision-making, and new collaborative business models to benefit all companies in the value chain, from cradle to grave.

This present document benefited a lot from MEMAN work, about methodology and Energy and Material contents.

The MEMAN project supports European companies in the metal mechanical sector in their efforts to maximise their resource saving potential and increase competitiveness. The project is based on an innovative approach that addresses optimisation of whole manufacturing value chain, from cradle to grave, instead of isolated single company or process optimisation, and includes energy, raw materials, and other supplies.

This was done through:

- Validating new business models via collaboration of different companies along the whole value chain;
- Providing tools for practical decision-making support by combining Material and Energy Flow Analysis (MEFA) and Life Cycle Analysis (LCA);
- Defining requirements for energy certifications at company and whole value chain levels;
- Providing a set of 3 full business cases that demonstrate the effectiveness of the tools and business models.

In this way, MEMAN provided an approach to achieve **major cost reductions, reduce emissions and improve environmental performance, as well as improve regulatory compliance**. At the same time the project methodology supports the incorporation of **smart manufacturing innovations** as solutions for integrated value chain optimisation. All the results of the project are presented in the MEMAN final publication "**Unlocking the resource saving potential of the metal-mechanic sector**"²²

EU strategy for resource efficiency and Ecological Transition are in large development in Europe, in parallel of Industry 4.0 technologies' implementation.

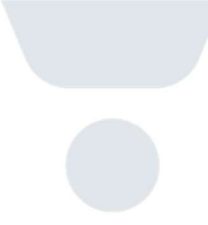
The Eco-design Directive, which provides consistent EU wide rules for improving the environmental performance of products, also plays a key role in EU energy policy. It has proven to be a highly politically feasible instrument, which is accepted by a wide range of stakeholders. The Directive has contributed not only to improve environmental performance of products but has also yielded positive effects on competitiveness of EU industry.

Statement 1: though aimed at product characterisation so far, the Eco-design approach could serve as blueprint for energy characterisation for companies. This in particular since the Eco-design Directive is a framework directive, meaning that it does not directly set minimum ecological requirements. Minimum requirements are adopted through specific implementing measures for each group of products defined by means of a so-called comitology procedure. The latter involves all relevant stakeholders.

Statement 2: The development of appropriate, and well accepted, indicators for Industry 4.0 impact on Supply Chain and Ecological Transition, and more generally for product

²² « MEMAN Virtual visit », MEMAN, consulté le 12 mai 2023, <https://umotique.fr/meman-project/>.





manufacturing from Cradle to grave could support the implementation of Industry 4.0 technologies inside Supply Chain, to achieve the targets.

Statement 3: Main results, furthermore than complex calculations and methodology, are that the Supply chain from cradle to grave is a whole and that modifications in one part of this whole can impact in favour or not favourably, the global results. The best in one point of the Supply chain from cradle to grave, is not surely the best for all the whole Supply chain. We have to study all the Supply chain from cradle to grave, to optimize a process, a product.

Statement 4: Experience from the implementation of the EU Energy Labelling Directive on the one hand, and the EU Ecolabel initiative on the other hand, suggests that any approach towards Industry 4.0 technologies' implementation in Companies should best be implemented under a voluntary scheme.

This could for instance follow the examples of existing Voluntary Agreements or the various Corporate Social Responsibility reporting schemes implemented at national and international levels. An according voluntary energy, and resource efficiency, characterisation scheme would also very well complement these global CSR approaches and Voluntary Agreement schemes for energy and resource efficiency.

Regarding the technical implementation of the Industry 4.0 technologies' implementation inside companies, this could actually lean on the implementation of the Eco-Design Directive, which is based on the 'Methodology for the Eco-design of Energy-related Products' (MEErP).



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