CEN WORKSHOP AGRREMENT ON

Requirements for A Methodology for the implementation of an Energy Management and Sustainable Manufacturing (EMSM) Project in factories of industrial organizations

•Índex

Cover page (to be completed)

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0 Introduction

Efficient management and the use of limited resources have always been one of society's goals. Achieving a safe, reliable, economical and environmentally friendly supply of resources implies the efficient use of available resources to increase the competitiveness and efficiency of the industry.

Current energy and environmental policy pursue three main objectives: to ensure security of supply (through energy savings and diversification of sources), to increase the competitiveness of economies, to promote sustainability and to fight climate change.

This document takes as a basis the work done in ECOFACT Project, which is a project through the European Horizon 2020 Research and Innovation Programme under Grant Agreement Nº 958373.

ECOFACT aims at enabling manufacturing industries to optimize the energy performance of their production systems in line with their relevant production constraints (time and resources), while at the same time introducing a novel green marketing approach through the concept of energy and environmental signature of the manufactured products from a life-cycle perspective.

Within the Project a range of Key Performance Indicators (KPI) to be used as a tool for the evaluation of sustainability in manufacturing and the monitoring of improvements achieved over time have been identified.

A Key Performance Indicator is a parameter r a value derived from parameters, which provides information about performance. As such, indicators are essential for measuring and monitoring sustainable performance in manufacturing to improving Europe's competitiveness on world markets with better use of raw materials, natural resources and renewable energies.
Therefore, a selection of indicators has been made to lay the foundations for an evaluation of the fulfilment of the objectives.

These indicators have been selected from different sources of information ranging from academic and industry reports or sectoral analysis to standards that include the energy, environmental, and resource management. The most important and most widely applicable ones have been chosen from the work done in ECOFACT for this CWA.

The chosen Key Performance Indicators (KPIs) comply with the SMART principle; that is, they are specific, measurable, achievable, realistic, and time-bound. They are:

— Specific: representative of the operations.

— Measurable: through using adequate variables.

— Achievable: the measurement defined in the KPI can be implemented. In addition, collecting data for the KPI is not complicated or expensive.

— Realistic: give more information about the organization’s performance to achieve its strategy.

— Time-bound: measure performance within a specific time frame.

In this document, the following verbal forms are used:

—“shall” indicates a requirement;

—“should” indicates a recommendation;

—“may” indicates permission;

—“can” indicates a possibility or a capability.

Information marked as “NOTE” or included in informative annexes is for guidance in understanding or clarifying the associated requirements.

1 Scope

This document specifies the requirements for a methodology (3.5) for the implementation of an Energy Management and Sustainable Manufacturing (EMSM) (3.3) Project (3.8) in factories of industrial organizations.

NOTE
It could be useful to benefit from the outcome of an energy/environmental/industrial auditor technological audit that might have previously been conducted In the factory, the baselines generated in the audit could be used as a reference for the Project.

This document is applicable to any EMSM Project implemented by any industrial organization, regardless its activity.

2 Normative references

No standards necessary to comply with this document have been identified.
Standards identified for guidance can be consulted in the bibliography chapter.

3 Terms and definitions

3.1 baseline:

quantitative reference(s) providing a basis for comparison of performance.

3.2 Digital Twin Platform (DTP):

web application which acts as Energy and Resource Management System for factory managers and operators combining industrial digital twin models of production lines and machines with simulation and optimisation tools into a single web environment.

3.3 Energy Management and Sustainable Manufacturing (EMSM) Project:

a project (3.8) implemented in an organization for the improvement of its energy and sustainable manufacturing performance.

3.4 functional unit:

quantified performance of a product system for use as a reference unit

[SOURCE: ISO 14040:2006, 3.20]

3.5 methodology:

collection of standards, procedures and supporting methods that define the complete approach to the development of a project.

3.6 Key Performance Indicator (KPI):

parameter, or a value derived from parameters, which provides information about performance.

[SOURCE: ISO 24523:2017, 3.13, modified − Term revised and Notes to entry removed.]

3.7 process parameter:

specified value for a process variable.

[SOURCE: ISO/TS 11139, 2.34]

3.8 project

temporary endeavor to achieve one or more defined objectives.

[SOURCE: ISO 21502:2020, 3.20]

3.9 sensitivity analysis

systematic procedures for estimating the effects of the choices made regarding methods and data on the outcome of a study.

[SOURCE: ISO 14040:2026, 3.31]

4 Requirements for the methodology for the implementation of an Energy Management and Sustainable Manufacturing (EMSM) Project

4.1 Definition of improvement measures to be implemented

The factory shall define, in first place, the improvement measures to be implemented and their physical and temporal scope.

When several of the identified improvements affect the same system (concatenation of improvements), they must be considered together to evaluate possible cross-effects.

When defining measurements to be taken the impact that those measures may have in maintenance, operation and end of useful life of the facilities must be considered.

4.2 Technical study or preliminary project of the improvement measures to be implemented

A technical study or preliminary project for the implementation of the proposed improvements shall be available, according to the needs.

Tecnical studies or preliminary projects should include, when appropriate:

- Descriptive report;
- Installation schematics;
- Purchase specifications;
- Guarantees to be provided;
- Budgets;
- Conditions and deadlines for execution;
- Responsibilities and obligations;
- Consideration of possible necessary licenses.

4.3 Key Performance Indicators for the EMSM Project

4.3.1General

The factory shall choose KPIs for measuring the improvements of the EMSM Project.

The KPIs can be selected among those indicated in 4.3.2, 4.3.3 and 4.3.4 or from audit/ baselines (3.1) previously obtained from energy/environmental/industrial factory technical approaches (see annex A)

NOTE 1

Previous baselines may be operating in quality, environmental or energy management systems supported by ISO standards implemented in the factories of industrial organizations and be useful for identifying consolidated KPIs in factories. Besides, integrating simulation and optimization tools into a DTP could enhance and improve the management in terms of energy, resources and costs.

NOTE 2

A Digital Twin Platform (3.2) can be used, as well, to ensure a user-friendly monitoring of field data KPIs, guaranteeing access to real-time data streams and historical datasets. Within the digital twins, advanced 3 D models of industrial plants and machinery, energy and resource IIoT devices are grouped by the parameter they monitor or type of meter.

As an example, a list of DTP parameters could be the following, among others:

- electrical energy;
- thermal energy;
- natural gas;
- compressed air;
- water;
- hot wate;
- operating hours;
- operating percentages;
- control valve percentage;
- current;
- pressure;
- temperature.
- Air meter data
- Air calometer data
- Chemical data

Depending on the industrial scenario, the DTP could also offer one or more simulation and optimization tools:

- energy flexibility (working as a production or energy optimizer);
- Predictive Maintenance (PdM);
- Industrial Energy Disaggregation by Product (IEDbyP);
- material-flow simulation;
- production planning and scheduling.

Indicators shall consider three pillars: Energy, Environment and Management and Use of resources.

4.3.2 Energy indicators

KPI	Definition	Units	Calculation Method
Energy consumption	Energy consumption per carrier (electricity, thermal... –gas, diesel, etc. –) and functional unit	kWh/functional unit (3.4)	Measured or calculated
Energy savings	Energy savings	kWh/functional unit	Difference between baseline and real energy consumption □ adjustments
RES generation	Renewable energy generation	kWh or kWh/functional unit	Measured or calculated
RES share	Share of renewable energies	%	Renewable Energy Sources (RES) contribution to the total energy consumption
Load factor	Load factor	%	Average demand/peak demand
Average demand	Average demand. Can also be added min. average demand and max. average demand	kWh	Measured and calculated

NOTE 1

In relation to the evaluation of energy in factories, the main point to be studied is energy consumption.

NOTE 2

Depending on the availability of energy meters, the measurement can be provided on a general, line-by-line, or per-process basis.

NOTE 3

Measurement may also consider different types of energy, distinguishing, for example, by different sources: electricity, natural gas, diesel, etc. It would be ideal to distinguish by uses and/or systems and/or processes and/or areas.

NOTE 4

Energy costs are considered within 4.3.4, Management and Use of Resources Indicators.

NOTE 5

Environmental aspects of the different types (sources) of energy used in the industry are considered within the environmental KPIs, covering the entire life cycle of a product.

4.3.3 Environmental indicators

Issue	KPI	Unit	Method used
Total environmental performance	Overall environmental performance	Dimensionless (Pt)	EF 3.0 single score (European Commission, 2019) [9]
	Total environmental costs	EUR	Environmental Prices (CE Delft, 2018) [10]
Climate change	Impact on climate change	kg CO2 eq.	Baseline model of 100 years of the IPCC (based on IPCC 2013) (Myhre et al, 2013)
Water consumption*	Total water consumption	M3 World eq.	Available WAter REmaining (AWARE) as recommended by UNEP, 2016 (Boulay et al 2018) [11] [12] [13]
Energy consumption	Cumulative Energy Demand	MJ	Cumulative Energy Demand (CED) (Hischier et al, 2010) [8]
Resource consumption	Resource use, minerals and metals	kg Sb eq.	CML 2002 (Guinée et al., 2002) and van Oers et al. 2002. [14]
	Resource use, fossils	MJ	CML 2002 (Guinée et al., 2002) and van Oers et al. 2002. [14]

*Water consumption is included here from the perspective of the water footprint which includes upstream processes. Note the difference with the in-situ use of water as a resource at the manufacturing site.

NOTE 1
They have been addressed by creating flexible models of business activities in which impact results are automatically updated based on changes in input data. This allows frequent monitoring of environmental KPIs based on high specificity models and without the use of average emission factors.

NOTE2
Through the analysis of critical points, high-impact processes are identified early. Models allow flexibility in terms of the KPIs that need to be calculated at a particular point in time.

4.3.4 Resource management and use

4.3.4.1 Generic resource management and use indicators

KPI	Definition	Units	Calculation Method	Ref
Utilization Rate	The ratio between how many units a company produces over a period of time and how many units the company could potentially produce in that same period with optimal use of time and labour	%	(actual level of output) ÷ (maximum level of output) x 100	[17] [18] [22] (Utilizion efficiency [%])
Throughput	The average number of units being produced over a time period	Units/ time	(units produced) ÷ (time)	[17] [18] [19] [22] (Through put rate [Quantity Unit] / Time unit])
Manufacturing Cycle Time	The total amount of time it takes to produce a product. The cycle time metric can be used to measure the time it takes to manufacture a completed product, each individual component of the final product, or even go as far as to include delivery to the end user. Thus, cycle time can be used to analyse overall efficiency of a manufacturing process on the macro scale, as well as determine inefficiencies on a micro scale.	Time	(Process End Time) – Process Start Time)	[17] [19] [18]
Downtime to Operating Time	The effectiveness of machinery maintenance and the machine itself.	Time	(Downtime) ÷ (Operating Time)	[19]
Availability	Availability is a ratio that shows the relation between the actual production time (APT) and the planned busy time (PBT) for a work unit.	%	Actual production time ÷ Planned busy time	[22]

Effectiveness	Effectiveness represents the relationship between the planned target cycle and the actual cycle expressed as the planned runtime per item (PRI) multiplied by the produced quantity (PQ) divided by the actual production time (APT).	%	(the planned runtime per item* produced quantity) ÷ actual production time	[22]

4.3.4.2 Manufacturing Resources

KPI	Definition	Units	Calculation Method	Ref
Demand Forecasting	The amount of raw materials they will require to meet future customer demand.	Raw Materials/t name	(Raw Materials) * (Production Rate)	[19]
Inventory turns	How many times inventory is sold over a specific time period and helps indicate resource effectiveness. Low ratio numbers indicate poor sales and excessive inventory, while high ratio numbers represent strong sales or insufficient inventory	# inventories sold/time	(Units of Goods Sold) ÷ (Avg. Inventory)	[19]
Worker efficiency	The worker efficiency considers the relationship between the actual personnel work time (APWT) related to production orders and the actual personnel attendance time (APAT) of the employee.	%	Actual personnel work time ÷ actual personnel attendance time APWT / APAT	[22]
Comprehensive energy consumption	Comprehensive energy consumption is the ratio between all the energy consumed in a production cycle and the produced quantity (PQ)	Joule / (number of units) or amount	$e = E/PQ = (\sum Mi*Ri + Q)/PQ$ where e: unit energy consumption of an equipment, E: comprehensive energy consumption Mi: actual consumption of certain kind of energy (kilowatt hour)	[22]

			Ria: conversion coefficient of certain kind of energy Q: algebraic sum of effective energy exchanges with the environment	
Water use strategy and management	Water use per functional unit	m3/ functional unit	Total water used at the single facility level divided by the functional units selected	[20] [21]
Waste prevention and management	Waste generation per functional unit	kg/ functional unit	Total waste generated (i.e. hazardous and non-hazardous) divided by the functional units selected	[20] [21]

NOTE1Energy consumption has been considered as a resource in the production process.

4.3.4.3 Manufacturing quality

KPI	Definition	Units	Calculation Method	Ref
Yield	The percentage of units that are produced the correct way and to the unit specifications the first time through the production line without rework	%	(Units manufactured properly) ÷ (total number of units that went through the company's production line) x 100	[18]
Scrap Rate	The percentage of material used that is not able to be used due to being defective or errors in the production process	%	(amount of material that has been scrapped) ÷ (total number of material used) x 100	[18]
Overall Equipment Effectiveness (OEE)	The percentage of manufacturing time that is truly productive. An OEE score of 100% means you are manufacturing only Good Parts, as fast as possible, with no Stop Time. In the language of OEE that means 100% Quality (only Good Parts), 100% Performance (as fast as possible), and 100% Availability (no Stop Time).	%	(Availability * Performance * Quality)	[19]
Quality ratio	The quality ratio is the relationship between the good quantity (GQ) and the produced quantity (PQ).	%	Good quantity ÷ produced quantity GQ / PQ	[22]

NOTE1

Production performance analysis is an important operational activity because it is part of product quality assurance. It includes analysis of production information, resource and equipment utilization, equipment performance, procedural efficiencies, and production variability.

4.3.4.4 Manufacturing costs

KPI	Definition	Units	Calculation Method	Ref
Total Manufacturing Cost (TMC) Per Functional Unit	The total costs of resources involved in producing products including material, labour and overhead	€ €/funct. unit	(Direct materials + Direct labour + Manufacturing overheads) ÷ functional units.	[18]
Energy Cost Per Functional Unit	The total cost per carrier of energy spent over a period of time and divides it by the number of units produced in that time frame.	€ €/unit	(Total Energy Cost) ÷ (Functional units Produced)	[19]

NOTE

By transforming financial and accounting data into KPIs, the industry can make sound business decisions.

4. 4 Measurement and Verification Plan

The organization shall define and implement a measurement and verification plan. For that, the organization shall:

- Establish the baseline for the KPIs selected in 4.3;
- Prepare the measurement and verification equipment;
- Identify a responsible for carrying out the measurements and calculations;
- Define and calculations and their frequency and implement them;
- Define and use a reporting document.

NOTE 1

The plan can be developed specifically for the Energy Management and Sustainable Manufacturing Project or come from protocols established by prestigious organizations.

NOTE 2

The implementation of the Measurement and Verification Plan will make it possible to know the degree of compliance with the objectives, providing information, where appropriate, of existing discrepancies and allowing the establishment of corrective measures.

4. 5 Improvement analysis

The improvement shall be demonstrated comparing the reference period baseline (KPIs data prior to the improvement measures) with the demonstration period baseline (KPIs data after improvement measures). The comparison shall show better results in the energy management and sustainability manufacturing performance for the Project.

The organization must carry out the corresponding sensitivity analysis (3.9) to show influence that certain changes in the most influential variables of the reference period baseline have on the viability and results of the project.

NOTE

This analysis permits to foresee the possible economic risks assumed in the project.

See annex A.

4. 6 Economic Approach of the EMSM Project

The organization shall approve an Economic Approach for the EMSM Project in order to demonstrate that the proposed activities are the most appropriate for achieving the economic and financial objectives of maximising benefits and minimising risk.

The Economic Approach shall:

- contain all the necessary activities for the EMSM Project and the timetable for their implementation, in order to implement the measures and identify the real funding needs;
- include the main milestones of the EMSM, the time frame for achieving them, and interconnections with the rest of the activities and the time planning for their implementation;
- be technically, economically and financially feasible, realistic and credible, so that there are no barriers that prevent the execution of any of its activities;
- contain the financial projections that cover the entire course of the planning, implementation, development and operation, including any replacements and residual values; as well as sensitivity analysis related to the main variables.

NOTE 1

The Economic Approach justifies the expectations of success of the EMSM Project and it is essential to show the technical-economic-financial viability of the EMSM.

NOTE 2

The economical/technical approach may be used internally for the company's economic planning and externally to inform and engage third parties, such as banks, investors and public bodies. See annex B.

4.7 Energy Management and Sustainable Manufacturing (EMSM) Report

Once, the organization has completed its EMSM Project, it must issue a Report providing information on the factory improvement for the established scope of EMSM Project, comparing the reference period baseline with the demonstration period baseline.

NOTE

Benchmarks allow a fair comparison of factories, regardless of size, and that are applicable to a wide range of facilities. This is achieved by ensuring that only a single benchmarking methodology is required.

Information provided in the report should be presented in a way that is verifiable by interested parties.

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Annex A
(informative)

Previous audit and baseline of a factory

A.0 General

It can be useful to conduct an energy/environmental/industrial audit in the factory prior to the EMSM Project that serves to define one or more baselines. Some of these baselines could be used as a baseline reference for the EMSM Project that the factory decides to implement.

A.1 Energy/environmental/industrial audit

An energy/environmental/industrial audit should provide information on the state and performance of facilities, facilities potential improvements, indicators potential improvements, impacts of the potential improvements on operation and maintenance, as well as the associated investments.

The physical and technical scope for the audit/survey to be conducted in the factory should be clearly defined.

In general, an energy/environmental/industrial audit in a factory should include the following stages:

a) Installation description;
b) Detailed inventory of equipment/processes/facilities/areas;
c) Assessment of the condition of the facilities;
d) Supply analysis;
e) Analysis of environmental impacts;
f) Processes analysis;
g) Analysis of horizontal and service technologies;
h) Data collection and measurement;
i) Energy, environmental and industrial accounting;
j) Mass/Energy/industrial resource balance;
k) Cost analysis of factory performance;
l) Analysis of improvement proposals;
m) Development of improvements;
n) Concatenation of improvements;
o) Recommendations and good practices;
p) Drafting of the audit/survey report.

NOTE

EN 16247-3:2022 [46] provides useful information for conducting an energy audit within a process.

A.2 Baseline

Baseline(s) in an existing factory can be useful to establish performance levels prior to the accomplishment of a modification (Reference Period). This baseline(s) physically exists and is measured before possible changes within a EMSM Project are implemented. The reference model is able to accommodate changes in process parameters (3.7) and conditions so that "adjustments" are made.

On the flexible models of the company's activities for which the results can be automatically updated based on changes in the input data, KPIs based on high-specificity models are tracked.

An EMSM Project thus can use previously developed relevant information of baselines already established in the factory, providing, transparency and rigor to the decision-making process of the improvement measures to implement within an EMSM Project.

It contributes also to generate the necessary confidence for the obtention of lines of aid of public or private financing for these improvements.

Annex B
(informative)

Economic Approach

(to be decided by partners, whether maintain or delete)

This annex provides guidelines on the possible content of the Economic Approach for the implementation of an EMSM Project

a) Description

- Project title;
- Background;
- Participating companies, their legal form, corporate structure and technical and financial solvency;
- Contracts between the parties;
- Location;
- Project duration, implementation and operation.

b) Technical considerations

- Supply companies;
- Connection to the grid;
- Description of project activities;
- Summary of technical data;
- Service delivery process;
- Advantages of the chosen technologies over other alternatives;
- Environmental Impact Measures;
- Emission Reduction Estimation;
- Methods of operation and taking measurements;
- Regulation and control system.
- Verification processes;
- Estimated hours of operation per year;

•Losses;
•References and prototypes.

c) Execution considerations

•Construction and operation;
•Execution schedule;
•Availability of technological infrastructure and maintenance logistics;
•Availability of skilled labor for development, operation and maintenance;
•Leading suppliers of equipment and services;
•Values of the magnitudes of the project and its financial correspondents;
•Human resources.

d) Legal considerations

•Legal framework. Applicable law, regulatory information, or industry standards.
•Compliance with all mandatory legal requirements and applicable regulations
•Documentation of reference market data, tariffs, standards, studies.
•National and local policies that are not legally binding.
•Administrative situation

e) Financial considerations

•Project Budget
•Financial planning
•Estimates of the cost of financing and the required return on capital
•Financing needs. Information on loans and their amortization.
•Interests
•Public Funds and Grants
•Market research, technological studies carried out.