Total Resource and Energy Efficiency Management System for Process Industries

Deliverable 1.6

Lessons Learned and Updated Requirements Report

Date: 28/11/2017

WP1 Requirements Engineering

T1.5 Evolutionary Requirements Elicitation

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Authors and Contributors

Name:	Alexander Schneider
Organisation:	Fraunhofer FIT
Name:	Otilia Werner-Kytölä
Organisation:	Fraunhofer FIT
Name:	Gunnar Große Hovest
Organisation:	ATB
Name:	Emanuel Lourenco
Organisation:	INEGI
Name:	Antonio Baptista
Organisation:	INEGI
Name:	Eduardo Joao Silva
Organisation:	ISQ
Name:	Zofia Masluszczak
Organisation:	LEI
Name:	Maria Holgado
Organisation:	UCAM
Name:	Ricardo A. Rato
Organisation:	ISQ
Name:	Enrico Ferrera
Organisation:	ISMB

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Executive Summary

The requirements elicitation in MAESTRI is carried out applying a user-centred approach (see D1.4 Initial Requirements Report for details). According to this approach, user workshops were carried out at each demonstration site where we interviewed employees involved in the processes that are relevant to the MAESTRI project. From those interviews and the deliverable D1.3 MAESTRI Business Cases we derived a set of functional and non-functional requirements. Within Task 1.5 (Evolutionary Requirements Elicitation) we went on to refine the level of detail of scenarios. The result of this work has been documented in chapter 2 of D1.5 Lessons Learned and Updated Requirements Report.

Based on the scenarios and on the work done in Task 5.1 (Architecture Design), D5.2 Final MAESTRI Platform Architecture Design & Specification, we have updated existing requirements and generated refined ones. They have been presented in chapter 3 of D1.5.

Task 1.5 has evolved and concrete use cases concerning each pilot site have been developed. This lead again to a refinement of the requirements. Chapter 2 lists the Lessons Learned according to work packages. The updated set of requirements is presented in chapter 3.

D1.7 Lessons Learned and Updated Requirements Report is planned for M38 and it will be based on D1.6.

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1 Introduction

1.1 Purpose, context and scope of this deliverable

The purpose of this deliverable is to give an overview of lessons learned, requirement updates and refinements considering the time between M15 and M26. It is based on the first common source of user requirements for the MAESTRI consortium which was presented in D1.4 as well as on D1.5 which was published in M14. The final version of Lessons Learned will be documented in D1.7.

As described in D1.4 the iterative process for the requirements management supports the continuous refinement of scenarios and requirements which will be performed by the project partners.

1.2 Deliverable Organization

This deliverable is organized as follows:

- Chapter 2 presents lessons learned.
- Chapter 3 contains an updated list of requirements.

2 Lessons Learned (LL)

This section presents MAESTRI's definition of a lesson learned, the MAESTRI LL process, the LL verification criteria, the categories a LL can be related to. Moreover, it lists the current lessons learned so far per work package.

2.1 What are Lessons Learned?

Lessons Learned (LL) belong to a project culture committed to Knowledge Management. Lessons are learned during project RTD work, during testing and integration, as a part of the validation of project prototypes and during literature search and technology watch. Further sources for LL are Dissemination and Exploitation activities, as a part of the process for commercialization of the project prototype. Lessons can thus be learned throughout the project work. As such, Lessons Learned constitute both individual and organisational knowledge and understanding gained by experience, either negative (missed targets, solutions that do not work as expected, wrong choice of technology) or positive (easier implementation than expected, faster response time, more interoperable devices than expected).

Lessons Learned help support project goals in the RTD work of:

- Promoting recurrence of successful outcomes
- Precluding the recurrence of unsuccessful outcomes.

In order to implement a workable Lessons Learned process, we need first to define what we understand by the term "lesson". We use the following characterisation for a lesson:

- It must be significant in terms of the project progress and ability to meet its goal

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- It must be valid, i.e., the experience gained must be repeatable and/or must be linked to at least one activity or phase of the project
- It must be applicable to the MAESTRI project
- It may contain or address pertinent info
- It may provide information of interest for existing stakeholders but also for future potential users of separate items/findings of the project.

Not all experiences will qualify as being Lessons Learned and it is important that reported Lessons Learned not merely restate existing information, and/or existing experiences *not* related to the MAESTRI work.

2.2 The MAESTRI Lessons Learned Process

The MAESTRI Lessons Learned process has six steps:

1. **Collection**: focuses on collecting LL from many sources internal and external to the project. To be undertaken in all WPs. The LL are collected and maintained centralized on a Wiki page: https://wiki.repository-pert.polito.it/xwiki-enterprise-web-7.4.5/wiki/maestri/view/Dashboard/MAESTRI+project+Home+page/WP1+-+Requirements+Engineering/Lessons+Learned/?srid=0Q7bQ9Uy
2. **Verification**: all LL must be verified for correctness, significance, validity, and applicability. The verification will be performed by the corresponding WP leaders. The WP leader will decide to add and remove Lessons Learned for the related WP as necessary.
3. **Storage**: LL will be stored on this wiki page.
4. **Dissemination**: all project workers are encouraged to continuously consult the LL repository, not only with the purpose of reporting, but also to continuously follow LL reported by other project partners. The final version of LL will be documented in D1.7.
5. **Reuse**: the WP leaders have a responsibility to consult the LL repository regularly and at least before any major decision affecting the scientific work and the project outcomes is to be made.
6. **Identification of improvement opportunity**: from the lessons learned, relevant new and/or updated requirements will be extracted. The concerning Work Package Leader will evaluate and describe the impact on the future development work arising from the re-engineered requirements and report this in the deliverable which follow the present one, namely D1.7.

After the successful completion of a prototype cycle, each work package will analyse and report their development results, experiences, lessons learned in the development and integration work and other relevant knowledge gained during the development cycle. Moreover, knowledge gained from formal testing and system integration will be collected together with the latest developments in technology, regulatory affairs and markets, which influence MAESTRI and its exploitability.

2.3 The MAESTRI Lessons Learned Criteria & Category

For the purpose of verification (step 2 described above) following **criteria** are to be analysed:

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- Relationship with the project flow
- Relevance to the project outcome
- Significance in terms of quality parameters such as robustness, ease of use, functionality
- Research aids used
- Systemic process issues.

When creating LL into the LL repository in the Wiki, the following codes for **category** are to be used:

- RTD: Research oriented
- PRO: Process oriented
- SWD: Software development experience
- ARC: Architecture oriented
- NET: Network oriented
- SEC: Security oriented
- TST: Testing result
- INT: Integration experience
- VAL: Validation experience
- REG: Regulatory
- IWU: Interaction with (end) user
- DIS: Dissemination and Exploitation

2.4 List of current Lessons Learned

This section lists the current lessons learned related to each work package.

2.4.1 WP1 Lessons Learned

Category	Experience and knowledge gained	Lesson learned	Analysis
PRO	The creation of homogenous scenarios taking into account four domains and the 4 pillars of the MAESTRI platform proved to be more complex than envisioned.	It is important to identify the cross-sectorial aspects of the platform and to put them into scenarios before deriving requirements.	Through scenario thinking prior to requirements specification we avoid wasting efforts by implementing components prematurely which would need to be rewritten later or would even require major changes to the system architecture. The reason behind was to enable us to develop components that are universal, easily adaptable and ultimately require less rework.
PRO, SWD	At the beginning of the project too wide and complex scenarios have been defined due to very	Simpler concrete use-cases must be defined since the beginning of the project in order to	A more agile approach for use-case definition and development phase can help to develop more features faster. To support

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	ambitious goals aimed at by the project partners.	generate few basic requirements to be selected as part of the initial specifications.	an agile approach is important to initially define very easy and basic use-cases involving just few data and data sources. The initial use-cases would serve as a base for more complex use-cases where further features are added to the basic system.

2.4.2 WP2 Lessons Learned

Category	Experience and knowledge gained	Lesson learned	Analysis
RTD	The strategy adopted to the development of the Efficiency Framework, based on the integration of results from Efficiency Analysis and Eco-Efficiency analysis proved to be a very modular and flexible way to construct the new framework. The advantages are clear, being more modular regarding the Process Steps analysis, easier to parameterize, it is self-contained for the analysis of each process step.	Validation of the adopted strategy.	Since the two base methodologies to the project, MSM and ecoPROSYS, are quite different and with different construction, the adoption of an integration based in the results of each other base method proved to be more robust and straightforward in modularity.

2.4.3 WP3 Lessons Learned

Category	Experience and knowledge gained	Lesson learned	Analysis
VAL	It is difficult to design an Eco Lean Management Board (ELMB) based on Eco Orbit View (EOV) workshop outputs if the EOV contains the challenges for the company but not a clearly stated goals.	It is necessary to use company strategic goals to design Eco Lean Management Board. If the company did not formulated the goals, the agenda of workshop should contain additional module in order do it.	Defining the strategic challenges for the company (without formulating the related strategic goals) is sufficient to successfully complete the EOV and get the expected results. However, if EOV need to be used to design ELMBs, the more precise definition of goals is required.
VAL	Eco Orbit View workshop results can be used in practice by the companies that are	Eco Orbit View workshop was designed to indicate the areas in the	Eco Orbit View workshop results are useful for numerous functions in the

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	certified according to ISO 14001.	company that will benefit from improving environmental performance and the correlated business performance (synergy effect). That aspect is explicitly required in the new revision of the norm ISO 14001.	company, e.g. production manager, continuous improvement manager, integrated management system specialist, energy and environment manager.
VAL	It is difficult to create Eco Lean Management Board beginning directly from strategic goals without cascading them first to the relevant organisational level.	Strategic goals resulting from the company strategy or from Eco Orbit View workshop should be cascaded to the relevant organisational level first (e.g. operational team). That creates the proper basis to design the management board.	The best way of implementing Eco Lean Management Boards in the company is to use Hoshin Kanri approach. Than it will start from the top management level and then boards for each lower level is created basing on the goals from the previous one. However, it may happen that for some reasons, the company starts implementing the management boards in a one particular pilot area e.g. particular production team. In such a case it is necessary to cascade the goals, even if the higher levels do not use management boards.

2.4.4 WP4 Lessons Learned

Category	Experience and knowledge gained	Lesson learned	Analysis
RTD	The study of IS has ranged from how IS can occur, the conditions and approaches which enhance the likelihood of success, to establishing the benefits of implementation in terms of economic and environmental performance. Research on IS implementation	There is a need to focus on the implementation of self-organised IS, as key area in which practitioners need more support.	Practitioners lack a stepwise guide that can use themselves to implement IS and are confused regarding even how to start with IS opportunity identification and exchanges implementation. This was reported in several interviews done in T4.1.

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	processes and stages, especially in regard to self-organised IS, is still limited.		
RTD	The European Waste Catalogue (EWC) is a useful means to classify waste but it has to be used in addition to other materials/flows' classifications in order to include all by-products and materials and to support a complete identification of opportunities for symbiotic exchanges implementation.	Use additional materials/waste classifications other than EWC codes in order to univocally identify all waste materials/by-products produced by a company.	The EWC allows to classify all wastes produced by a company but is highly focused on providing support to comply with waste disposal legislation and keep high security levels. Thus, when classifying waste in order to support a complete identification of opportunities for symbiotic exchanges implementation, this might not allow to include all useful materials/by-products in the analysis. For example, sugar production by-products such as bagasse or molasses (that are often used for symbiotic exchanges) cannot be classified according to EWC, nor it is possible to associate an EWC code to waste heat or energy. Other classifications such as for example the CPA (European Classification of Products by Activity) include these materials/flows, and can therefore be used to complement the EWC.

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2.4.5 WP5 Lessons Learned

Category	Experience and knowledge gained	Lesson learned	Analysis
VAL	In systems integration topic, for instance the connectors for Euromap or similar standards, the complexity of such integration/deployment continues to be very high, and could carry big delays in projects similar to MAESTRI where data acquisition from sensors or legacy systems are of fundamental importance. This can both be time consuming and costly, since the Machines Suppliers apply have costly business models to end users and offer resistance to other SW integration that is not of their supply or recommendation.	The analysis and pre-selection of KPI to be transferred from the OEM machines must be anticipated as far as possible to avoid the selection of connectors that are both costly and with long delivery periods.	Depending of the machine type and use case, if it possible to customize the connectors for data acquisition, that could be a solution to surpass the integration. Other recommendation is to adopt, as far as possible, standard forms/means to data transfer.
VAL	It is difficult to engage industrial partners in the implementation of assessment tools, and definition of use cases for complex scenarios. Implementation should therefore start with simple use cases that offer the possibility of being up scaled.	Implementation should start with a simple use case (e.g. small production area). To assure engagement, assessment tools must be demonstrated using simple scenarios defined with the participation of the industrial partners.	Without a simple use case demonstration using real data, it can be difficult to explain the objectives and outputs of the tools.
SWD, INT	The standard LinkSmart device connectors are targeting individual sensors and rather simple time series data, but they are not appropriate for connecting complex existing systems. For complex data queries to existing systems, custom connectors need to be developed.	In case that complex systems are serving as data sources for MAESTRI, e.g. larger amounts of data are required from databases of existing enterprise applications, the standard LinkSmart device connectors are not appropriate to implement these connections.	LinkSmart device connectors are aiming to allow for integration of all kinds of sensors into the MAESTRI IoT platform, therefore their functionality aims to be simple with a focus on interoperability. This is fully appropriate in case of integrating rather simple sensors. However, in case that complete systems like

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			ERP or MES systems should be integrated, and not just simple time series values should be read from those systems, the configurations of device connectors for each parameter to be received can be quite cumbersome. Therefore, for complex database queries, custom connectors (enterprise application services) should be implemented.
INT	The IoT platform is composed by several components which require many dependencies. It could be tricky and time consuming to install all of them especially if people without extensive IT skills have to deal with deployment phase.	It's difficult and time consuming to deploy all the components of an IoT platform which has to deal with the complexity of an industrial shop floor. Means to make the deployment phase easier and quicker have to be envisaged.	Some modern approaches to easily deploy complex software system such as Docker containers must be considered in order to reduce the complexity of the deployment phase. A new requirement has been generated from this lessons learned.

2.4.6 WP6 Lessons Learned

Category	Experience and knowledge gained	Lesson learned	Analysis
PRO	It can be complex to assess process and resource efficiency in the process industry. Particularly in companies with many different products that require different combinations of raw materials and different reaction/processing times. The high complexity of those production systems can create delays in the development of projects similar to MAESTRI. Characterizing the process, flow and defining VA (value added) and NVA (non-value added)	To avoid delays in project development, the analysis and characterization of the pilot lines in the process industries must be anticipated as much as possible, and the engagement of the production team has to be a priority from the start.	Starting with simple cases within the pilot area (such as a single product or even one batch) can help to simplify the approach, however, the large complexity lies in the dependencies between products/batches. Therefor it is more important to engage the production team and to define some initial KPIs that they consider important to monitor/understand the key issues in the pilot line.

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	process steps can be demanding, because there are so many interdependencies between process steps and resources.		
INT, VAL	Existing MES/SCADA systems in process industry are already collecting data from sensors and actuators in the production installations. In case that this data is accessible, it can be reused in order to enable a basic implementation and validation of the MAESTRI platform.	To allow an early validation of the MAESTRI platform concept, the existing infrastructure provided by MES/SCADA systems should be leveraged to enable a basic collection and analysis of data.	Analysing the overall MAESTRI IoT platform architecture in comparison with existing installations in process industry, it became clear that some basic functionality of the IoT platform - like receiving data from production installations, annotating this data with information about related batches and process steps, and storing the data in a historical database - is partly already done by existing MES. Therefore, to facilitate the early validation of the MAESTRI platform, it should be analysed in how far the existing data in the MES is accessible and in how far it is sufficient for realising a basic MAESTRI implementation/application.
SEC, INT	Safety restrictions in industry can restrict the implementation of IoT technologies or can increase the implementation efforts/costs.	Due to safety requirements in industry, the installation of new sensors and measurement equipment as well as the access to existing systems can be restricted. Strategies to deal with limited data availability have to be developed.	In case of safety-critical production installations, existing systems of the companies have to be isolated and the installation of new sensors and devices has to consider safety aspects like explosion prevention requirements. Therefore, only specific expensive equipment can be installed, or in some cases there is no appropriate equipment available. As a result for the MAESTRI platform implementation, only the non-safety-critical systems can be used as data sources, and some

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			values from safety-critical areas are either not possible to get, or the necessary measurement equipment can be very expensive, so that only limited measurements are feasible/reasonable.

2.4.7 WP7 Lessons Learned

Category	Experience and knowledge gained	Lesson learned	Analysis
VAL, IWU, DIS	It is difficult to guide the project towards a viable Exploitation strategy and to create Business model, particularly with partners who have many different roles and activities within the project. It requires identification of different approach, and definition of different use cases for complex scenarios in terms of the future economic plans for each of the partner	It is necessary to use strategic goals (economic) of each of the partner, in terms of project activities for preparation of feasible Exploitation strategy and Business model, for particular partner and for project as a whole	Defining the strategic challenges for the company (incl. related strategic economic goals), and definition of Value Proposition of Exploitable Results is sufficient to successfully complete the Exploitation strategy and Business model, respectively. In terms of Industrial partners without a simple use case demonstration using real data, it can be difficult to propose the Exploitation strategy and Business model

3 Updated Requirements List

All MAESTRI requirements which are documented in JIRA and have been quality-checked (see D1.4 Initial Requirements Report for all details on requirement's workflow) are listed in the following.

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Requirement Key	Summary	Fit Criterion	Requirement Type	WP #
MAES-1	The platform will store the monitoring data permanently in order to access it later	Some monitoring will be stored permanently to permit advanced analysis. Those needs to be timestamped and the access to them should be provided by specific instrument (e.g. an API set or other approaches).	Functional	5
MAES-2	The system administrator can specify the time interval for monitoring the data in order to reduce the amount of data to be processed.	For every sensor the system administrator can specify the time interval for the measurement.	Functional	5
MAES-3	The MAESTRI user can see and use data from existing systems without the need for manual data transfer	Data from relevant existing systems can be accessed through the interfaces provided by the MAESTRI IoT platform without the need to be manually inserted by users.	Functional	5
MAES-4	The production scheduler can get historical production schedules as suggestions/templates in order to be able to create an efficient scheduling for the current day	The user can get an overview (ranked list) as well as details of historical production schedules. The suggested schedules are similar to today's production plan and are therefore appropriate suggestions from the user point of view.	Functional	6
MAES-5	A user can export data in order to re-use it in other tools (e.g. for reporting)	MAESTRI provides an export function for calculated/monitored KPIs to text/CSV files, and an export function for an eco-efficiency and efficiency PDF report.	Functional	2
MAES-6	The production manager can access a waste database in order to find IS	For each waste type of a given set of waste types, there is an entry in the waste database providing examples of	Functional	4

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	opportunities for a certain type of waste	industrial symbiosis opportunities for these waste types		
MAES-7	The production manager gets a prediction of short term customer demands in order to enable an efficient production planning	A forecast of the expected customer demands for different types of products in the short term is displayed	Functional	2
MAES-8	Changes to process parameters need to be performed quickly in order to test out new parameter sets for production processes	The prototyping time for process parameter changes will be reduced by 10% for the processes related to the MAESTRI project	Non-functional - performance	2
MAES-9	Downtimes of machines need to be recorded and analysed in order to optimize the machine availability	The relevant monitoring data of each machine has been documented and the data is collected and stored accordingly	Non-Functional - operational	5
MAES-10	Relevant set of KPIs needs to be defined in order to maximize the impact	For each process a set of KPIs and KRIs has been identified and documented, these allow proper monitoring of the company processes in terms of efficiency and eco-efficiency performance	Non-Functional - operational	2
MAES-11	Access to forecasting data needs to be included in production planning in order to meet delivery deadlines	Forecast data is accessible to the production planner either based on data coming from external sources or it is derived based on the analysis of the historic production data of the processes.	Non-Functional - operational	2
MAES-12	The production manager is able to identify different alternatives for the exploitation of waste	The production manager is able to find a list of potential industrial symbiosis activities for a specific waste and explore possible exploitation choices	Functional	4
MAES-13	The waste responsible of a company can	A waste manager is able to insert detailed	Functional	4

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	access a waste database in order to find potential uses for waste flows	information about the company's waste and obtain information about possible uses of similar waste types		
MAES-14	The production manager is able to monitor, analyse and mine eco-efficiency and efficiency performance data in order to find eco-efficiency and efficiency hotspots	MAESTRI is able to monitor eco-efficiency related data sources (databases, sensors, etc.). MAESTRI is able to analyse monitored data to identify hotspots of energy consumption and waste generation. MAESTRI presents the weak points to the production manager as potential issues for improvement.	Functional	2
MAES-15	The supply chain manager is able to analyse historical data about problems the supply chain in order to get decision support for future planning	Relevant historical data related to the supply-chain are collected. Historical plan and historical actual data will be compared and analysed for deviations. Statistical deviations are presented to the user.	Functional	2
MAES-16	The production process designer can get information about the different production steps in order to evaluate options for process/installation changes	The production process designer gets enough information about the current situation in order to estimate the possible success of process/installation changes and enable a calculation of the expected payback period of the investment, and expected eco-efficiency and efficiency performance	Functional	2
MAES-19	The waste responsible can access a guideline in order to	The user can access a "how to see waste" guideline and get help	Functional	4

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	get help on how to uncover waste sources in the company	on how to uncover waste sources in the company		
MAES-20	Trainings on low-cost improvement methods are available for employees in order they know how to improve the eco performance	The training material is available.	Constraint - scope of the product	
MAES-21	The department manager can access a management board in order to check status of key performance and eco indicators	The user can access a management board and check for a given set of KPIs and eco indicators: values, chart with current trend vs. target value.	Functional	
MAES-22	The sector manager can access the Total Efficiency Platform in order to monitor a production line's efficiency and eco-efficiency	The Total Efficiency Platform is available and can be used to monitor a production line's efficiency and eco-efficiency	Functional	2
MAES-24	The board can use the Total Efficiency Platform in order to define sustainability targets	The user can define sustainability targets using the Total Efficiency Platform	Functional	2
MAES-25	Plant managers can use the Total Efficiency Platform in order to simulate the effect of higher efficiency and eco-efficiency performance	Plant managers can simulate the effect of a higher efficiency and eco-efficiency performance on their plant through the Total Efficiency Platform	Functional	2
MAES-26	Existing suite of applications needs to better integrated in order to make them easier to use	80% of the functionality of the process systems functions are integrated in a unified Human Machine Interface (HMI).	Non-Functional -> usability	6
MAES-27	Plant managers communicate with shift and sector supervisors in order to spread the knowledge on how to enhance efficiency and eco-efficiency performance	Plant managers organize 6 workshops per year to communicate best practices on how to enhance efficiency and eco-efficiency performance	Functional	3
MAES-28	Reorder amount of raw material needs to	Calculating the reorder amount of raw	Functional	2

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	be calculated automatically in order to reduce miscalculations	material can be automated and the algorithm can be specified to match the company's need.		
MAES-29	Relationship between process variables and material properties need to be understood in order to support individualization of products to customer needs.	For 80% of the process variables used in the production process it is known how changes to material properties would influence the output qualities.	Non-Functional - operational	2
MAES-30	Plant managers can use the Total Efficiency Platform in order to select KPIs to appear on the dashboard	The user selects a given set of KPIs using the Total Efficiency Platform and have them displayed on the Total Efficiency dashboard on the shop floor: KPI evolution and deviation from the target values	Functional	2
MAES-31	Plant managers can use the Total Efficiency Platform in order to create monthly reports on efficiency and eco-efficiency	The user can create on a monthly basis a standard report to document the efficiency and eco-efficiency performance of the respective plant	Functional	2
MAES-32	Energy consumption must be monitored based on the process steps in order to find potential optimization steps	Process energy consumed is monitored for all process stages in the processes under assessment	Non-Functional - operational	
MAES-35	Management system supports eco improvements	Eco aspects are measured and eco improvements are conducted based on eco performance gaps	Constraint - purpose	3
MAES-36	The current value of indicators related to significant environmental aspects is visualized in order for everyone involved to be able to see and know the status	All indicators that have been identified by the organization to be relevant for the improvement of processes are visualized and filled in with current data	Functional	3

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MAES-37	The training for an improvement method must include on-the-job training in order for employees to acquire practical skills	The training program for a certain improvement method includes on-the-job training.	Non-Functional - performance	3
MAES-38	The training must include a follow-up in order to aid the participants with problems that may arise after first steps of method implementation	The training program for a certain improvement method includes follow-up	Non-Functional - performance	3
MAES-39	Eco aspects are integrated into the visualized performance measurement system	Eco indicators are equally visualized, updated and monitored as business KPI's	Functional	3
MAES-40	The user can access a "how to see waste" guideline and get help on how to uncover waste streams in the company	A waste manager will read the brief guideline and learn a methodology to identify waste flows in his company. The guideline will provide support regarding the implementation of the methodology	Functional	4
MAES-41	The user can get support to characterise waste	Following the method detailed, the waste management team should be able to easily characterise waste at the right level of detail in order to enable the identification of suitable exchange opportunities	Functional	4
MAES-42	The user get support to identify internal / external possible re-usability of waste	Following the method detailed, a waste manager should be able to identify possible uses of the company's waste, also using the waste database provided by MAESTRI	Functional	4
MAES-43	Define the structure and contents for the standard efficiency	For each section of the standard PDF report a set of indicators and performance aspects	Non-Functional - operational	2

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	and eco-efficiency reports	has been identified and, these allow proper communication of the company processes in terms of efficiency and eco-efficiency performance		
MAES-44	A manager can export a standard efficiency and eco-efficiency report	MAESTRI provides an export function for a standard eco-efficiency and efficiency PDF report	Functional	2
MAES-45	Visual mapping tools	MAESTRI, via DSS (see task 5.2), will encompass Visual Analytics engine presenting different state-related views of the production operations, supporting comparative assessment of material and resource management, enabling managers to visualise the entire process as well as each unit process and the respective inputs and outputs. Moreover, managers will be able to map the process (process design).	Functional	2
MAES-46	Define the information and contents for the environmental footprint	The environmental footprint of each product belonging to a given set of products can be determined.	Non-Functional - operational	2
MAES-47	The board and managers are able to define the company's sustainability targets	For each company or site/plant a set of environmental and economic aspects and KPI has been identified and quantified, these allow the definition of the company's sustainability targets	Non-Functional - operational	2
MAES-48	Definition of the simulation models for assessing scenarios	For each scenario, the efficiency and eco-efficiency performance has been	Non-Functional - operational	2

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		quantified, these results allow the company to foresee the overall performance regarding a certain scenario		
MAES-49	The production manager gets a prediction the best scenario in order to enhance overall efficiency and eco-efficiency	A forecast of the expected efficiency and eco-efficiency performance for different scenarios is displayed.	Functional	2
MAES-50	Definition of the optimization models for energy and resources efficiency	The adoption of an optimization tool, will enable fast generation of optimized scenarios for improvement, since improvement scenario design optimization can be very time-consuming and unmanageable task a "trial-error basis"	Non-Functional - operational	2
MAES-51	The production manager to perform optimization simulations and optimized scenarios for materials and energy consumption, via overall efficiency and cost-saving targets	A forecast of the expected optimized scenarios is displayed.	Functional	2
MAES-52	Prioritize options to support decisions for improvement measure (both cost-saving and efficiency improvements)	The major inefficiencies are identified and results are available, therefore the priority of each improvement action can be determined.	Functional	2
MAES-53	Definition of the LCA impact assessment methods and databases	Environmental impacts are evaluated according to selected LCA impact assessment methods and databases	Non-Functional - operational	2
MAES-54	Perform Life Cycle Assessment	MAESTRI Platform provides a function for Life Cycle Assessment and user can	Functional	2

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		calculate environmental impact		
MAES-55	Definition of the Life Cycle Costing Analysis and Value Modelling approaches	Costs and value are evaluated for all process stages in the processes under research assessment	Non-Functional - operational	
MAES-56	Perform and evaluate Life Cycle Costing Analysis and Value Modelling	MAESTRI Platform provides a function for Life Cycle Costing Analysis and Value Modelling.	Functional	2
MAES-57	Managers can evaluate, through scenario analysis, the expected costs and perform simple payback analysis, considering the cost reduction and/or reduction of waste/missuses of resources	A forecast of the expected costs and a simple payback is displayed.	Functional	2
MAES-58	Develop models to identify and simulate appropriate consumption patterns and waste flows, leading to optimisation of materials and energy use via cost-saving optimization approach	A forecast of the expected consumption patterns and waste flows is displayed.	Functional	2
MAES-59	Real time metering must be adopted to monitor energy and resource flows by adopting the Internet of Things (IoT) concept	The data collection is automated, so that the energy and resource consumption as well as other process related activities will be monitored in real time (or near real-time)	Functional	5
MAES-60	MAESTRI platform needs to be defined in order to maximize the improvements in a single plant or across multiple companies, and enable more integrated and cross-sectorial interactions	A holistic approach will enable process monitoring and optimization, as well as focus on an integrated and cross-sectorial interaction that can have a greater impact within the process industry.	Non-Functional - operational	2
MAES-61	The production manager is able to	MAESTRI is able to analyse monitored	Functional	2

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	monitor, analyse and mine efficiency performance data in order to find inefficiencies (assess overall efficiency performance using MSM© analysis)	data and to identify major inefficiencies regarding energy and resource consumption. MAESTRI presents the overall efficiency performance of a production system.		
MAES-62	The production manager is able to monitor, analyse and mine eco-efficiency performance data in order to assess environmental and economic performance (assess overall eco-efficiency performance using ecoPROSYS©)	MAESTRI is able to analyse monitored data and to identify major environmental and economic impacts regarding energy and resource consumption. MAESTRI presents the overall eco-efficiency performance of a production system.	Functional	2
MAES-63	Plant managers are able to implement MAESTRI Platform gradually, since the Platform is scalable and flexible, concerning the scope of application (i.e. can be applied for production units, single plants, single companies or multiple companies)	The MAESTRI Platform is available and can be used to assess the overall efficiency and eco-efficiency of production units, single plants, single companies or multiple companies	Functional	2
MAES-64	Plant managers are able to assess Environmental Performance Evaluation (as defined by ISO 14031)	The MAESTRI platform (or its frontend applications) should provide assistance on defining significant environmental aspects. Standardised methods, namely ISO 14001, should be considered for this purpose.	Functional	2
MAES-65	A clear approach needs to be outlined in order to define the value added and non-value added fraction, for each energy and resource flow in order to assess overall resource and energy efficiency	The MAESTRI Platform is available and can be used to quantify the NVA of each stage of the process system	Non-Functional - operational	

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MAES-66	Maestri Platform encompasses a methodology for modelling industrial processes, which includes resources and energy efficiency related aspects	Managers are able to perform model the process and consequently are able to perform optimization simulations	Non-Functional - operational	2
MAES-67	Plant managers can use the MAESTRI Platform in order to create an overall efficiency index and company eco-efficiency profile	The user can evaluate on a monthly basis the efficiency performance and company eco-efficiency profile.	Non-Functional - operational	2
MAES-68	MAESTRI IoT platform must provide API to allow ecoPROSYS© to calculate the eco-efficiency output	Relevant data for eco-efficiency assessment are accessible through at least one of the interfaces provided by MAESTRI IoT platform (e.g. REST API, MQTT, or other interfaces), as soon as it is made available from relevant data sources.	Functional	5
MAES-69	MAESTRI IoT platform must provide API to allow MSM© to get data to calculate the efficiency performance output	Relevant data for eco-efficiency assessment is accessible through at least one of the interfaces provided by MAESTRI IoT platform (e.g. REST API, MQTT, or other interfaces), as soon as it is made available from relevant data sources.	Functional	5
MAES-70	Necessary data for MAESTRI Platform: Material flows and costs	Actual materials that make up the final product for a particular process (primary materials) and materials that are used in the processing of a product for a particular process. Materials may be non-renewable (i.e., materials extracted from nature that are non-renewable or stock resources such as coal), renewable, or flow resources such as	Non-Functional - operational	2

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		water. Quantification, at each stage of the process system, of "what adds value" (AV) and "what does not add value" (NVA) to a product or service.		
MAES-71	Necessary data for MAESTRI Platform: Energy flows and costs	Process energy and pre-combustion energy consumed and/or generated by any process in the business case. Quantification, at each stage of the process system, of "what adds value" (AV) and "what does not add value" (NVA) to a product or service.	Non-Functional - operational	2
MAES-72	Necessary data for MAESTRI Platform: Water flows and costs	Water consumed and/or generated by any process within the business case, including effluents. Quantification, at each stage of the process system, of "what adds value" (AV) and "what does not add value" (NVA) to a product or service.	Non-Functional - operational	2
MAES-73	Necessary data for Maestri Platform: Emissions to Air	Air outputs represent the releases to the environment of gaseous or particulates from a point or diffuse source of any stage of business case, after passing through emission control devices, if applicable.	Non-Functional - operational	2
MAES-74	Necessary data for MAESTRI Platform: Emissions to water	Water outputs represent liquid surface and groundwater discharges, from point or diffuse sources of any stage of business case, after passing through any water treatment devices.	Non-Functional - operational	2

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MAES-75	Necessary data for MAESTRI Platform: Emissions to soil	Soil emissions represent discharges chemical substances that are considered pollutants to soil from point or diffuse sources of any stage of business case.	Non-Functional - operational	2
MAES-76	Necessary data for MAESTRI Platform: Wastes	Represents the mass of a product or material, either solids or liquids, that are deposited as hazardous or non-hazardous waste, either before or after treatment (e.g., incineration, composting), recovery, or recycling processes. Quantity/volume of waste as well as route/treatment.	Non-Functional - operational	2
MAES-77	Necessary data for MAESTRI Platform: Intermediate Products	Products or substance outputs from a process that are received as input by a subsequent unit process within the business case, enabling managers to keep track of the intermediate products.	Non-Functional - operational	2
MAES-78	Necessary data for MAESTRI Platform: Equipment data and cost	Includes data on equipment used in the different processes within the business case, working related costs, including amortization, opportunity cost, etc.	Non-Functional - operational	2
MAES-79	Necessary data for MAESTRI Platform: Labour cost	Direct and indirect (benefits and payroll taxes) labour costs	Non-Functional - operational	2
MAES-80	Necessary data for MAESTRI Platform: Maintenance Activities and Costs	Maintenance activities schedule and costs related to any process and/or equipment or infrastructure used in a process within the business case.	Non-Functional - operational	2
MAES-81	Production system unused materials, energy and resources should be quantified	The aim is to exploit possible synergies with other production systems, as well as to incorporate the	Non-Functional - operational	4

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		identification exercise into the daily routine of decision making in every company		
MAES-82	Environmental performance evaluation should be used for simulation	The view of the company and the way it understands the production system should be included in scenarios simulation	Functional	2
MAES-83	Effect of an elementary flow variation in all other elementary flows should be predicted		Functional	2
MAES-84	The production manager selects a KPI in order to monitor it	The production manager is able to select KPIs that will be monitored by the MAESTRI platform	Functional	2
MAES-85	The production manager is able to connect a KPI with a data source in order to monitor that KPI	The production manager is able to connect KPIs to a data source.	Functional	5
MAES-86	MAESTRI Platform user should be able to select the significant environmental aspects	MAESTRI frontend applications user is able to select high environmental significant aspects	Functional	2
MAES-87	The MAESTRI platform should be able to present the environmental impact related to each environmental aspect	MAESTRI platform user is able to import or calculate the environmental impact related to each environmental aspect by using the frontend applications	Functional	2
MAES-88	The MAESTRI platform user should be able select eco-efficiency ratios	MAESTRI frontend applications user is able to select a limited number of eco-efficiency ratios	Functional	2
MAES-89	The MAESTRI platform should provide assistance on defining eco-efficiency ratios	MAESTRI frontend applications user is able to define eco-efficiency ratios	Functional	2
MAES-90	The MAESTRI platform user should be able to select different methods to quantify environmental	MAESTRI frontend applications user is able to define different methods and categories to assess	Functional	2

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	influence, damage and impacts	environmental performance		
MAES-91	The MAESTRI platform user should be able to assess/monitor the environmental influence considering cradle-to-gate or gate-to-gate analysis.	MAESTRI frontend applications user is able to select different scopes for environmental influence calculation.	Functional	2
MAES-92	The MAESTRI platform user should be able to assess the intensity of each process/parameter/aspect to each eco-efficiency performance	MAESTRI frontend applications user is able to assess the intensity of each process/parameter/aspect to each eco-efficiency principle.	Functional	2
MAES-93	The MAESTRI platform user should be able to perform sensitivity analysis to the results	MAESTRI frontend applications user is able to perform sensitivity analysis of the results	Functional	2
MAES-94	The MAESTRI platform user should be able to simulate changes in the process and create alternative scenarios	MAESTRI frontend applications allows simulation and creation of "what if" scenarios.	Functional	2
MAES-95	MAESTRI IoT platform must be able to provide relevant data for KPIs and eco-efficiency ratios calculation/monitoring integrating relevant hardware and/or software data sources in the target company		Functional	5
MAES-96	The MAESTRI platform should be able to present different KPIs and eco-efficiency ratios results according to the different needs of the different level of the organisation	It is possible to select and show different efficiency and eco-efficiency results for shop floor and management	Functional	2
MAES-97	The MAESTRI platform should allow an integrated/simultaneous analysis of efficiency and eco-efficiency - Total Efficiency Index (TEI)	User is able to quantify TEI	Functional	2

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MAES-98	Database of LCA module should be periodically updated	User has the possibility to have updated LCA database	Non-Functional - maintainability	2
MAES-99	Defined KPIs, eco-efficiency ratios and efficiency performance should be calculated using company's own data		Functional	2
MAES-100	MAESTRI platform user can introduce manually data related to the process	User is able to manually input data	Functional	2
MAES-101	MAESTRI Platform user should be able to define targets for efficiency assessment	MAESTRI frontend applications allows target setting via manual data insertion	Functional	2
MAES-102	MAESTRI Platform user should be able to assess the environmental influence related to VA and NVA portions	MAESTRI frontend applications allow user to quantify the VA and NVA environmental influence	Functional	2
MAES-103	MAESTRI Platform user should be able to visualise MSM© efficiency dashboards	MAESTRI frontend applications show the efficiency dashboards	Functional	2
MAES-104	MAESTRI Platform should not allow efficiency values over 100% (MSM©)	No efficiency values over 100%	Functional	2
MAES-105	MAESTRI Platform should enable the user to consecutively aggregate the efficiency performance and eco-efficiency	MAESTRI frontend applications allows user to calculate efficiency and eco-efficiency of, for instance, a plant by integrating the results of the several production lines	Functional	2
MAES-106	The MAESTRI Platform should be able to model business processes using Business Process Based Monitoring to monitor relevant process variables	MAESTRI frontend applications allows user to model the process	Functional	5
MAES-107	The MAESTRI Platform should be able to map data coming from sensors and	Process can be monitored in real-time and the data can be used for a more detailed analysis	Functional	5

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	production systems to process steps			
MAES-108	The MSM© should be able to assess resource and operational efficiency	Assess operational and resource efficiency	Functional	2
MAES-109	The MAESTRI platform should be able to provide GUI/dashboards, containing KPI's/information resulting from the IoT platform, MSM©, ecoPROSYS© or Efficiency Framework		Functional	2
MAES-111	MAESTRI Platform user should be able to assess the costs related to VA and NVA portions	MAESTRI frontend applications allows user to quantify the VA and NVA costs	Functional	2
MAES-112	MAESTRI IoT Platform has to provide access to EUROMAP 63 data	Recorded data from the Euromap63 interface is provided as event (e.g. by MQTT) and stored in permanently in a data store. Both the event data and the historical data should be provided by a web service interface.	Functional	5
MAES-113	The user can access a waste database in order to find out what similar companies have done as donors or receivers of waste	Entries in the database are classified according to the NACE codes of the companies taking part to the exchange, so the user can enter it with his/her NACE code and find exchanges implemented by similar companies	Functional	4
MAES-114	The user can access a waste database to find possible alternative inputs and materials and what kind of company might be a supplier	The database has a "Use" field for each entry allowing the companies to look for a specific use and therefore to extract information regarding what materials could serve in their cases	Functional	4

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MAES-115	The user can link the relevant flows he/she has individuated in the waste database to the corresponding case studies in the library of case studies	A unique numerical ID is assigned to each case and to each source in the library of case studies, and those IDs are recalled for each flow in the waste database, so that the user can always easily identify them	Functional	4
MAES-116	The user can access a library of case studies to gather ideas on how Industrial Symbiosis has been implemented and how it worked in different case studies	The library of case studies contains information regarding different Industrial Symbiosis implementations involving companies from different industrial sectors	Functional	4
MAES-117	The user can search the library using keywords related to his/her country, main challenges in resource efficiency and barriers to overcome	The user can keyword search the country, challenge or barriers in the library of case studies and find corresponding cases	Functional	4
MAES-118	The user can link relevant cases from the library of case studies to the original sources, in order to find more information	The user can use the link provided in the library in order to find the original source of information	Functional	4
MAES-119	The user can send comments and suggestions regarding the library of case studies and waste database to add content related to new cases	After accessing the library/database, the user is redirected to a comments/suggestions form	Non-Functional - maintainability	4
MAES-120	The user can send information regarding own case and waste flows to be added to the library of case studies and waste database	After accessing the library/database, the user is redirected to a "Send us your own case/waste flows" form	Non-Functional - maintainability	4
MAES-121	The user can identify a set of sectors where it could potentially start early conversations on industrial symbiosis with	The information contained in the library and database regarding the sectors and business activities	Functional	4

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	companies in those sectors	of companies involved in exchanges can be easily extracted		
MAES-122	The user gets support in prioritising potential improvement opportunities for Industrial Symbiosis	The method will support the user to define priorities for implementation of potential reuse solutions of wasted resources	Functional	4
MAES-123	The user gets support in identifying several internal/external solutions to reuse a wasted resource	The method will enable a brainstorming where several potential solutions can be identified by the user	Functional	4
MAES-124	The user wants to foster innovation culture, cooperative organisational culture and a learning approach	The management system enables idea generation for improvements and innovations related to resource and energy efficiency	Functional	4
MAES-125	The user can gather ideas on how important is to segregate certain types of waste within the company	The method to classify waste will help to understand whether further segregation is needed within a company operations in relation to certain types of waste	Functional	4
MAES-126	Relevant data from machines must be visualized on a dashboard	A user interface showing constantly updated data from the shop floor is available	Functional	4
MAES-127	The Dashboard must be accessible from any connected smartphone, tablet, laptop, PC, server in the company	Dashboard can be visualized by at least two locations within the company	Functional	5
MAES-128	Dashboard must be visualized properly by monitors with different sizes	The Dashboard is properly visualized both on a Smartphone and on a PC's monitor	Functional	5
MAES-129	The Dashboard should visualize different data according to the rights of logged-in users	Different data are shown after users with different rights have logged-in	Functional	5
MAES-130	Dashboard must not be seen by users who don't have access rights		Functional	5

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MAES-131	Alarms can be generated whenever certain data values are above or below a threshold	An email to the managers is sent whenever specific data passes a predefined threshold	Functional	5
MAES-132	The MAESTRI IoT platform must be configurable	The IoT platform provides means to allow system administrators to configure it	Functional	5
MAES-133	The IoT platform must be easily deployed	A dockerized version of the IoT platform is provided	Functional	5

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