MAESTRI

Total Resource and Energy Efficiency Management System for Process Industries

Deliverable 3.2

Management System Framework for Continuous Improvement in Process Industries

Date: 28/02/2017

WP3 Management system

T3.2 Embedding eco performance into management system

T3.3 Integration with strategy, management system and managers' behaviours

Dissemination Level: Public

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SPIRE Sustainable Process Industry through Resource and Energy Efficiency

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 680570

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Executive Summary

The MAESTRI project aims to advance the sustainability of European manufacturing and process industries, providing a management system in the form of a flexible and scalable platform, guiding and simplifying the implementation of an innovative approach, the Total Efficiency Framework. The overall aim of this framework is to support the improvement of companies' environmental and economic performance.

The core of Total Efficiency Framework consist of four pillars:

- efficiency assessment tools (developed by Work Package 2 Efficiency Framework),
- industrial symbiosis paradigm (developed by Work Package 4 Industrial Symbiosis),
- Internet-of-Things infrastructure (developed by Work Package 5 IoT Platform Development),
- an effective management system (developed in Work Package 3 Management System).

The aim of this report is to present the results of work carried out within Work Package 3 Management System, especially definition of MAESTRI management system elements and supporting methods developed to fit specific needs of process industries. MAESTRI Management system is based on the Lean Management concept.

There is also discussed the topic how improvement of eco performance and continuous improvement culture can be embedded into companies strategy and management system. Last but not least interactions between the Management system and other elements of the MAESTRI Total Efficiency Framework are depicted. The concepts described in this deliverable will be further validated within Work Package 6 Pilot Implementation and Validation activities.

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Abbreviations

CI – Continuous Improvement

CSR - Corporate Social Responsibility

EOV – Eco Orbit View

EPEI - Every Product Every Internal

ERP – Enterprise Resource Planning system

IoT – Internet of Things

IS – Industrial Symbiosis

KEPI - Key Environmental Performance Indicator

KGI – Key Goal Indicator

KPI – Key Performance Indicator

MTEF - MAESTRI Total Efficiency Framework

PDCA – Plan-Do-Check-Act

QCD – Quality, Cost, Delivery

T4IS – Toolkit for Industrial Symbiosis

WIP – Work In Progress inventory

WPx – Work Package no. x

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Definitions

5S - Five related terms, beginning with an S sound, describing workplace practices conducive to visual control and lean production. The five terms in Japanese are: Seiri: Separate needed from unneeded items (tools, parts materials, paperwork), and discard the unneeded; Seiton: Neatly arrange what is left — a place for everything and everything in its place; Seiso: Clean and wash; Seiketsu: Cleanliness resulting from regular performance of the first three Ss; Shitsuke: Discipline, to perform the first four. (Lean Enterprise Institute 2014)

Every Product Every Internal (EPEI) - The frequency with which different part numbers are produced in a production process or system. (Lean Enterprise Institute 2014)

Gemba - the Japanese term for "actual place," often used for the shop floor or any place where value-creating work actually occurs. The term often is used to stress that real improvement requires a shop-floor focus based on direct observation of current conditions where work is done (Lean Enterprise Institute 2014)

Gemba walk - A management practice for grasping the current situation through direct observation and inquiry before taking action. Japanese companies often supplement gemba with the related term "genchi gembutsu" -- essentially "go and see" -- to stress the importance of empiricism. (Lean Enterprise Institute 2014)

Hoshin Kanri - (also Policy or Strategy deployment) is a management process that aligns an organization's functions and activities with its strategic objectives. A specific plan (typically annual) is developed with precise goals, actions, timelines, responsibilities, and measures (Lean Enterprise Institute 2014).

Kaizen - Continuous improvement of an entire value stream or an individual process to create more value with less waste (Lean Enterprise Institute 2014)

One-Piece Flow - Producing and moving one item at a time (or a small and consistent batch of items) through a series of processing steps as continuously as possible, with each step making just what is requested by the next step. Continuous flow can be achieved in a number of ways, ranging from moving assembly lines to manual cells. It also is called continous flow, single-piece flow, and make one, move one. (Lean Enterprise Institute 2014)

Takt Time - The available production time divided by customer demand. The purpose of takt time is to precisely match production with demand. It provides the heartbeat of a lean production system. (Lean Enterprise Institute 2014)

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1 Introduction

The purpose of this deliverable is to define the management system promoting continuous improvement (CI) for sustainable resources usage. Deliverable 3.2 reflects the work performed in *Task 3.2 Embedding eco performance into management system, Task 3.3 Integration with strategy, management system and managers' behaviours* and partially in *Task 3.4 Low cost eco improvement methods*. In particular it summaries the objectives of *Work Package 3 Management System*:

- Defining the mechanisms ensuring that eco efficiency aspects and sustainable resource usage will be embedded in strategy, KPIs, every day managers' routines and existing management system within a production company;
- Defining the mechanism to create proper motivation and people engagement;
- Developing the management system:
    1. integrating all the methods and approaches into a single management system suitable for specific conditions of process industries;
    2. consistent with the platform (*WP5 IoT Platform development*);
    3. promoting CI approach based on root cause analysis;
    4. integrating eco efficiency aspects and sustainable resource usage into existing management systems and normal daily routines within a production company.

An analysis of organizational challenges and barriers for improving energy and resource usage in process industries was delivered in the Deliverable *D3.1. Internal challenges and barriers for energy and resource management.*

This deliverable is organized as follows:

- Chapter 2 presents MAESTRI management system elements divided into three subchapters. In the first one, the brief overview of Lean management system is provided, the second one presents the methods and tools developed to fulfil the specific needs of process industries, the third subchapter discusses interdependencies between particular elements of the MAESTRI management system.
- Chapter 3 provides and discusses the methods proposed to embed eco performance and continuous improvement into management systems
- Chapter 4 presents the position of MAESTRI management system in the Total Efficiency Framework concept and illustrates the role of particular MAESTRI pillars in the MAESTRI management system.
- Chapter 5 provides conclusions and further steps for validation of MAESTRI management system and supporting tools.

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2 MAESTRI Management System elements

The MAESTRI project aims to advance the sustainability of European manufacturing and process industries. That will be achieved thanks to developing the MAESTRI Total Efficiency Framework (MTEF), which is a MAESTRI management system in the form of a flexible and scalable platform and methodology.

The MTEF is based on four pillars (Ferrera et al. n.d.):

a) an effective management system targeted at process and continuous improvement;
b) Efficiency assessment tools to support improvements, optimisation strategies and decision support;
c) Industrial Symbiosis paradigm to gain value from waste and energy exchange;
d) an Internet-of-Things infrastructure to support easy integration and data exchange among shop-floor, business systems and tools.

The MAESTRI management system, which is described in this chapter as a one of the pillars supporting MTEF, combines two groups of elements (Figure 1):

a) conventional Lean Management System;
b) MAESTRI specific elements – to meet the requirements caused by specific conditions of process industry, a set of methods and tools has been proposed: Eco Orbit View, Focused Gemba Walk, Retrospective Analysis, Eco Lean Management Boards.

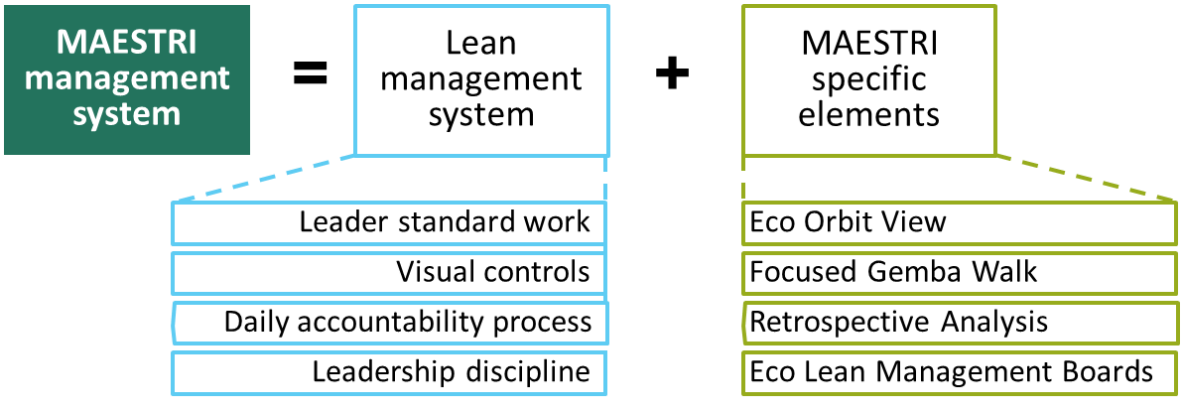

Figure 1 MAESTRI management system elements

A more detailed description of the elements of effective management system is provided in the following subchapters.

2.1 Lean Management System

The management system being developed in WP3 of the MAESTRI project is based on the Lean Thinking and Lean Management principles. 'Lean' concept was introduced worldwide to describe Toyota's business during the late 1980s by a research team headed by Jim Womack, at MIT's International Motor Vehicle Program (IMVP). The results of that research revealed that Toyota's management style is substantially different from the conventional management style used in the Western world. Conventional management style is frequently associated with Henry Ford, mass production, economies of scale. Lean philosophy brings a shift of paradigm. The selected aspects of Lean and conventional management of production are listed in the Table 1.

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Table 1 Comparison of Lean and conventional management approaches in selected aspects

	Conventional management	Lean Management
Approach towards improvements	Innovations, investment projects	Continuous improvement, small incremental everyday changes, kaizen
Perception of problems	Result of someone messing up	Deviation from standard
Cause of the problem	Individual	System
Expected reaction to the problem	Individual should solve problem on own if possible	Individual should call attention to problem for assistance and to avoid recurring of the problem in the future
Responsibility for the problem	Person who makes mistake	Management

Based on: (Mann 2015, pp.23, 26); (Liker et al. 2008, p.166)

Lean Management recommends the companies to maximize customer value while minimizing waste. The core of the concept was formulated in the form of five Lean Thinking principles:

1. Precisely specify value for specific product/service
2. Identify the value stream for each product/service
3. Make value flow without interruptions
4. Let the customer pull value
5. Pursue perfection

The fifth principle indicates striving for perfection and operational excellence, which Toyota made its strategic advantage. It is fulfilled by continuous improvement done every day by everyone in the form of small improvements (kaizen), short improvement cycles based on PDCA approach and structured problem solving methods.

Lean Thinking changed also the way in which people and organizational structure are perceived. Toyota calls it 'servant leadership' and presents in a form of inverted pyramid (Figure 2). The key insight in this perspective is that the further someone is from the value stream (e.g. because of the position in organizational structure), the less value that person directly adds to the product. In other words, the team members are the only people who actively add value to the product, and the leaders are responsible for supporting them. The prerequisite in this approach is the empowerment of lower levels of organisation, mutual trust and respect.

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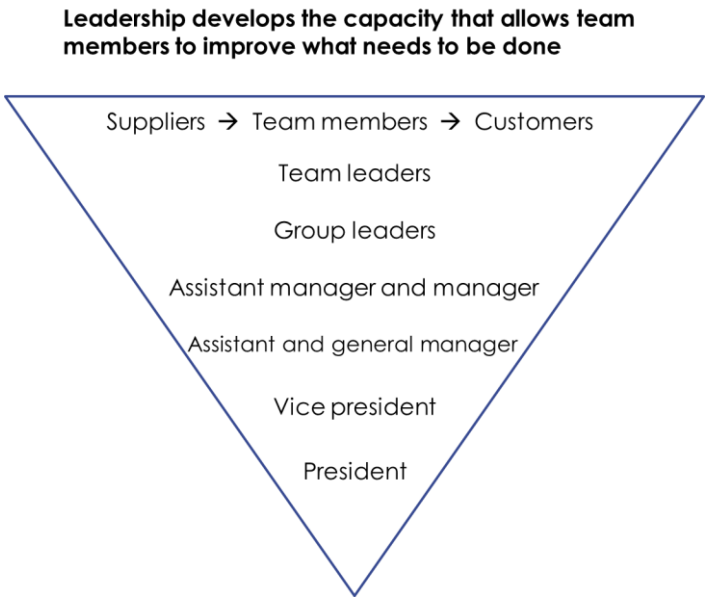

Figure 2 Servant Leadership in Toyota Plants, source: (Liker et al. 2008, p.321)

Lean Management has been proved to be a successful way to organize production operation, however very often companies tend to overlook the critical element needed to sustain it. According to D. Mann, this element is a Lean Management System, which contains four principal elements (Mann 2015, p.xxv):

1. Leader standard work – daily checklists for line production leaders, team leaders, supervisors, and value stream manager, that shows expectations for what it means to focus on the process.
2. Visual controls – tracking charts and other visual tools that present authentic performance output compared with planned performance.
3. Daily accountability process – brief, structured, tiered meetings focused on performance with visual action assignments and follow up to close gaps between actual results vs. expected performance.
4. Leadership discipline – leaders themselves consistently following the process that defines the first three elements and following up on others' adherence tothe same process. .

A more detailed description of the four elements of Lean Management System is provided in the report *D1.2 Technology Watch Report* (chapter 4).

Implementing these elements in the company makes Lean production sustain and shapes the culture of the company in a way that enables development and continuous improvement in every aspect of performance.

2.2 MAESTRI specific elements to support MAESTRI implementation roadmap

One of the goals of *Work Package 3 Management system* was to investigate whether the existing low cost improvement methods suit the specific conditions of process industries. Based on interviews with Lean Management experts (working as consultants for LEI Poland) and literature research, the differences between continuous processes and discrete processes have been elaborated in terms of implementing low cost improvements (Mann 2015, pp.43–47), (JD Edwards World 2013), (Floyd 2010).

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There are two main types of production process in manufacturing industry: continuous process (process industry) and discrete process (mechanical manufacturing). Continuous process is a process with continuity of introducing raw material to the environment of transformation and withdrawing completed product. Industry sectors that can be classified as continuous processes are: chemicals, synthetic fibres, oil refining, pulp, paper, natural gas processing, continuous casting of steel, synthetic fibres etc. Processes with individual or separate unit production like automobiles, furniture or toys are called discrete processes. These type of processes characterize by individual or separate unit production.

The main difference between process industry and mechanical manufacturing is the way of raw material transformation. In process industry raw material experiences a transformational change as it becomes a product, opposed to a reconfiguration change in mechanical manufacturing. Another significant difference between process industry and mechanical manufacturing is the manner in which the process of transformation occurs. In discreet manufacturing the changes that occur in the raw material so that it becomes a finished product are achieved by applying a direct touch either personally by operators (like in assembly) or by some tools or devices (e.g. cutting tool). On the contrary, in the process industries the raw material changes itself by applying the proper environment conditions. In some sectors, the material and even the finished product is never seen by operators in normal operation as it flows in the closed fitting from raw material storage to the stage of finished goods inventory. That characteristic results also in the different relation to time. In case of process manufacturing transformation of raw material is frequently dependent on time because of a physical phenomenon or chemical reaction occurring inside the container, whereas mechanical manufacturing is independent of time. The differences mentioned above cause that both types of manufacturing processes require different approaches to process improvement as well as Lean Manufacturing implementation and face different types of difficulties as well.

Generally continuous processes are more capital-intensive. That results from the higher dependence on machinery and equipment both in terms of the production process organisation and of implementing improvements. Improving availability of finished goods, flexibility and product quality can be achieved rather by mitigating machine problems than by improving operators' work by implementing such Lean Management techniques like e.g. 5S and workstation organisation.

Discrete processes are more labour intensive due to the fact that operators generate most added value to the process. Effective improvements focus on standardization of operators' work for example by 5S which makes better results and has a wider range of application than in the continuous processes.

The Table 2 summarizes and compiles the most significant differences between Lean Manufacturing implementation in continuous and discrete processes.

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Table 2 Differences in Lean implementation in continuous and discrete processes

Continuous Processes	Discrete Processes
Little accumulation of material between production stages	Significant accumulation of material between production stages
Rare discontinuities in production process	Frequent discontinuities in process tend to accumulate Work In Process inventory (WIP)
Problems in production process results in accumulating resources other than inventory e.g.: excessive maintenance, additional redundant equipment (excessive consumption of capital), excessive support technicians, lack of maintenance, not properly adjusted technological parameters	Inventory as a warning signal of inefficiency for operators and possibility of introducing improvements
Improvements are related to standardization of machines	Improvements are related to people's work organisation
Sometimes is it possible to correct samples without consequences by making numerous adjustments	It is difficult to correct pieces (results in costly rework or increasing scrap)
It is more difficult to achieve flexibility of product mix - production more in large batches (greater potential for improvement)	It is easier to achieve flexibility of product mix, lower potential for improvement and higher possibility of one-piece flow
Production planning has a higher every part every internal (EPEI)	Production planning has a lower every part every internal (EPEI)
Key measures of process focus on comparing expected vs. actual performance expressed in tons or barrels	Key measures of process are based on takt time as the pace for production
Improving availability, flexibility and product quality is achieved by mitigating machine problems	Improving availability, flexibility and product quality is achieved by focusing on organisation of operators' work
It is difficult to directly observe the production flow because of closed production equipment and long lead time	It is relatively easy to make a direct observation of production flow because of typically shorter lead time

To provide relevant solutions to the specific conditions of process industries, the following methods and tools have been proposed:

- Eco Orbit View,
- Focused Gemba Walk,
- Retrospective Analysis,
- Eco Lean Management Boards.

2.2.1 Eco Orbit View

Aim of method

Eco Orbit View (EOV) is a simple method intended to indicate areas in the production process where the company should focus the improvement activities in order to get simultaneous improvement of business and environmental performance. The EOV method

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concentrates on looking for synergies between business and environmental perspective in order to gain the proper motivation to achieve goals in both aspects.

Brief description of the method

The name Eco Orbit View originates from space exploration and reflects the idea that the Earth, seen from an orbital spacecraft reveals only the largest objects like oceans, mountain chains, etc. The infinite complexity of details remains hidden. Likewise, the proper judgement about the state of a production process can be made without complex analysis of data thanks to focusing on the methodologically selected key aspects.

The Eco Orbit View analysis is performed in 4 steps:

1. Identification of production process steps (for a selected product family)
2. Identification of Key Performance Indicators (KPIs) relevant for each process step
3. Identification of Key Environmental Performance Indicators (KEPIs) or Environmental Aspects relevant for each process step
4. Identification links and synergies between KPIs and KEPIs
5. Prioritisation of improvement ideas, selection of the potential improvement areas

The Eco Orbit View analysis may be performed in a form of consultancy or a workshop for a group of people. Such a workshop may serve as an eye opening exercise and was very appreciated by the MAESTRI industrial partners that had the chance to participate in it during development phase (July 2016, December 2016 and January 2017).

The agenda for an Eco Orbit View workshop embraces also the element of *gemba walk*. An exemplary agenda is depicted in the Table 2.

Table 2 Agenda for Eco Orbit View workshop

Time	Activity
Day 1	
09.00 - 10.00	**Introduction** **Identification of product family to analyse**
10.00 - 12.30	**Gemba walk (factory visit)** • Process map • Critical factors, main KPIs
12.30 - 13.00	**Lunch**
13.00 - 15.00	**KPIs & improvement objectives (interviews)** • Final set of KPIs • Targets for KPIs
15.00 - 17.00	**Environmental aspects, indicators, targets (interviews)**
Day 2	
09.00 - 12.30	**Drawing Eco Orbit View** **Looking for connections (moderated session)** • Connections between KPIs and environmental aspects • Improvement potentials
12.30 - 13.00	**Lunch**
13.00 - 15.00	**Confirming improvement potential (Focused Gemba Walk)**
15.00 - 17.00	**Summary**

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Outputs

In summary, the Eco Orbit View shows KPIs (reflecting company needs) and KEPIs or environmental aspects (reflecting environmental needs) side by side for chosen process steps. The analysis results in the indication of potential improvement areas, reflecting the needs of the company to improve both the economic and environmental performance. Thus, the areas where the eco-efficiency of the company may be improved can be identified.

The pre-validation runs of Eco Orbit View workshop showed that visualisation of the results plays an important role to achieve the goals of the method. In order to organise the improvement ideas that are generated or gathered during the workshop, the following three means have been proposed:

1. Visualisation of EOV process map together with potential improvement areas – created during the workshop with the active input from participants. The data on KPIs, KEPIs and correlations are handwritten. The forms are put on a wall or whiteboard so that the visualisation is big and easy to read. That also facilitates the discussion about improvements.

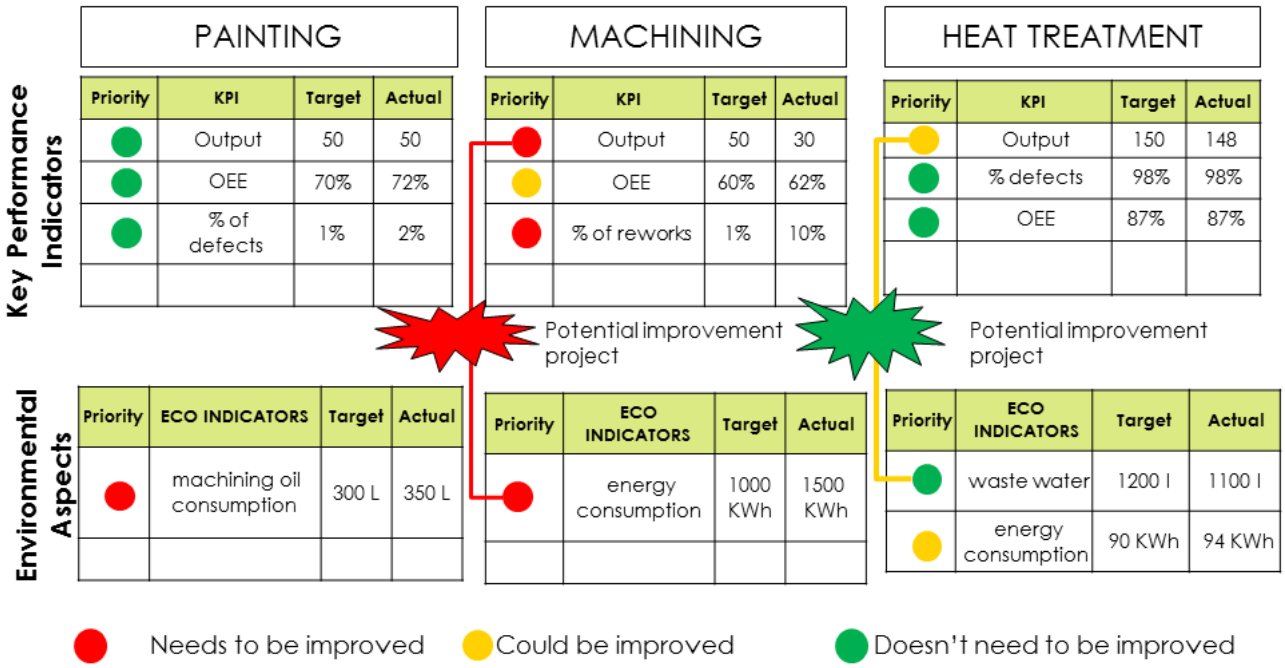

Figure 3 Eco Orbit View workshop results presented in a visual form

2. Success equations – a simple form of presenting the most important strategic challenges for the given company or facility.

$$\text{Sum} = \text{summand} + \ldots + \text{summand}$$

Sum reflects the key factor that determines the business success of the company and might be expressed by a particular KGI. Summands represents KPIs that influence the given KGI. The same logic is in the force for environmental perspective. An example from one of the workshops is shown in the Figure 4.

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Business Success

To produce sales order on time = Right quantity of parts after cutting on time + Reduce downtimes (area 2) + Control of missing parts (area 3) + Engineering time within standards

Environmental Success

To be more environmental friendly = Reduce metal scrap (area 1) + Reduce electrical energy consumption (area 1, area 4) + Reduce internal transportation

Figure 4 Examples of success equation for business and environmental aspects

3. The table summarizing potential improvement areas and improvement ideas.

During Eco Orbit View the improvement ideas arise, especially during the gemba walk phase. Usually they need to be classified. The Table 3 depicts an example of such of classification that helps to manage the implementation of improvements. Each column represents a Potential Improvement Area (which means: where and what should be improved e.g. "high rate of quality problems after milling"). For each potential improvement area, ideas are grouped in three categories: quick wins – short, quick changes that can be completed in few following weeks; systematic change – ideas that require a change in management system, usually requires more time and effort to complete; more analysis needed – the ideas that need to be refined by collecting some additional data or performing deeper analysis.

Table 3 Table summarizing potential improvement areas and improvement ideas

	Potential improvement area 1	Potential improvement area 2	Internal transportation reduction
Quick wins	- first part validation - measurement of rejects - …	- create standardized work instruction for setups - 15 minutes maintenance meeting	- integrating production in one plant - Store WIP in point of use - new system to control stocks and monitor
Change in production system required	- Improving 1st level maintenance - Visualizing indicators for all the people in the area (efficient data collection) - …	- visualization of status of the machine - include the machine & maintenance audit into workplace audit	
More analysis needed	- moving some parts to punching machines	- monitoring the reason of downtimes by operators	- test with smaller boxes for smaller parts - …

The basis version of Eco Orbit View was developed in the scope of the Eco Lean Compass project (funded by the National Centre for Research and Development programme ERA-NET ECO-INNOVERA under agreement No ERA-NET-ECO-INNOVERA 2/2/2014). The work carried out within the MAESTRI project aimed at further development, validation and adjusting the method to the specific conditions of process industries.

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2.2.2 Focused Gemba Walk

Aim of method

Focused Gemba Walk is a method for a very quick analysis focused on a potential improvement area identified during an Eco Orbit View analysis. The result of this analysis should be low-cost organisational (process) improvement ideas, which could be implemented within a few following weeks.

Brief description of method

Focused Gemba Walk is a direct observation of a problematic area or process to understand the root cause of a problem and identify an improvement that will lead to permanent elimination of the problem.

Example:

During Eco Orbit View analysis it was identified that a potential improvement area is an injection moulding process, where the quantity of scrapped material should be reduced. From this moment the scrap in injection moulding is perceived as a problem to eliminate (or reduce). Focused Gemba Walk is a direct observation of the moulding process to understand why scrap occurs, what are the reasons, what simple improvements of the process could be implemented to eliminate or reduce scrap.

Let's assume that during observation it was stated that a big portion of scrap is generated just after changeover of the machine (after changing a mould). The reason is that the mould is not always positioned properly and the operator produces some parts, checks visually if they are "OK", and if not, adjusts the mould and tries again. He repeats such a loop until the produced parts are correct (which usually takes 2-3 iterations). There are several options of simple improvements to eliminate scrap after changeover, e.g.:

- creation of a good procedure of verification if the mould was positioned right first time,
- adding extra guide pins to moulds to ensure proper positioning of the mould (right first time),
- better training for operators to teach them how to position moulds right first time.

There are some limitations of using this method:

- Focused Gemba Walk can be used only for the areas where direct observation of process is possible.
- Focused Gemba Walk can be used only if the problem occurs quite frequently, so that it can be noticed during few hours of observations.

If the above mentioned criteria are not met, the Retrospective Analysis should be used, described in 2.2.3 (instead of Focused Gemba Walk).

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Brief description of steps

Focused Gemba Walk is based on the Go-See-Act approach.

1. Go
   Go to the place where the problem occurs.
2. See
   Observe the process from 6 perspectives:
   - Method – are work procedures and standards available in work place and accurate (e.g. setup procedure, process parameters, quality check instruction).
   - Man – is operator working according to procedures and instructions.
   - Machine – is machine working properly (it includes also the surrounding elements of infrastructure e.g. transportation system, system supplying technical gasses).
   - Material – is material correct, without flaws and within the required specification.
   - Measurement – is measurement equipment working properly.
   - Environment – is environment correct for the process, are there any phenomena that could influence the process negatively (e.g. moisture or temperature of air, vibrations of building generated by other areas of plant)

3. Act
   Based on step 2 find the root cause of the problem (usually related to one or few of the 6 analysed perspectives) and identify low cost organisational (process) improvements to implement.

Outputs

The result of Focused Gemba Walk is a list of low cost improvement ideas that could be implemented.

2.2.3 Retrospective Analysis

Aim of method:

The main aim of the Retrospective Analysis is to find root causes of a problem quickly, without the need for an extensive data collection over a long period (like in statistic-based methods).

Brief description of steps:

The Retrospective Analysis consists of three steps (Figure 5). The method has been described in more details in *D3.3 Improvement Tool*.

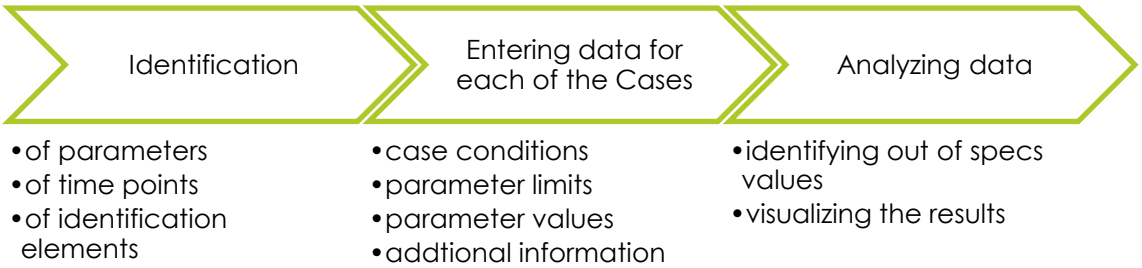

Figure 5 Steps of Retrospective Analysis

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Outputs:

The outputs of Retrospective Analysis are identified root causes of a problem. After root causes being identified, an organization may undertake actions to eliminate those root causes and in that way eliminate or at least mitigate the problem.

2.2.4 Eco Lean Management Boards

Eco Lean Management Board is one of the practical means for implementing the visual control element of a Lean Management system (see: chapter 2.1 Lean Management System). This is a visual management board which presents the most important improvement goals and indicators tracking the progress towards these goals.

In order to get the best benefits from managements boards the routines of regular reviews should be established. Review routine is a clear standards of structured regular meeting defining who, when, how often and in which way should review the indicators presented on the management board. From that meetings the list of actions should origin, which then in turn are reviewed during the next regular meeting. In that way a daily accountability process is built in the company, which is one of Lean management system elements.

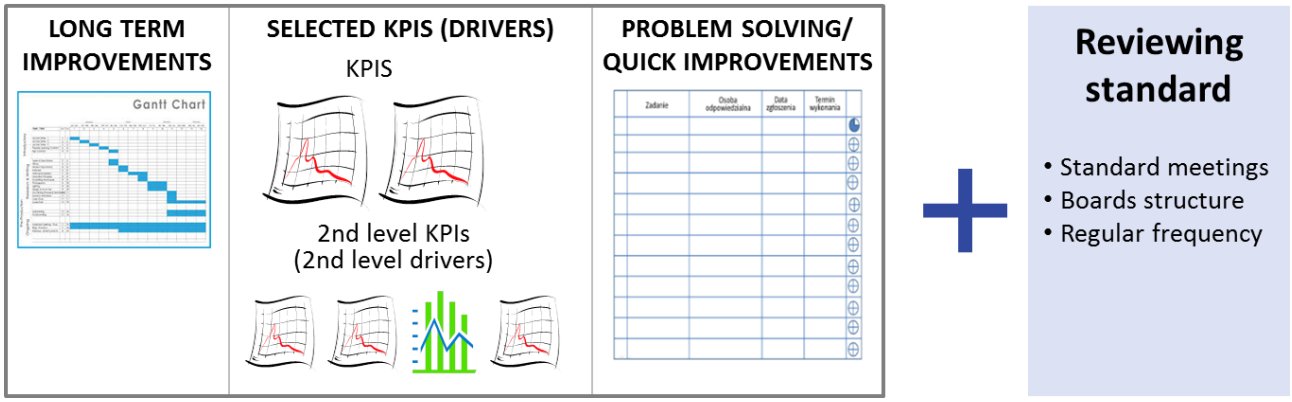

Figure 6 Eco Lean Management Boards elements

The aim of introducing Eco Lean Management Boards to the company is to:

- Link daily operation with the most important improvement projects resulting from the company strategy
- Provide enough resources for improvement activities on every level of the organisation
- Embed eco performance into improvement activities
- Build a culture of continuous improvement and leadership discipline.

For the reason that the companies differ from each other regarding their organisational maturity level, strategic orientation and current needs, MAESTRI proposes two possible approaches for implementing Eco Lean Management Boards. The first approach is based on the Hoshin Kanri approach and provides a complex holistic system for the whole organisation. The other approach proposes focusing on a selected pilot area (that could be a selected department, production line, critical machines etc.). Implementing Hoshin Kanri approach takes a significant amount of time. Typically in a medium size company it takes 1-3 months to teach the basis of the method and to develop the first level boards with agreed goals, methods and indicators. After that it takes a full yearly cycle of regular monthly reviews before this way of management becomes natural and effective. Usually

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there is also a need for help from somebody experienced in the Hoshin Kanri approach with the relevant knowledge and facilitation skills.

The comparison of benefits and limitations of both proposed approaches to implementing Eco Lean Management Boards is presented in Table 4.

Table 4 Comparison of possible approaches to implement Eco Lean Management Boards

	Approach 1 Eco Lean Management Boards based on Hoshin Kanri	Approach 2 Eco Lean Management Board as a single example in a pilot area.
Description	There are several Eco Lean Management Boards in the company that build a system encompassing all organisational levels and departments. The hierarchy of boards and the goals presented reflects the Hoshin Kanri process of deploying strategy to lower levels of organisation and the catchball process of getting consensus around the yearly strategic objectives.	There is one or a few Eco Lean Management Boards that support implementation of improvement projects in the selected pilot area
Benefits	Alignment of the whole company around the strategy and strategic objectives	A visual management tool that helps conduct improvements in the selected pilot area and sustain the proper motivation. Simultaneously the people learn how to use Lean management system based on a small example
Limitation for implementation	Implementation requires company-wide engagement. It takes several months and a year of reviews before the approach brings its best benefits	No significant limitations to implementation

The benefits of the pilot implementation are relatively smaller compared to the holistic approach. However, it enables to 'start small' and gradually get benefits and build a Lean culture especially in the situation when there is no consensus in the company about entering Lean transformation. The proposed two approaches address the following challenges related to management boards:

- there is a need for a simple method to establish management boards in critical areas of the company.
- there is a need for guidelines how to translate decisions coming from Eco Orbit View into KPIs and improvement plans on management boards.
- there is a need for guidelines how to select drivers (KPIs) for management boards for a given area.

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Eco Lean Management Boards based on Hoshin Kanri approach (approach 1)

Hoshin Kanri (called also Policy or Strategy deployment) is a management process that aligns an organization's functions and activities with its strategic objectives. A specific plan (typically annual) is developed with precise goals, actions, timelines, responsibilities, and measures (Lean Enterprise Institute 2014). What is important, during the phase of development Hoshin Kanri goals, the company is forced to match available resources with desirable projects. Only the projects that are aligned with strategic goals and achievable are authorized for implementation. That helps to avoid the following situations:

- there are too many improvement projects running in comparison to available resources;
- the improvement projects are spread around the company and do not contribute to the common vision and strategic goals.

Typically the number of goals or projects selected is between 3 and 5. This is to avoid the practice in many organizations of embarking on many improvement initiatives that are popular in parts of the organization, but are not completed for lack of cross-function agreement and resources (Lean Enterprise Institute 2014). Usually strategic goals are organised in categories reflecting QCD (quality, cost, delivery) aspects. The board should visualise four elements: plans (objectives and methods), current results, problems and corresponding corrective actions. An example of a Hoshin Kanri board is presented in Figure 7.

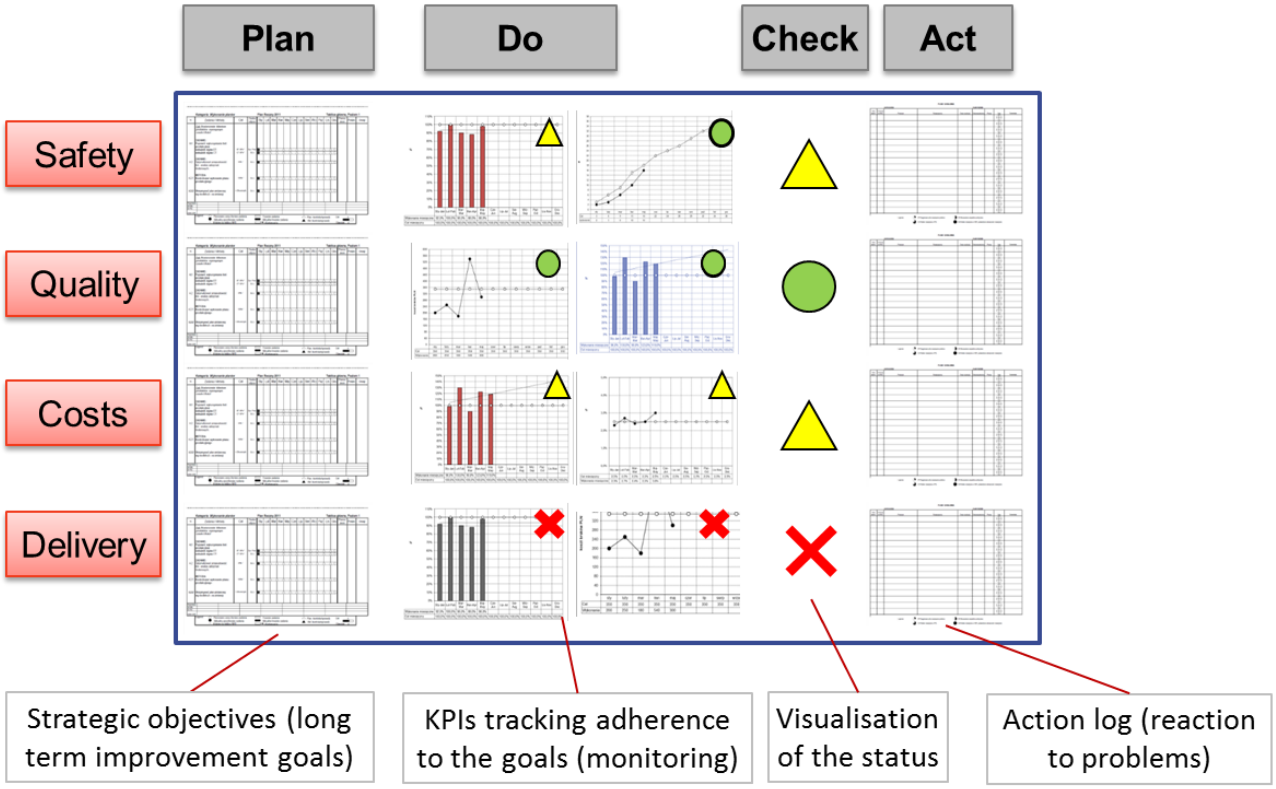

Figure 7 Example of Hoshin Kanri board

When the first level goals, methods, KPIs and visualisation are agreed, the strategic goals can be divided and deployed down the organisation. Typically every level of organisation has its own Hoshin Kanri board. The process of building consensus around the strategic goals is called catchball and is described more detailed in the deliverable *D1.2*

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Technology watch report. The main assumptions of cascading strategic objectives to the lower levels of an organisation are presented in Figure 8.

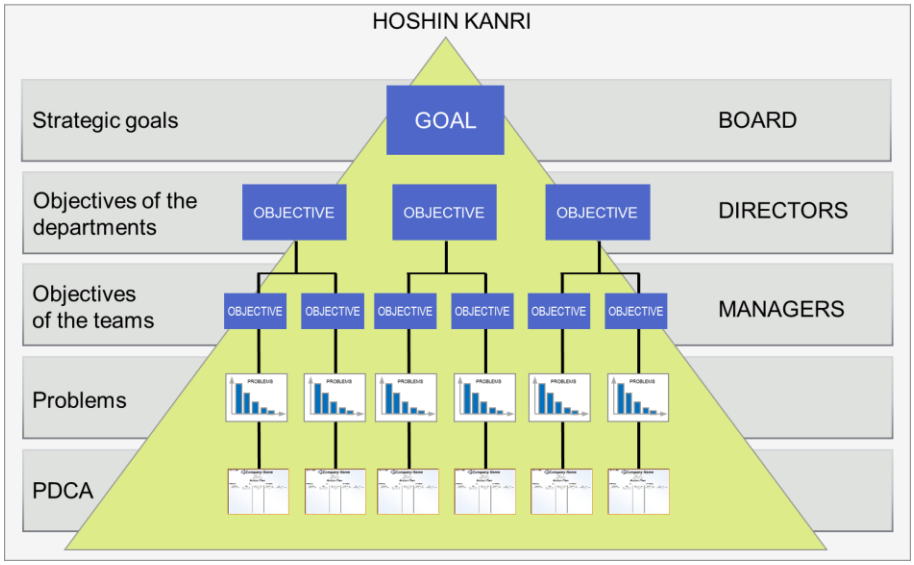

Figure 8 Hierarchy of Hoshin Kanri boards and corresponding deployment of goals (source: LEI Poland training materials)

The relationship between planning and execution phase of Hoshin Kanri process and the role of visual management boards is depicted in Figure 1.

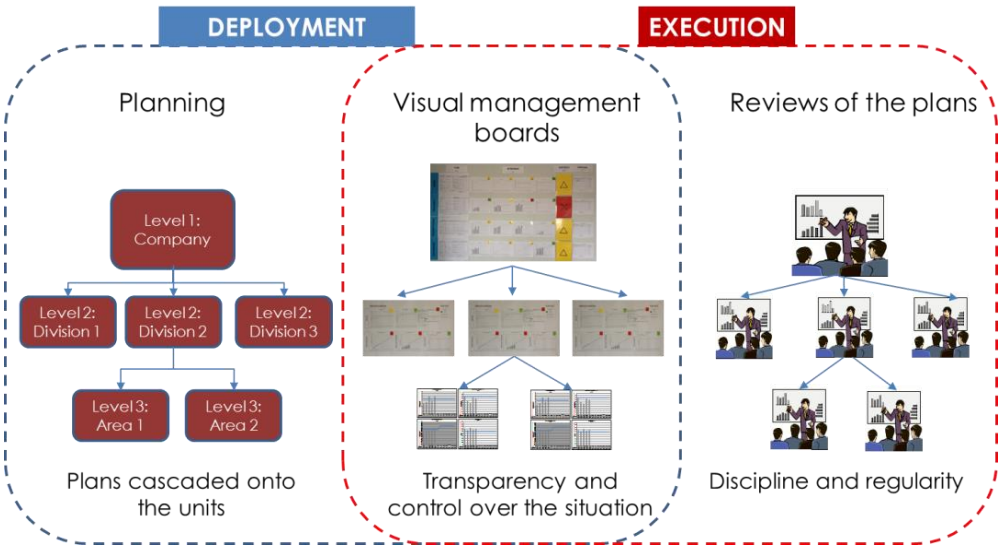

Figure 9 The relationship between deployment and execution in hoshin Kanri approach (source: LEI Poland training materials)

In order to execute the Hoshin Kanri approach, regular reviews need to take place. Therefore a review routine plan needs to be developed for each level of the management. It should cover frequency, dates and place of meetings. Usually the boards for the top management level of Hoshin Kanri are reviewed once a month, the ones for second level of management once a week and the ones at the operational level on a daily basis. However, the frequency should be adjusted to company size, processes and management style. It is important to synchronize the reviews on different levels with each other. This helps to secure the proper flow of information for example from the operational

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level to the second level of management (in this case the operational meeting should be held first before the second level of management meeting).

Reviews should be conducted according to a standard. The standard should define the agenda of the meeting, participants and time of the meeting. Preparation for the review should be done prior to the meeting – for example updating the data and charts before the meeting. During the meeting results should be discussed, especially those which are not in target, and the corrective actions should be noted down. If a problem is too complex for the current level of the organization, the review is a place to escalate it a level up. The review is neither a place to search for root causes of problems, nor for solving those problems. It is a good practice to audit the meetings: has the data been updated prior to the meeting?, was everybody present?, did the meeting finish on time? etc.

Eco Lean Management Boards in a pilot area (approach 2)

The Hoshin Kanri approach brings significant benefits to companies' operation thanks to focusing the efforts of the whole organisation on the common strategic goals. However, the organisations that for some reasons do not decide to implement that approach may try to use an Eco Lean Management Board in a designated pilot area (for one improvement project for one production line). The benefit will be to start almost immediately with relatively low effort for implementation.

One possible approach to begin with Eco Lean Management Boards for a pilot area is to use the results from an Eco Orbit View workshop. The results that are summarized in the form of success equations reflect the most critical issues for the given business. The method of deriving the structure of Eco Lean Management Boards from success equations is depicted in Figure 10. Each sum of success equations is represented by Key Goal Indicators while each summand corresponds with one or more Key Performance Indicators.

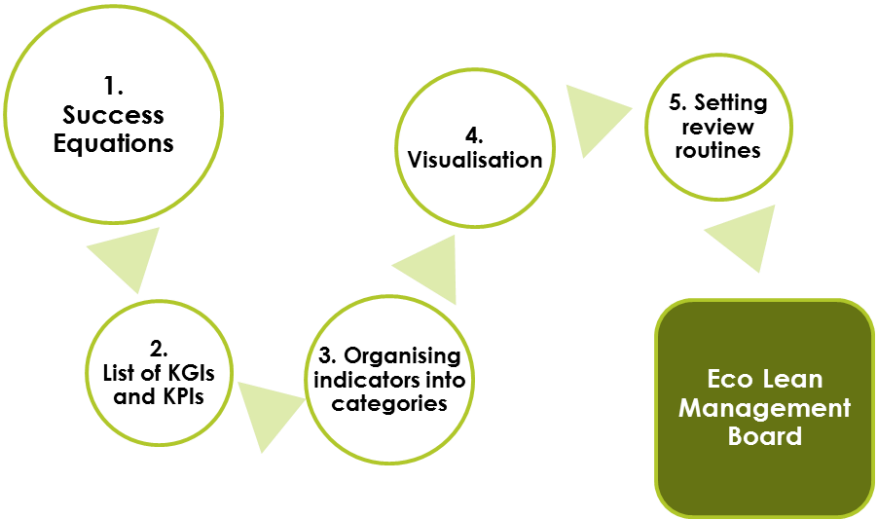

Figure 10 Method of deriving the structure of Eco Lean Management Boards from success equations

An example of an Eco Lean Management Board, whose structure was built upon success equations, is depicted in Figure 11. The structure of the board was created on the base of Eco Orbit View workshop results. The results were summarized in the form of success equations for business and environmental perspective (Figure 12).

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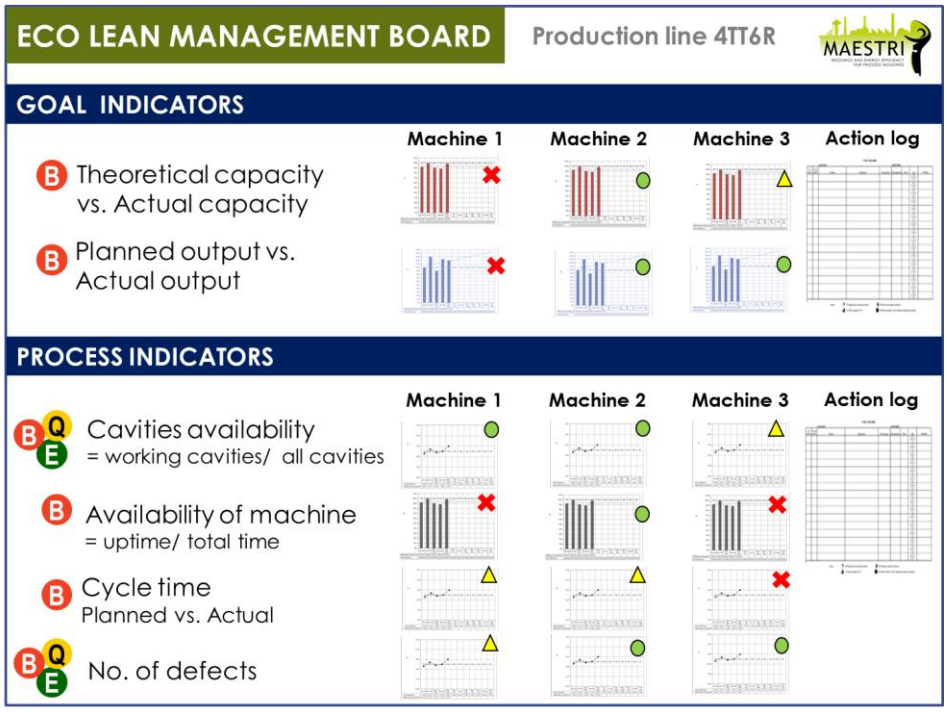

Figure 11 Example of Eco Lean Management Board for pilot area

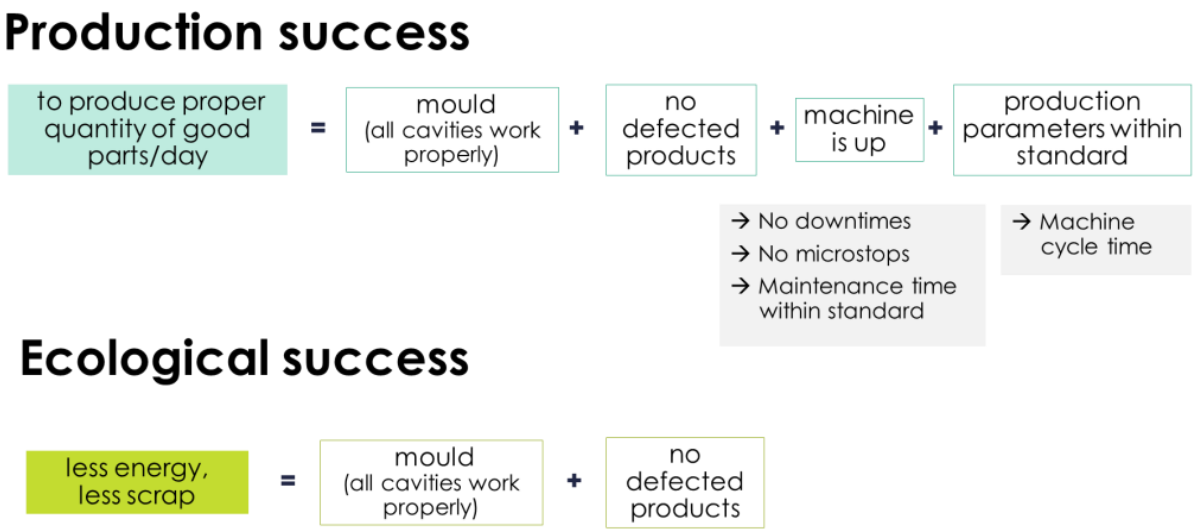

Figure 12 Example of results of EOV in the form of success equations for plastic injection business

Implementing the Eco Lean Management Board in a pilot area requires setting a review routine which is very similar to the reviews held in the approach based on Hoshin Kanri (compare Approach 1).

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3 Embedding Eco Performance and Continuous Improvement into Management System and Company Strategy

Very often environmental aspects are neither present in companies' strategic goals nor in every day operations. The research carried out by LEI Poland among Polish production companies in first quarter of 2015[1] showed that improvement projects focus on productivity, cost and quality. It shows that managers concentrate more on economic business goals ('business first'). For that reason environmental improvements have usually lower priority and less resources assigned than the ones directly connected with business goals.

A lot of managers also believe that 'eco' is expensive. The most natural and immediate association about environmental improvements are connected with investments: new more environmental friendly technology, more efficient machine, LED lights in warehouse etc. Many managers think about ecological issues from a cost perspective and do not treat them as an opportunity to increase profits and competitiveness. On the other hand, popular methods used for analysis or improvement of the environmental impact of the company or product require quite often a significant amount of time and effort for analysis and implementation. This is a factor that additionally discourages managers to take any actions in this direction and is a barrier for implementation.

When the Lean Management concept became famous worldwide in the 90s of the 20th century, it appeared that Lean Production differs from the conventional also in the way improvements are seen. The Western companies value more significant innovation changes, while e.g. Toyota insists on continuous improvement, understood as numerous small improvements that are implemented every day by every employee (*kaizen*). It has been proven that *kaizen* approach lets organisations improve much quicker than in conventional way. However, it also appeared that in order to benefit from massive kaizen improvements, a cultural change is required. Numerous organisations worldwide struggle to implement continuous improvement culture and make a lot of effort to sustain the change.

The approach proposed as MAESTRI management system allows to embed both continuous improvement mechanism and environmental focus into the existing management system of the company.

3.1 Integrating environmental aspects with strategy

One of the internal barriers identified *in D3.1 Internal challenges and barriers for energy and resource management* is the fact that ecological aspects are not an integral part of corporate strategy. That in turn has several causes:

- Corporate strategies are oriented mainly on QCD aspects
- Impact of ecological aspects on QCD is indirect and therefore difficult to grasp

[1] The research was conducted in the scope of Eco Lean Compass project (funded by the National Centre for Research and Development programme ERA-NET ECO-INNOVERA under agreement No ERA-NET-ECO-INNOVERA 2/2/2014).

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- Top management tends to omit ecological aspects while building corporate strategy
- Ecological aspects are foreseen as Corporate Social Responsibility (CSR) related issue
- Ecological aspects on regular basis are perceived as long term and therefore they are not prioritised in short term planning horizon. Usually, there is no establishment of costs or gains to apply environmental measures.

To mitigate these barriers, the Eco Orbit View method has been developed. The method provides the following benefits regarding integration of environmental aspects within strategy, KPIs and managers' routines:

1. Identification of improvement projects that are beneficial both from business and environmental perspective (Figure 13) ensure the proper motivation to achieve environmental gains;

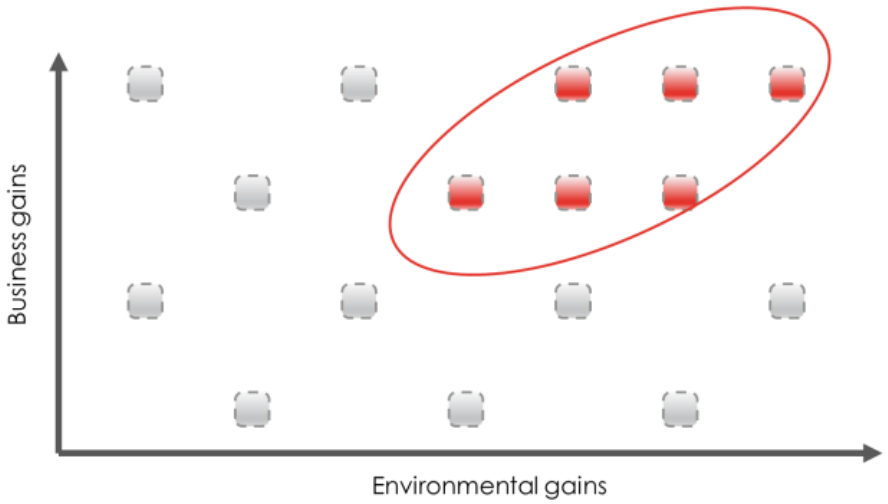

Figure 13 Eco Orbit View as a method identifying synergies between business and environmental perspective

2. Provide a direct link to strategic goals thanks to identifying KPIs or Key Challenges for every production process step.

3.2 Embedding environmental perspective into daily improvement routines

Lack of ecological aspects in strategy deployment to the operational level has been identified as a barrier for effective energy and resource management. Implementing Eco Lean Management Boards in the company might be an effective solution for that problem.

There are three possibilities to include environmental aspects to the management boards:

1. Ecology included as a separate category on management boards.
2. Ecological aspects included in a form of KEPIs in other categories.
3. Ecology present through related KPIs.

The first solution presents ecology as a separate category (Figure 14). That seems to emphasise the importance of this aspect in everyday operation. However, this approach often leads to the situation that ecology in fact is perceived as something outside the existing performance measurement system. In this way also the environmental goals are

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perceived by middle management as less important and much less or no efforts are undertaken to improve ecological performance within the framework of organisational innovations.

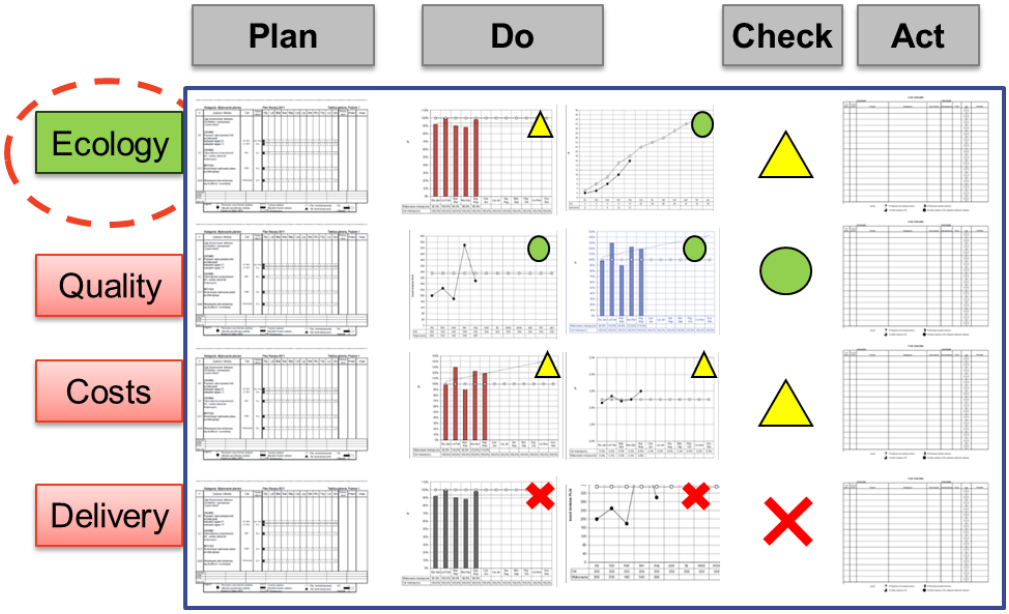

Figure 14 Ecology included as a separate category on management boards

The approaches when environmental goals are really integrated with other categories build more consistent every day management routines (Figure 15, Figure 16).

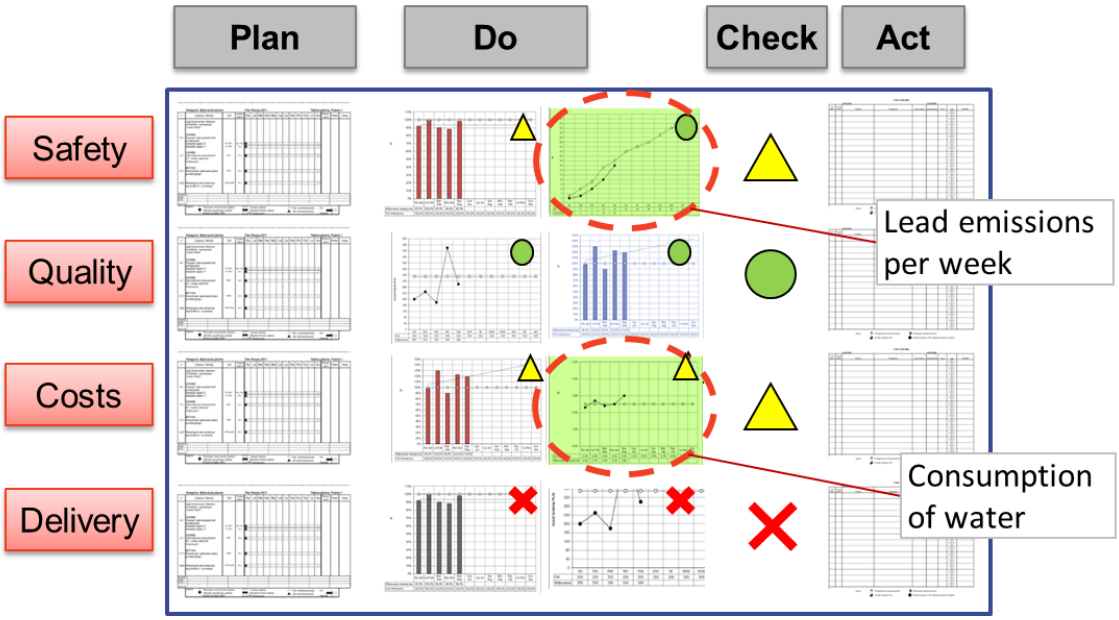

Figure 15 Ecological aspects included in a form of KEPIs in other categories

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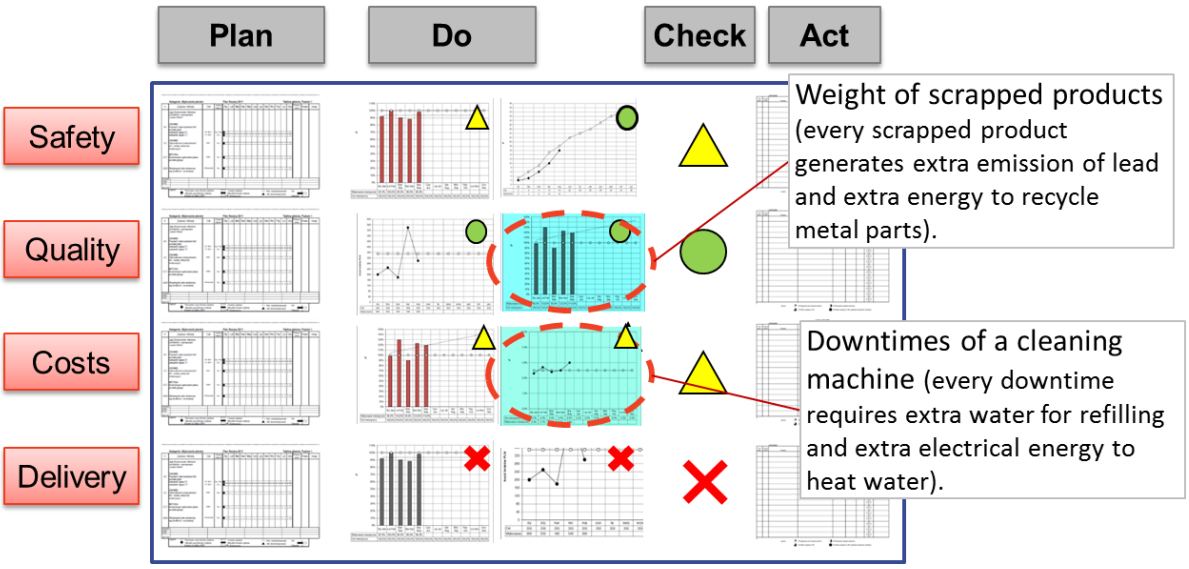

Figure 16 Ecology present through related KPIs

3.3 Integration of MAESTRI Management system with ISO norms

MAESTRI Management system ensures synergies with ISO standards in order to support implementing the management culture focused on continuous improvements and to be more easily adopted by companies that already have ISO standards implemented. The expected improvements include both business and environmental aspects of a company. Management instruments as ISO 9001, ISO 14001 and ISO 50001 standards allow to support decision making processes in the company.

3.3.1 ISO 9001

ISO 9001 is an international standard that presents requirements for quality management systems. If the company implements ISO 9001 it is required to have a stable management system taking into account quality aspects. The ISO 9001 short description of advantages and disadvantages was delivered in *D2.1 Efficiency Framework*.

In order to define a management system that encompass environmental aspects, one should assess the available management systems in order to build on the best practices.

MAESTRI project is compatible with ISO 9001 standard in many aspects. Eco Lean Management Boards includes the following components of ISO 9001: visual controls, daily accountability process and leadership discipline. Eco Lean Management Boards can also support increasing the awareness of the quality policy, quality objectives and their contribution to the effectiveness of the quality management system. The boards allow visual control over the status of processes and information if everything has been carried out as planned. Unintended changes in plan can be resolved by Plan-Do-Check-Act. Plan-Do-Check-Act is mentioned likewise in ISO 14001 and ISO 50001.

The implications of incompatibility with the quality management system can be identified by the Focused Gemba Walk method and can help to find low cost organisational improvement ideas that improve the quality of a product.

Retrospective Analysis provides a method to identify parameters, time point and identification elements that quality policy determined.

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3.3.2 ISO 14001

ISO 14001 is an international standard that outlines how to develop an effective Environmental Management System in the company. This standard can help to better control factors impacting on the environment such as water consumption, energy consumption, wastes, gases emission etc.

The Eco Orbit View supplements ISO 14001 in terms of waste reduction and costs optimization. By using Eco Orbit View it is possible to designate areas for improvement and monitor it further with Eco Lean Management Boards. ISO 14040 describes Life Cycle Assessment, ISO 14045 is about quantitative management tool – eco-efficiency assessment of product systems. A detailed description of this standard is included in *D2.1 Efficiency Framework*.

The main principles of ISO 14001 are consistent with the MAESTRI project's point of view in terms of identification of resources and waste management. The MAESTRI project provides also a management system with Key Performance Indicators and Key Environmental Performance Indicators that allows to measure and monitor processes in respect of business and environmental aspects as assumption in the Implementation and Operation principle of ISO 14001.

3.3.3 ISO 50001

ISO 50001 concerns energy management system in order to implement processes and systems to improve energy performance and consequently improve energy efficiency and energy consumption aspects. Following the ISO 50001, the top management has to establish, implement and maintain the energy policy. When the ISO 50001 is implemented, the top management ensures that the results are measured and reported at specific intervals. The section of energy planning includes recommendation for continuous improvement of energy consumption. In details an analysis of the energy consumption should point the areas with the highest energy consumption and assess the future use of energy. ISO 50001 standard allows for flexibility in defining what is the result of energy analysis – reducing a peak demand, utilising the excess energy or improving operational control systems.

High energy consumption can be indicated by Eco Orbit View as an improvement area. It creates a possibility to monitor by Key Environmental Performance Indicators, improve energy consumption and reduce cost of energy used.

4 Interactions between Management system and other elements of Total Efficiency Framework

The Total Efficiency Framework's elements (pillars and tools) are intended to support the implementation of the MAESTRI roadmap. The initial version of the roadmap and interdependencies between elements of the Total Efficiency Framework are depicted in Figure 17 and will be further elaborated in *WP6 Pilot Implementation and Validation*, WP7 *Exploitation and Sustainability actions* and *WP8 Dissemination and communication*.

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However, for this stage of development several connections between MAESTRI Management system elements and other pillars can be already defined.

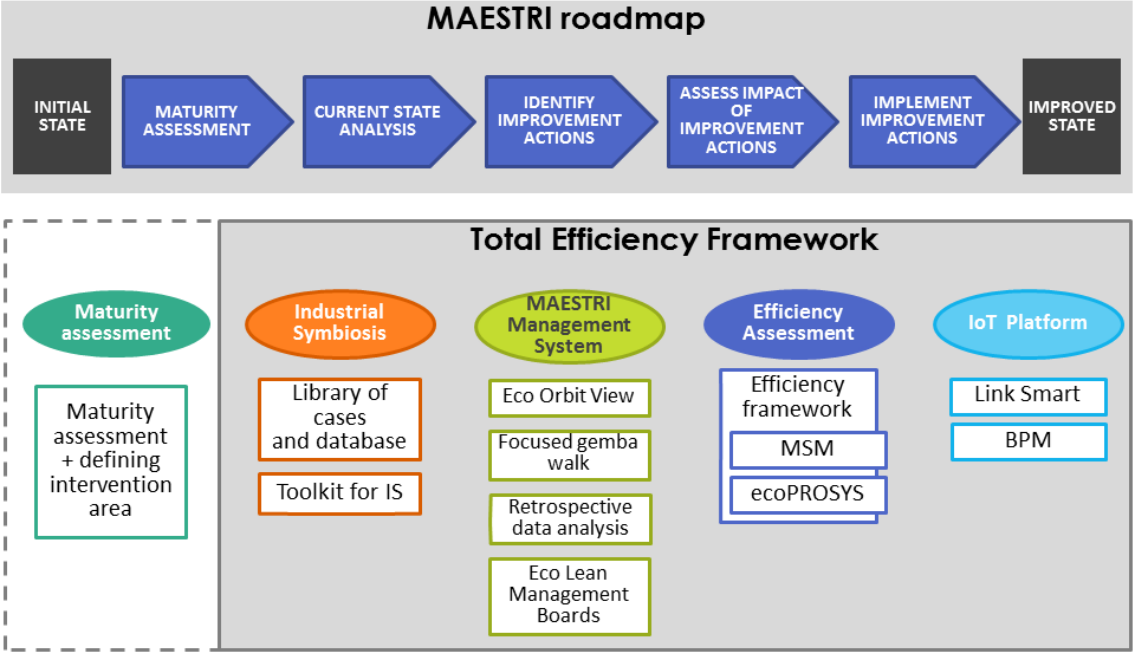

Figure 17 Total Efficiency Framework and supporting elements complementing MAESTRI roadmap of implementation

4.1 Integration of maturity assessment with MAESTRI management system

The role of MAESTRI maturity assessment in MAESTRI roadmap is to prepare an optimal implementation plan for the given company. As MAESTRI's objective is creating both concepts and tools capable to achieve the adoption of energy and resource efficiency in production systems of any company regardless its of size (large, medium or small), an important issue to address is the ability of adjusting the implementation plan for the needs and specific conditions of the given company. For that reason the MAESTRI maturity assessment will be developed, which provides the assessment of the management system aspects as well.

4.2 Interactions between the Efficiency Assessment and MAESTRI Management System

The Efficiency Framework is one of the pillars of the Total Efficiency Framework together with MAESTRI management system. The Efficiency Framework was developed within *WP2 Efficiency Framework*. Several interactions between Efficiency Framework and MAESTRI management system have been identified. The most important connections are present to the Eco Orbit View and the Eco Lean Management Boards.

Interconnections between the Efficiency Framework and Eco Orbit View

Performing Eco Orbit View in a form of workshop or consultancy parallel with the Efficiency Framework allows making use of the data gathered by that tool, which significantly speeds up the initial steps of Eco Orbit View. The aspects in which EOV can benefit from Efficiency Framework are listed in the Table 5 .

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Table 5 Aspects in which EOV can benefit from Efficiency Framework

Topic	Dependencies between Efficiency Framework and Eco Orbit View
Process Mapping	One of the first steps in Eco Orbit View is drafting a simplified process map. That can be done easily with the help of information gathered by the Efficiency Framework, which provides a more detailed process description.

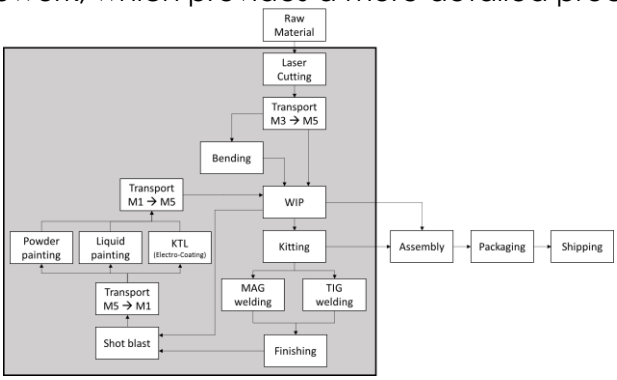

Figure 18 Example of process map created for the purpose of Efficiency Framework

Figure 19 Example of process map created for the purpose of Eco Orbit View

Defining environmental aspects/ KEPI or challenges	Efficiency Framework defines inputs and outputs for each process step. The results can be used to feed the environmental level of Eco Orbit View.

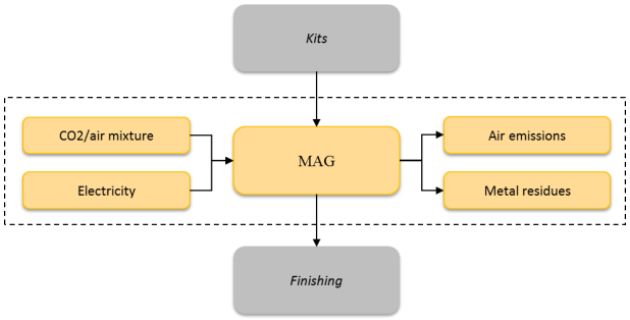

Figure 20 Definitions of inputs and outputs for production process step for the purpose of Efficiency Framework

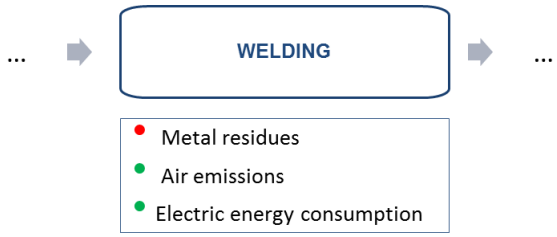

Figure 21 Definition and assessment of environmental aspects/ environmental challenges for the purpose of Eco Orbit View

KPI/ KEPI assessment	Use of data from the Efficiency Framework about quantification of process parameters can facilitate the process of assessing the degree in which the improvement needs to be implemented in the given business or environmental aspect. For that the newly developed Total Efficiency Index (TEI) can provide a very important information towards decision making, balancing the operations performance (or overall efficiency) with eco-efficiency.

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Topic	Dependencies between Efficiency Framework and Eco Orbit View
Identification of KEPIs/ environmental aspects	If the company does not have eco-efficiency indicators or significant environmental aspects identified, the Environmental Performance Assessment (a module of ecoPROSYS) can facilitate the process.
Selection of priorities in improvement	Use of information provided by e.g. ecoPROSYS simulation dashboard about the impact of different potential improvement can help to set priorities of improvement projects in a more data-based mode
Selection of process parameters that need to be improve	Efficiency Framework may provide additional information which parameter in which process needs particular attention e.g. because of very high non-value adding fraction (from Multi-Layer Stream Mapping). That kind information may complement the information from strategy and Eco Orbit View workshop participants.

Interconnections between the Efficiency framework and Eco Lean Management Boards

Eco Lean Management Boards are used on a daily basis to facilitate implementing improvement actions, increase the efficiency of information flow and create the proper motivation. The set of indicators that is monitored on the boards is very dependent on the particular use case. The monitoring data are presented in the form of printed charts on a board. Each chart presents an updated value of the given indicator in comparison to its goal value. The results of indicators monitoring are updated before every review (see chapter 2.2.4). Some of the indicators are based on typical production data that can be easily derived from ERP system. Some of them however need special calculation or manual data collection. In term of eco-efficiency indicators which are typically not in ERP nor other production control systems, the great facilitation can provide the Efficiency Framework tools.

4.3 Interaction of industrial symbiosis with MAESTRI management system

Industrial Symbiosis (IS), within the scope of sustainable manufacturing for process industries, fosters the sharing of resources (energy, water, residues and recycled materials) between different processes of a single company or between multiple companies. The IS approach within MAESTRI looks at providing companies with a set of tools and methods that they can use to apply IS internally or externally. These tools and methods are under development within *WP4 Industrial Symbiosis* and include a library of case studies linked to a waste database, containing examples of IS implementation and feasible synergies identified in scientific and gray literature, and a toolkit for Industrial Symbiosis (T4IS), which is based on four guiding questions:

- How to see waste?
- How to characterise waste?
- How to value waste?
- How to exploit waste?

It is important to note that "waste" in what regards IS refers to unused materials, energy, water or by-products. In a general sense, this brings a complementary view to the Lean Management system. Therefore, with this reasoning, several interactions between Industrial Symbiosis and Management System tools have been identified and are described briefly in the Table 6.

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Table 6 Interactions between Industrial Symbiosis and tools supporting the MAESTRI Management System

<table>
<tr><th rowspan="2">Industrial Symbiosis tools</th><th colspan="4">Management System tools</th></tr>
<tr><th>Eco Orbit View</th><th>Focused Gemba Walk</th><th>Retrospective Analysis</th><th>Eco Lean Management Boards</th></tr>
<tr><td>1. Library of case studies and waste database</td><td colspan="3">The information included in the library of case studies and the waste database could provide new improvement opportunities for the resource-related issues identified in Eco Orbit View and in the direct observation of a problematic area or process (Focused Gemba Walk and Retrospective Analysis)</td><td>N/A</td></tr>
<tr><td colspan="5">2. T4IS</td></tr>
<tr><td>2.1 How to see waste</td><td>Mapping manufacturing processes (inputs and outputs included) is the basis to identify wasted resources subject to IS. This is strongly linked to the process map within Eco Orbit View and the Efficiency Framework.</td><td colspan="2" rowspan="2">IS tools and methods to identify and characterise waste could complement the information to be gathered during Focused Gemba Walks and Retrospective Analysis. This will bring new insights, i.e. the resource efficiency perspective, to the Lean analysis.
Additionally, the Focused Gemba Walk and the Retrospective Analysis could identify, as result of their application, new wasted resources thanks to the depth of the analysis in a problematic area or process. Thus, providing valuable input to the T4IS.</td><td>N/A</td></tr>
<tr><td>2.2 How to characterise waste</td><td>The analysis of KPIs within Eco Orbit View and the Efficiency Framework could support the characterisation of wasted resources, by providing data on quantities and qualities, when needed.</td><td>N/A</td></tr>
<tr><td>2.3 How to value waste</td><td rowspan="2">Eco Orbit View focuses in company's current most important strategies, this will provide valuable input to identify forms to value and exploit waste that are aligned with business strategy. Additionally, the analysis of valorisation and exploitation possibilities for new waste streams could provide new insights for the business strategy.</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
<tr><td>2.4 How to exploit waste</td><td>N/A</td><td>N/A</td><td>The eco lean management boards can support the implementation of synergetic exchanges based on IS and monitor its progress and success towards targets of reducing waste and creating higher value.</td></tr>
</table>

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4.4 Relationship between the IoT platform and the MAESTRI management system

The MAESTRI management system and the supporting tools like Eco Orbit View and Eco Lean Management Boards will use the data provided by the IoT platform to the Efficiency Assessment tools. Therefore the management system tools will make use of the IoT Platform in an indirect way. For the time being, they do not need any direct software interfaces to get online data via the IoT platform.

The process of implementing Eco Lean Management Boards foresees that in the initial phase the management boards should be in physical form e.g. magnetic boards or whiteboards hanging or staying in the shop floor. That is required to train the user in the proper utilisation, make them understand the information flows and create the right habits regarding review routines and responsibilities. However, in the further stage it will be useful to utilise the possibility of digitalisation and make the Eco Lean Management Boards in a form of large LCD screens located in the shop floor as well. These digitalized management boards could possibly be provided with data via the IoT platform.

5 Conclusion

It is expected that MAESTRI Management system based on Lean Management system can be used as a very efficient way for managing and improving performance of process industries. However, as process industries differ from discrete processes, some additional methods have been proposed to fit their specific needs. Eco Orbit View provides a quick method to link improvements with strategy and indicate synergies between ecological and business perspective.

Focused Gemba Walk and Retrospective Analysis are the methods to gain more detailed improvement ideas, thanks to deeper analysis of potential improvement areas resulting from Eco Orbit View.

Eco Lean Management Boards are visual management boards used for managing improvement projects, linking operations with strategic goals, supporting embedding ecological perspective and continuous improvement into daily operation and managers' priorities. Implementing the MAESTRI management system contributes towards embedding environmental perspective into daily improvement routines.

It also provides a link between strategy and environmental issues thanks to the structure of the Eco Orbit View method, which sets a base for further improvements. Implementing the MAESTRI management system can also support the company in implementing ISO 9001, ISO 14001 and ISO 50001.

Last but not least, interactions between the Management system and other elements of the Total Efficiency Framework have been depicted: the interconnections between MAESTRI Management System and Maturity Assessment, Efficiency Assessment and IoT platform, as well as interactions that exists between Industrial symbiosis concept and management system supporting tools. The concepts described in this deliverable will be further validated within *Work Package 6 Pilot Implementation and Validation* activities.

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