FOSTERING INDUSTRIAL SYMBIOSIS FOR A SUSTAINABLE RESOURCE INTENSIVE INDUSTRY ACROSS THE EXTENDED CONSTRUCTION VALUE CHAIN

FISSAC IS Performance Evaluation Report

February 2020

D6.5: FISSAC IS Performance Evaluation Report

WP 6, T 6.3

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[1] PU = Public
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RE = Restricted to a group specified by the consortium (including the Commission Services)
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Executive Summary

FISSAC Project has the ambition to create a viable industrial symbiosis (IS) network for the construction value chain and create a replicable IS model comprised of an IS methodology and an ICT Platform to enable the implementation of the methodology. D6.5: FISSAC IS Performance Evaluation Report along with D6.6: FISSAC LCI Database Report submitted at the end of M54 mark the end of T6.3 targeting the monitoring and evaluation of the results with the Platform. Furthermore, with the submission of D6.5, a portion of the **Milestone 21 that is the "performance evaluation of the demo and real scale tests using the Platform"** is completed. The overall completion Milestone 21 is also linked to D6.6 for the LCI database, D6.7 for delivery of final FISSAC methodology and D6.8 on the FISSAC model and validation.

The main activities carried out under T6.3 have been

- Elaboration of the resource efficiency and economic KPIs for seamless KPI evaluation with a new KPI, which is the Material Intensity of Products and Services (MIPS) that represents a life-cycle approach to material flow based assessment
- Development of the evaluation methodology for the Platform validation
- Completion of the functional and user tests by internal and external testers
- Inclusion of the LCA inventories as FISSAC life cycle inventory (LCI) delivered by the results of WP5 LCA study
- Validation of the Platform using user scenarios and finally
- FISSAC IS Community creation and improvement of the user support aspects of the Platform.

During Task 6.3, based on the requirements specified in Task 6.1 and the software design delivered in Task 6.2, the Platform is improved by considering the entire range of user types including network managers, individual facility users, solution providers including transportation services and waste processing facilities. For the purpose of transparency and guidance to the users, the technical background on KPI calculation methodologies are provided in this report. The final KPI list is based on the two criteria

1. The common utilization of the indicators in industrial symbiosis cases based on D1.6
2. Applicability of the indicators based on input/output relations that can be conveniently understood and provided by the users.

Each class of indicators have been associated with sub-classes following the structure proposed in D1.6, (i) absolute, (ii) relative and (iii) intensity type indicators to aid the industrial symbiosis establishment and monitoring purposes.

The evaluation of the Platform was carried out according to three level involvement of users including the Platform development team, domain experts and the end users. The internal testers are comprised of the development and environmental team of EKO who are able to run both functional and non-functional requirement test. Additionally, detailed external tests were performed by seven FISSAC Project partners through online sessions accompanied by development and environmental team members from EKO. All tests were carried out by realistic test scenarios before the delivery of FISSAC LCI database from WP5.

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1 INTRODUCTION

1.1 Objectives of WP 6

This project has an important role acting as a bridge between stakeholders at all levels of construction and demolition value chain and synergies among different parties. To realize this linkage, a methodology supported by a software platform is developed to facilitate material, energy, waste, by-product and even information exchanges. In respect of Figure 1, the reason behind the formation of WP 6 within FISSAC project is to enable the opportunity analysis, enhance the decision support for relevant end users and validate the replicability of the applied symbiosis through different field studies across construction value chain.

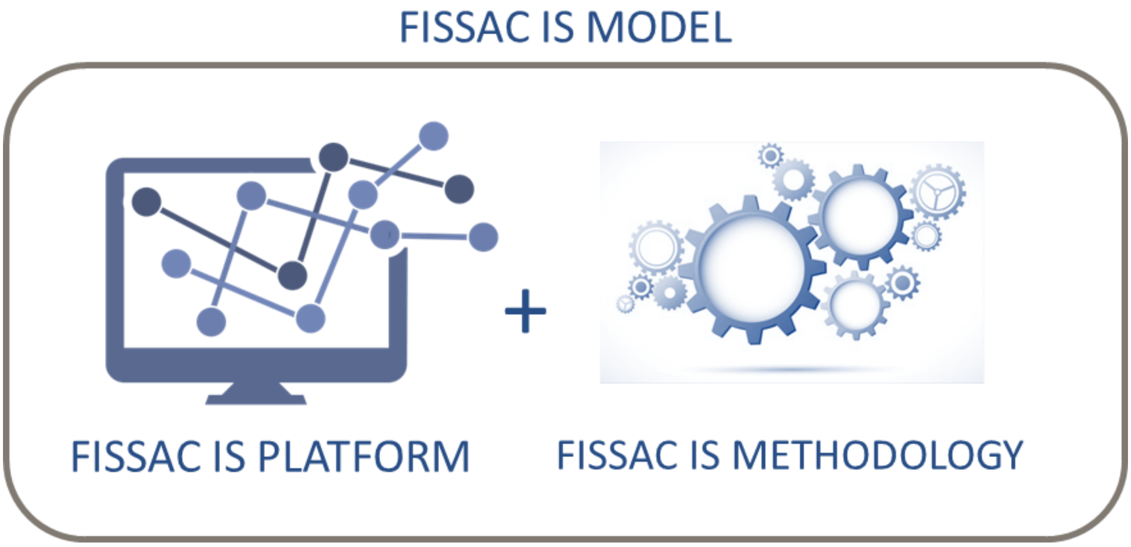

Figure 1 FISSAC IS Model Structure

Within this FISSAC IS Model, it is intended to practice “Towards a zero-waste” approach in the resource intensive industries via cross-sectorial businesses by means of valorisation of different exchange flows respectively. For this purpose, FISSAC IS Platform is developed to enable the decision-making process in an easy manner by facilitating the formation, assessment and identification of IS networks following FISSAC IS Methodology. This methodology is nourished from different work packages of the project and reach its final shape during WP 6 studies.

1.2 FISSAC IS Platform

The FISSAC IS Model consists of FISSAC IS Methodology and FISSAC IS Platform. FISSAC methodology is a part of the FISSAC model describing the necessary steps to establish industrial symbiosis. During this project, these steps are realized and applied to construction value chain then validated through different case studies. In this context, various steps in this methodology is supported by FISSAC IS Platform covering opportunity identification, process and network designs and analysis of different key performance indicators. Hence, it acts as an enabler of the IS methodology and assist the FISSAC IS Model to be replicable beyond construction value chain.

The “**FISSAC IS Platform**” which will be one of the important outcomes of the FISSAC Project is aimed to be a decision support system / tool for facilitating Industrial Symbiosis. The ICT Platform will operate as a cloud-based service to be modular, inclusive, replicable on different value chains and international.

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This deliverable, which is one the crucial one, is showing an integrated Industrial Symbiosis (IS) Management Software Tool (FISSAC IS Platform), supporting decision making in industrial clustering respecting Material Flow Analysis (MFA). This is achieved by considering Circular Economy structure in different perspectives such as maximising social (Increase in Job and Employment with respect to the created networks), environmental and financial benefits that is gained from Industrial Symbiosis Networks. In addition to that, the platform is right now simplifying the formation and operation of IS networks with the support of FISSAC IS Methodology.

In that respect, following activities except Activity-7 were accomplished during WP 6 studies. Activity-7 is the main subject covered by this document in order to make a fine tuning cycles covering technical and non-technical items (e.g. user interface, user experiences, platform stability, analysis results, etc.).(Figure 2)

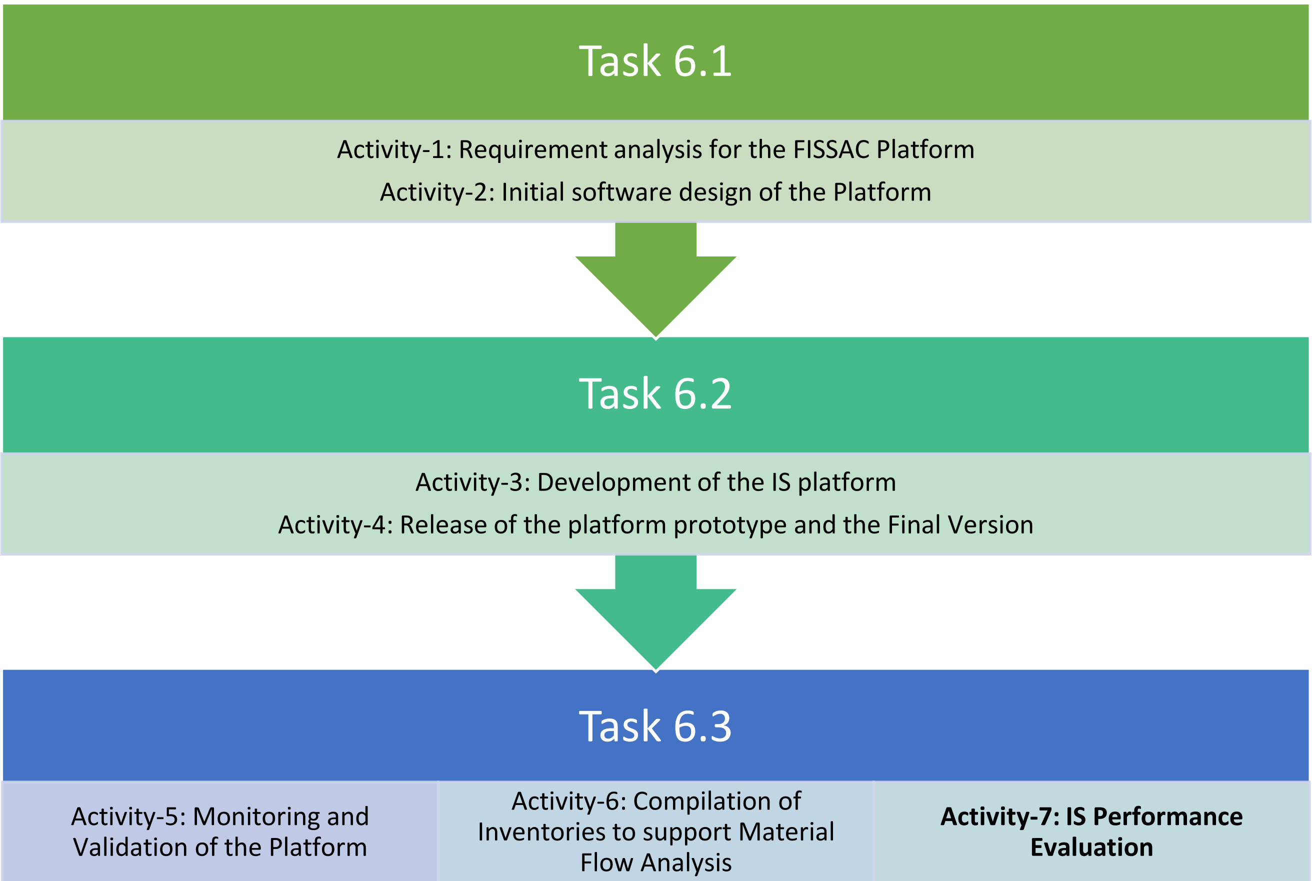

Figure 2 WP6 Activity Flow

This is ultimate objective of the validation period to see whether the main scope of the FISSAC project related with three aspects of Industrial Symbiosis framework such as “Opportunity Identification, Opportunity Creation(Designing of Manufacturing Processes) and Opportunity Assessment” is achieved. Platform is worldwide available and ready for all users without any registration fees and evaluating different features of the platform has utmost importance. For this purpose, following chapters were designated to establish a robust methodology to monitor and assess the platform evaluation steps with the support of internal and external user tests where;

-Internal Users: Development team and domain experts that supported the Platform Design

-External Users: Project partners

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1.3 Target Beneficiaries

Stakeholders or in other words potential target groups/users of FISSAC IS Platform mainly include Industrial Zone Managements, Manufacturers, Technology Solution Providers, Ministries, Local Authorities (e.g municipalities, regional development agencies), chamber of industries, research institutes and other relevant parties. These parties are the building blocks of a FISSAC IS Community that will be described in Section 6.

The objective is to attract symbiosis related stakeholders with the help of different user roles and platform features enabling the application and assessment of industrial symbiosis. For this purpose, following table(Table 1) is showing the exploitable properties of the platform linked with stakeholders and user roles.

Table 1 Target Beneficiaries, User Type and Benefits Matrix

User Type	Benefits	Related Stakeholder
Observer	They can view the IS processes and the related results. Observer role is suitable for any read-only access needs. This role can view benchmarking results.	All type of user
Symbiosis Expert	A Symbiosis Expert should be highly experienced on IS processes and they are involved in every step of IS process. Some of the important tasks of Symbiosis Experts are facility engagement, data gathering, opportunity assessments, monitoring, performance assessments and general management tasks. Additionally, Symbiosis Experts are responsible with the data input tasks and its validity. For this purpose, the main duties of this role will inevitably be facilitated with the support of the platform.	Domain experts, Environment engineer, waste engineer, process manager, consultants
Facility Representative	Facility owner can be any industrial establishment manager that wants to join to IS network or build one. They can view any inventory to observe the reliability of their processes and production modelling phases. This role can also check possible opportunity offers.	Manufacturing Company Representative, Manager, Owner
Technology/Solution Provider	They are mainly responsible for the design, implementation and integration of the required technologies and solutions for waste transportation, conversion, recycling and integration. So FISSAC IS Platform is the best place to reach and be a part of different synergies in that sense.	Intermediary, Convertor, Handler, Transporter
Network Manager	Network manager can have different responsibilities depending on the type and sharing options of network. If it is a private network, the manager has an important role, abilities and responsibilities as he can manage sharing options, assign the name of network, answer to specific requests, and assign the symbiosis expert and the system designer. Managing facilities and all other supervision tasks are also the responsibility of this role. If it is a public network, the manager has less tasks to do. Most of tasks are validation and supervision. Of course, this role also has the ability of changing data sharing options.	Organized Industrial Zone Management, Eco-Industrial Park Management, Industrial Clusters

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2 IS ASSESSMENT METHODOLOGY

2.1 Methodology

In FISSAC IS Model, the main concept for the evaluation and monitoring of the established IS and related components is to utilize indicator-based calculations. Regular assessment of indicators reveals the direction of change across different units and through time. They serve the purpose of setting policy priorities as well as benchmarking or monitoring performance.[1] Indicators implemented in FISSAC software platform help to monitor environmental and economic patterns covering FISSAC project value chains.

In FISSAC IS Model for establishment and monitoring of IS, the indicator-based assessment plays an important part. The indicator-based assessment methodology implemented in the FISSAC Model can defined as the quantification of indicators based on the comparison between before and after implementation of the IS network by means of a reference time frame. [1] Furthermore, comparisons can be made periodically to reveal continuous improvement created by IS in terms of reduced environmental impacts, economic gains of associated companies or progress on social issues. Therefore, baseline for assessment can be set to showcase effects of establishment of the FISSAC IS network or constant progress over the years.

It is inevitable and substantial to evaluate the cumulative added value during an establishment or ongoing industrial symbiosis activities. In such a network, performance monitoring is the key subject revealing the status of a company or eco-industrial park seek for mutual benefits. (Figure 3)

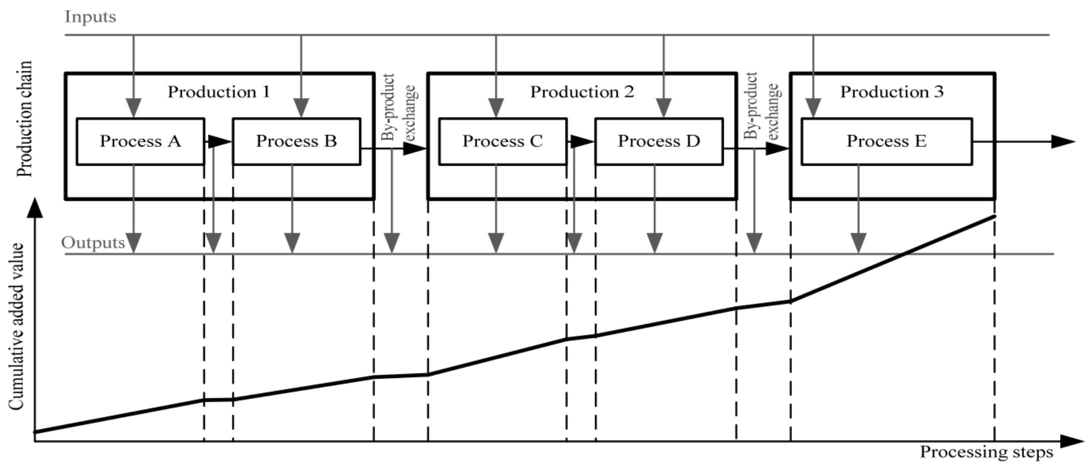

Figure 3 Generic model for evaluation of Industrial Symbiosis performance [2]

FISSAC industries utilize various types of equipment and processes that are a challenge to control and maintain in order to achieve highest efficiency and profit for the plant. Thus, one of the main usage of KPIs is to identify poor performance and the improvement potential.[3] In addition to that, it is crucial to analyse symbiotic relations since various benefits or disadvantages have to be demonstrated and validated via different KPIs utilizing Material Flow Analysis technique.

2.2 Key Performance Indicators for IS Assessment

This methodology described in previous section mainly uses before and after scenario, including symbiosis system models by comparing the indicators quantified. Moreover, the assessment is not only for before and after scenario consisting symbiotic relations but also for continuous monitoring of the system tracking the improvement in the process over time. These indicators were already studied during Deliverable 1.6 and

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main indicator groups are identified during Task 6.3 works described below. In that sense, within the scope of these evaluation methodologies, FISSAC platform makes it possible to determine reduced environmental impacts, economic status, network strength and Material Input Per Unit Services (MIPS) analysis respectively. Following section will presents the short description and formulas together with sample calculations regarding before and after symbiosis scenarios.

Before starting the indicator section, following figure(Figure 4) is one the good illustration taking account the Material Consumption Indicators describing the Absolute and Intensity Indicator as sub-categories. More details on the basics of the indicators can be found in Chapter 5 of Deliverable 1.6.

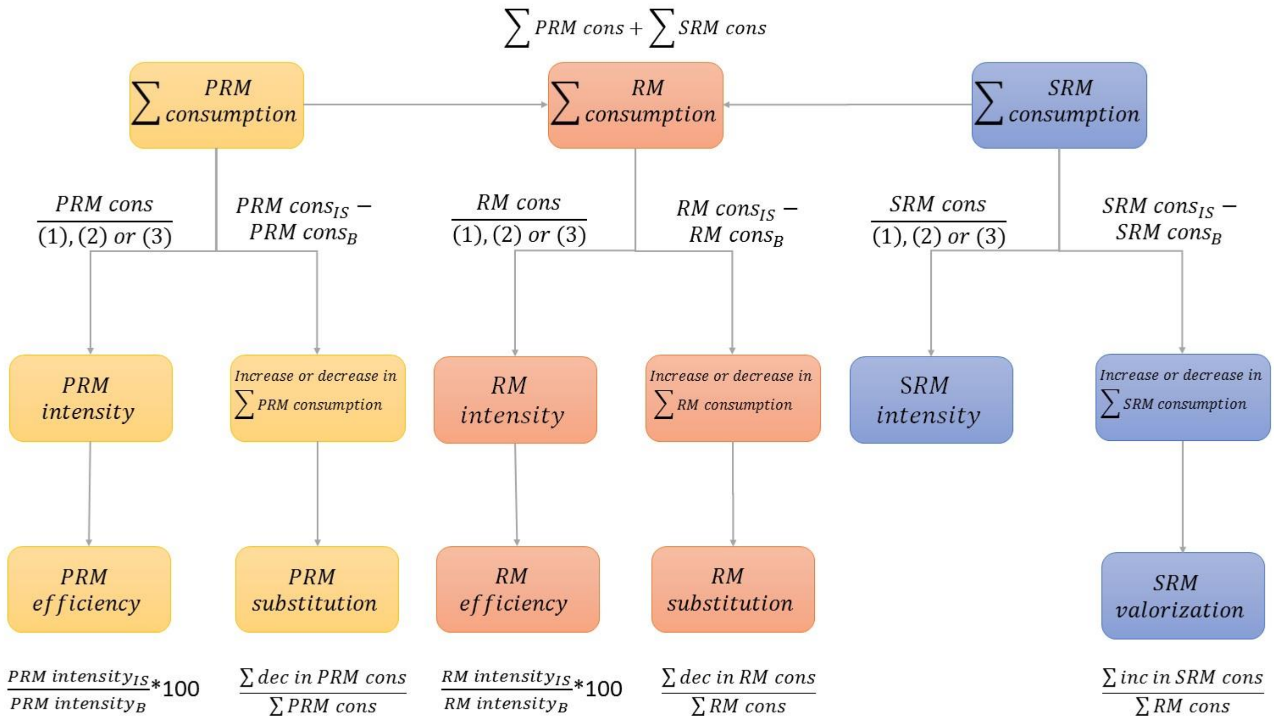

Figure 4 Schematic representation of absolute, absolute change, intensity and efficiency indicators based on primary and secondary material consumption (Note: (1) product quantity, (2) turnover, (3) net value added)

2.2.1 Environmental Indicators

In order to monitor the environmental performance of a system model, facility or a network, following indicators are implemented to FISSAC IS platform. (Table 2)

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Table 2 Environmental KPIs Implemented in FISSAC Software Platform

Subject	Indicators	Classes	Sub-Classes
ENVIRONMENTAL INDICATORS	***Material Consumption (See Annex I for Sample Calculation)***	Primary Raw Material Consumption	▪ Total PRM consumption ▪ PRM intensity (Specific PRM consumption) ▪ Increase or decrease in total PRM consumption ▪ Absolute change in PRM substitution ▪ Relative change of PRM substitution ▪ PRM efficiency
		Secondary Raw Material Consumption	▪ Total SRM consumption ▪ SRM intensity (Specific SRM consumption) ▪ Increase or decrease in total SRM consumption ▪ Relative change of increase or decrease in total SRM consumption ▪ SRM valorisation (substitution) ▪ Relative change of SRM Valorisation ▪ SRM efficiency
		Raw Material Consumption	• Total RM consumption • RM intensity • Increase or decrease in total RM consumption • Relative change in increase or decrease in total RM consumption • RM valorisation (substitution) • Rate of RM substitution • RM Efficiency
	Energy Consumption (See Annex I for Sample Calculation)	Fuel Consumption	• Total fuel consumption • Fuel intensity (Specific fuel consumption) • Increase or decrease in total fuel consumption • Relative change of increase or decrease in total fuel consumption • Fuel substitution • Relative change of fuel substitution • Fuel efficiency
		Thermal Energy Consumption	• Total thermal energy consumption • Thermal energy intensity (Specific thermal energy utilization) • Increase or decrease in total thermal energy consumption • Relative change of increase or decrease in total thermal energy consumption • Relative change of Thermal Energy Substitution • Thermal energy efficiency

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Subject	Indicators	Classes	Sub-Classes
		Electricity Consumption	• Total electricity consumption • Electricity intensity (Specific electricity consumption) • Increase or decrease in total electricity consumption • Relative change of increase or decrease in total electricity consumption • Electricity substitution • Relative change of Electricity Substitution • Electricity efficiency
		Renewable energy Consumption	• Total renewable energy consumption • Share of renewable energy consumption • Renewable energy intensity (Specific renewable energy consumption) • Increase or decrease in total renewable energy consumption • Increase or decrease in share of renewable energy consumption • Relative change of increase or decrease in total renewable energy consumption
		Total Energy Consumption	• Total energy consumption • Total energy intensity (Specific energy consumption) • Increase or decrease in total energy consumption • Relative change of increase or decrease in total energy consumption • Energy substitution • Relative change of energy substitution • Energy efficiency
	By-products* (See Annex I for Sample Calculation)	By-product generation	• Total by-product generation • By-product generation intensity (per quantity) • Increase or decrease in total by-product generation • Relative change of increase or decrease in total by-product generation Change in by-product generation intensity

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Subject	Indicators	Classes	Sub-Classes
	Air emissions (See Annex I for Sample Calculation)	Greenhouse gas (GHG) emissions	• Total GHG emissions • GHG emissions from electricity consumed and purchased • GHG emissions from fuel consumption • GHG emission intensity (Specific GHG emissions) • Increase or decrease in total GHG emissions • Relative change of increase or decrease in total GHG emissions 2 • Change in GHG emission intensity
	Solid Waste Generation* (See Annex I for Sample Calculation)	Hazardous wastes (HW)	• Total HW generation • HW generation intensity (Specific HW generation) • Increase or decrease in total HW generation • Relative change of increase or decrease in total HW generation • HW recycling • Share of recycled HW • Relative change of HW recycling • Change in HW generation intensity
		Non-hazardous wastes (NHW)	• Total NHW generation • NHW generation intensity (Specific NHW generation) • Increase or decrease in total NHW generation • Relative change of increase or decrease in total NHW generation • NHW Reycling • Share of recycled NHW • Relative change of NHW recycling • Change in solid waste generation intensity

*This KPI is slightly different than other KPIs. It is used for continuous monitoring/tracking of a process. Its results can vary depending on the process modifications in time.

In the next section of this deliverable, all the environmental indicators involved will be explained with the help of following abbreviations(valid for economic indicators) demonstrating the code used for different parameters in environmental KPIs calculation formula. (Table 3**Error! Reference source not found.**)

Table 3 List of Codes and Definitions

Code	Definition
PRM	Total Primary Raw Material
SRM	Total Secondary Raw Material
RM	Total Raw Material
...S	After Symbiosis Suffix
PI/SI/RI	PRM Intensity/SRM Intensity/RM Intensity
P/T/NVA	Product/Turnover/Net Value Added

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FC	Total Fuel Consumption
FI/TI	Total Fuel Consumption Intensity
NG	Total Thermal Energy Consumption
TI	Total Thermal Energy Consumption Intensity
E	Total Electrical Energy Consumption
EI	Total Electrical Energy Consumption Intensity
RE	Total Renewable Energy Consumption
REI	Total Renewable Energy Consumption Intensity
SER	Share of Renewable Energy Consumption
TEC	Total Energy Consumption
TEI	Total Energy Consumption Intensity
TBP	Total by-product Generation
BPI	By-product Generation intensity
…M	Modified Process Suffix (also it means future state of a process)
TG	Total GHG Emission
EG	GHG Emissions from electricity consumed and purchased
CF	Conversation Factor
FG	GHG Emissions from fuel consumed
GI	GHG Emission Intensity
H/N	Total Hazardous Solid Waste(HSW) Generation/Total Non-Hazardous Solid(NHSW) Waste Generation
HI/NI	HSW Intensity/NHSW Intensity
ROR	Rate of Recycling
HWR	HW recycling
TMC	Total Material Cost
SMC	Specific Material Cost
TWC	Total Water Cost
SWC	Specific Water Cost
TEC	Total Energy Cost
SEC	Specific Energy Cost
TLU	Total Land Use Cost
SLU	Specific Land Use Cost
TLC	Total Labour Cost
SLC	Specific Labour Cost
TM	Total Maintenance Cost
SM	Specific Maintenance Cost
TOC	Total Operational Cost
SOC	Specific Operational Cost
MIPS	Material Intensity per Unit Service

For the calculation, formulas and examples for each environmental KPI implemented in FISSAC platform together with concise definition are described as below.

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Material Consumption

Definition

In the framework of the strategies and tools for closing loops of resources and circular economy, a growing interest towards IS stands out, addressed at making the residues of one productive sector available for another one. This approach is not only a potential factor of competitiveness for industrial activities, but also a factor of enrichment, since all resources are valorised locally and not dissipated, delegated or given away to third parties. The European Commission assigned to IS a strategic role in the efficient use of resources, clearly identified in various planning and funding documents ("European Resource Efficiency Platform" (EREP), "Roadmap to a Resource Efficient Europe" ,Communication COM (2014) 398 "Towards a circular economy: A zero waste programme for Europe" , Circular Economy Package).[4] For this purpose, secondary raw material applications gain significant popularity.

The basic materials for the primary production industries are called raw materials and classified into two categories such as;

1. Primary Raw Material (PRM)
2. Secondary Raw Material (SRM)

For the primary raw material, main challenge is the usage of natural resources covering a lifelong period from extraction stage to their final use, considered as waste or by-product depending on possible valorization. For potential up-downcycling operation of waste materials meeting End of Waste Criteria for a "demand-end" discipline, emerges the secondary raw material term. Total or partial replacement of natural raw material depends on several limitations[2] such as;

-Industrial processes constraints,

-Environmental constraints,

-Technical requirements for final applications

Secondary Raw Material utilization in total raw material consumption at the receiving end of a symbiotic relationship is addressed by a company's ability to use recycled input materials. SRM usage helps to reduce the demand for PRM and protect natural reserves respectively.

In order to assess the performance status of a network including industrial symbiosis scenario, the initial measurement unit covers the material consumption figures. In that respect, following indicators provides performance measurements and comparisons for "before-after symbiosis" scenarios supporting decision makers in different symbiosis opportunities.

[2] FISSAC Project-Deliverable 2.1 "Definition of technical requirements of secondary raw material" 2015.

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Formula

Table 4 Material Consumption KPIs

Sub-Classes	Unit	Formula(Before Symbiosis)	Formula (After Symbiosis)
Total PRM consumption	unit amount of PRM	Σ PRM before symbiosis	Σ PRM after symbiosis
PRM intensity (Specific PRM consumption) (per quantity)	unit amount of PRM(S) per P or T or NVA	PI=Σ PRM before symbiosis/P	PIS= Σ PRM after symbiosis /PS
PRM intensity (Specific PRM consumption) (per turnover)		PI=Σ PRM before symbiosis/T	PIS= Σ PRM after symbiosis /TS
PRM intensity (Specific PRM consumption) (per net value added)		PI=Σ PRM before symbiosis/NVA	PIS= Σ PRM after symbiosis /NVAS
Increase or decrease in total PRM consumption	unit amount of PRM	Σ PRM after symbiosis - Σ PRM before symbiosis	
Absolute change in PRM substitution	unit amount of PRM	(Σ PRM after symbiosis - Σ PRM before symbiosis)	
Relative change of PRM substitution	%	100*[Σ PRM after symbiosis - Σ PRM before symbiosis]/Σ PRM before symbiosis	
PRM efficiency	%	100*PIS/PI	
Total SRM consumption	unit amount of SRM	Σ SRM before symbiosis	Σ SRM after symbiosis
SRM intensity (Specific SRM consumption) (per quantity)	unit amount of SRM(S) per P or T or NVA	PI=Σ SRM before symbiosis/P	PIS= Σ SRM after symbiosis /PS
SRM intensity (Specific SRM consumption) (per turnover)		PI=Σ SRM before symbiosis/T	PIS= Σ SRM after symbiosis /TS
SRM intensity (Specific SRM consumption) (per net value added)		PI=Σ SRM before symbiosis/NVA	PIS= Σ SRM after symbiosis /NVAS
Increase or decrease in total SRM consumption	unit amount of SRM	Σ SRM after symbiosis - Σ SRM before symbiosis	
Relative change of increase or decrease in total SRM consumption	%	100*[Σ SRM after symbiosis - Σ SRM before symbiosis]/Σ SRM before symbiosis	
SRM valorisation (substitution)	unit amount of SRM	Σ SRM after symbiosis - Σ SRM before symbiosis	
Relative change of SRM Valorisation	%	100*[Σ SRM after symbiosis - Σ SRM before symbiosis]/Σ SRM before symbiosis	
SRM efficiency	%	100*SIS/SI	
Total RM consumption	tonne SRM	RM=Σ PRM before symbiosis + Σ SRM before symbiosis	RMS=Σ PRM after symbiosis + Σ SRM after symbiosis

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Sub-Classes	Unit	Formula(Before Symbiosis)	Formula (After Symbiosis)
RM intensity (Specific RM consumption) (per quantity)	unit amount of RM per per P or T or NVA	RI=RM/P	RIS=RMS/PS
RM intensity (Specific RM consumption) (per turnover)		RI=RM/T	RIS=RMS/TS
RM intensity (Specific RM consumption) (per net value added)		RI=RM/NVA	RIS=RMS/NVAS
Increase or decrease in total RM consumption	tonne RM	RMS-RM	
Relative change in increase or decrease in total RM consumption	%	100*(RMS-RM)/RM	
RM valorisation (substitution)	tonne RM	RMS-RM	
Rate of RM substitution	%	100*(RMS-RM)/RM	
RM Efficiency	%	100*RIS/RI	

Energy Consumption

Definition

Another significant consumption level in a manufacturing chain beside material usage is utilization of different sources of energy. All the industries, one way or another, needs energy input whether directly or indirectly. Energy is one the main components of resource efficiency concept appearing in many forms (i.e. potential/kinetic energy, work, heat).

Energy is a fundamental aspect in resource efficiency. Key energy-related issues include dependency in fossil fuels, greenhouse gas emissions, energy security and dependency as well as cost. Promoting energy efficiency not only cuts fuel dependency but also can reduce costs and greenhouse gas emissions. Energy indicators play a crucial part in monitoring the mid-term and long-term shift towards a low-carbon economy in the EU. For this reason, energy indicators is a part of every sustainability indicator set currently in use globally.

The indicators described in Table 4 Material Consumption KPIs Table 5 includes energy consumption in terms of fuel, thermal energy, electricity, and renewable energy consumption. Following table can be further disaggregated in terms of specific types of energy sources.

Formula

Table 5 Energy Consumption KPIs

Fuel		Formula (Before Symbiosis)	Formula (After Symbiosis)
Total fuel consumption	kWh Fuel	FC= Σ Fuel consumption before symbiosis*Fuel CF	FCS= Σ Fuel consumption after symbiosis*Fuel CF

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Fuel intensity (Specific fuel consumption) (per quantity)	unit amount of Fuel per P or T or NVA	FI=FC/P	FIS=FCS/PS
Fuel intensity (Specific fuel consumption) (per turnover)		FI=FC/T	FIS=FCS/TS
Fuel intensity (Specific fuel consumption) (per net value added)		FI=FC/NVA	FIS=FCS/NVAS
Increase or decrease in total fuel consumption	kWh Fuel	Total FCS-Total FC	
Relative change of increase or decrease in total fuel consumption	%	100*(FC-FCS)/FC	
Fuel substitution	kWh Fuel	FCS-FC	
Relative change of fuel substitution	%	100*(FCS-FC)/FC	
Fuel efficiency	%	100*FIS/FI	
Thermal Energy		**Formula (Before Symbiosis)**	**Formula (After Symbiosis)**
Total thermal energy consumption	kWh Thermal energy	NG= Σ Thermal Energy before symbiosis*Fuel CF	NGS= Σ Thermal Energy after symbiosis*Fuel CF
Thermal energy intensity (Specific thermal energy utilization) (per quantity)	unit amount of Thermal Energy per P or T or NVA	TI=NG/P	TIS=NGS/PS
Thermal energy intensity (Specific thermal energy utilization) (per turnover)		TI=NG/T	TIS=NGS/TS
Thermal energy intensity (Specific thermal energy utilization) (per net value added)		TI=NG/NVA	TIS=NGS/NVAS
Increase or decrease in total thermal energy consumption	kWh Thermal energy	NSG-NG	
Relative change of increase or decrease in total thermal energy consumption	%	100*(NSG-NG)/ NG	
Relative change of Thermal Energy Substitution	%	100*(NSG-NG)/NG	
Thermal energy efficiency	%	100*TIS/TI	
Electricity		**Formula (Before Symbiosis)**	**Formula (After Symbiosis)**
Total electricity consumption	kWh Electricity	E= Σ Electricity consumption before symbiosis	ES= Σ Electricity consumption after symbiosis
Electricity intensity (Specific electricity consumption) (per quantity)	unit amount of Electricity per P or T or NVA	EI=E/P	EIS=ES/PS
Electricity intensity (Specific electricity consumption) (per turnover)		E/T	ES/TS

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Electricity intensity (Specific electricity consumption) (per net value added)		E/NVA	ES/NVAS
Increase or decrease in total electricity consumption	kWh Electricity	ES-E	
Relative change of increase or decrease in total electricity consumption	%	100*(ES-E)/E	
Electricity substitution	kWh Electricity	ES-E	
Relative change of Electricity Substitution	%	100*(E-ES)/E	
Electricity efficiency	%	100*EIS/EI	
Renewable Energy		**Formula (Before Symbiosis)**	**Formula (After Symbiosis)**
Total renewable energy consumption	kWh Renewable energy	RE= Σ Renewable Energy before symbiosis	RES= Σ Renewable Energy after symbiosis
Share of renewable energy consumption	%	SER=100*RE/(NG+E+F+RE)	SERS=100*RES/(NGS+ES+FS+RES)
Renewable energy intensity (Specific renewable energy consumption) (per quantity)	unit amount of Renewable Energy per quantity or turnover or net added value	REI=RE/P	REIS=RES/PS
Renewable energy intensity (Specific renewable energy consumption) (per turnover)		REI=RE/T	REIS=RES/TS
Renewable energy intensity (Specific renewable energy consumption) (per net value added)		REI=RE/NVA	REIS=RES/NVAS
Increase or decrease in total renewable energy consumption	kWh Renewable energy	RES-RE	
Increase or decrease in share of renewable energy consumption	%	100*(SERS-SER)/SER	
Relative change of increase or decrease in total renewable energy consumption	%	100*(RES-RE)/RE	
Total Energy		**Formula (Before Symbiosis)**	**Formula (After Symbiosis)**
Total energy consumption	kWh Energy	TEC= Σ (NG+E+FC+RE)	TECS= Σ (NGS+ES+FCS+RES)
Total energy intensity (Specific energy consumption) (per quantity)	unit amount of Total Energy per P or T or NVA	TEI=TEC/P	TEIS=TECS/PS

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Total energy intensity (Specific energy consumption) (per turnover)		TEI=TEC/T	TEIS=TECS/TS
Total energy intensity (Specific energy consumption) (per net value added)		TEI=TEC/NVA	TEIS=TECS/NVAS
Increase or decrease in total energy consumption	kWh Energy	TECS-TEC	
Relative change of increase or decrease in total energy consumption	%	100*(TECS-TEC)/TEC	
Energy substitution	kWh Energy	TECS-TEC	
Relative change of energy substitution	%	100*(TECS-TEC)/TEC	
Energy efficiency	%	100*TEIS/TEI	

By-product Generation

Definition

Industrial production processes are often complex and can generate several different materials with different economic values, environmental impacts and waste/non-waste statuses. In addition to this the consequences of waste/non-waste status can vary from sector to sector. In some sectors, materials that are sold whilst being classified as wastes are traded freely amongst businesses throughout the internal market. In other sectors, such as the food and drink sector, a clear distinction between waste and product is crucial to the economic exploitation of the material concerned. The technical situation is evolving continuously, with rapid changes in technology, both in production processes and the waste treatments available.

In this set of indicators, the main objective is to monitor the supply end of a process independently. In an industrial process, the target is equal to the scope of the industry itself meaning that producing a product. In that sense, there can be one or several outputs except from main product possibly having low value. These materials are called by-product, which are also considered and evaluated as SRM in different set of indicators. The indicators in this category supplies profound vision of the by-product together with the process that generates.

Formula

Table 6 By-product Generation KPIs

By-products		Default Process	Future Process
Total by-product generation	tonne	TBP=Σ by-product generation (baseline process)	TBPM= Σ by-product generation (future process)
By-product generation intensity (per quantity)	unit amount of By-product	BPI=TBP/P	BPIM=TBPM/PM
By-product generation intensity (per turnover)		BPI=TBP/T	BPIM =TBPM/TM

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By-product generation intensity (per net added value)	per P or T or NVA	BPI=TBP/NVA	BPIM=TBPM/NVAM
Increase or decrease in total by-product generation	tonne	TBPM-TBP	
Relative change of increase or decrease in total by-product generation	%	100*(TBPM-TBP)/TBP	
Change in by-product generation intensity	%	100*(BPIM-BPI)/BPI	

GHG Emissions

Definition

In recent years, one of the most critical subject remarkable in global scale is the GHG emission which influences negatively the climate. In that respect, the main industries included in FISSAC project are considered as an important source together with their GHGs potential. Thus, GHG involving indicators are one of the most popular monitoring activities, which reveal the fact behind the GHG emission figures. In order to quantify GHG based indicators, it is necessary to convert all determined GHG types and sources into carbon dioxide equivalent.

The six main greenhouse gas emissions are:

- Carbon dioxide (CO2)
- Methane (CH4)
- Nitrous oxide (N2O)
- Hydrofluorocarbons (HFCs- a group of several compounds)
- Perfluorocarbons (PFCs- a group of several compounds)
- Sulphur hexafluoride (SF6)

Formula

Table 7 GHG Emission KPIs Formulas

Greenhouse Gas (GHG) Emissions		Formula (Before Symbiosis)	Formula (After Symbiosis)
Total GHG emissions	kg $CO_{2\text{-eq}}$	TG= Σ GHG sourced from Gas/Electricity/Fuel before symbiosis	TGS= Σ GHG sourced from Gas/Electricity/Fuel after symbiosis
GHG emissions from electricity consumed and purchased	kg $CO_{2\text{-eq}}$	EG=E*CF	EGS=ES*CF
GHG emissions from fuel consumption	kg $CO_{2\text{-eq}}$	FG=Σ (Fuels*Fuel CF) before symbiosis	FGS=Σ (Fuels*Fuel CF) after symbiosis
GHG emission intensity (Specific GHG emissions) (per quantity)	tonne $CO_{2\text{-eq}}$ per P or T or NVA	GI=TG/P	GIS=TGS/PM
GHG emission intensity (Specific GHG emissions) (per turnover)		TG/T	TGS/TM

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Greenhouse Gas (GHG) Emissions		Formula (Before Symbiosis)	Formula (After Symbiosis)
GHG emission intensity (Specific GHG emissions) (per net value added)		TG/NVA	$TGS/NVAM$
Increase or decrease in total GHG emissions	tonne CO_{2-eq}	$TGS-TG$	
Relative change of increase or decrease in total GHG emissions	%	$100*(TGS-TG)/TG$	
Change in GHG emission intensity	%	$100*(GI-GIS)/GI$	

Solid Waste Generation

Definition

This indicator is related with the hazardous and non-hazardous solid waste generated in an industrial process and it is mainly dealt with the process itself acting like a continuous monitoring tool.

Formula

Table 8 Solid Waste Generation KPIs

Hazardous Solid Wastes (HW)		Baseline Scenario	Future Scenario
Total HW generation	kg or tonne	ΣH	ΣHS
HW generation intensity (Specific HW generation) (per quantity)	unit amount of ΣHW per per P or T or NVA	$HI=\Sigma H/P$	$HIS=\Sigma HS/PS$
HW generation intensity (Specific HW generation) (per turnover)		$HI=\Sigma H/T$	$HIS=\Sigma HS/TS$
HW generation intensity (Specific HW generation) (per net value added)		$HI=\Sigma H/NVA$	$HIS=\Sigma HS/NVAS$
Increase or decrease in total HW generation	kg or tonne	$\Sigma H-\Sigma HS$	
Relative change of increase or decrease in total HW generation	%	$100*(\Sigma H-\Sigma HS)/\Sigma H$	
HW recycling	kg or tonne	$HWR=\Sigma H*ROR/100$	$HWRS=\Sigma HS*ROR/100$
Share of recycled HW	%	100*Recycled H/(ΣH)	100*Recycled HS/(ΣHS)
Relative change of HW recycling	%	$100*(HWR-HWRS)/HWR$	
Change in HW generation intensity	%	$100*(HI-HIS)/HI$	
Non-Hazardous Solid Wastes (NHW)		**Baseline Scenario**	**Future Scenario**
Total NHW generation	tonne	ΣN	ΣNS
NHW generation intensity (Specific NHW generation) (per quantity)	unit amount of ΣNHW	$NI=\Sigma N/P$	$NIS=\Sigma NS/PS$
NHW generation intensity (Specific NHW generation) (per turnover)		$NI=\Sigma N/T$	$NIS=\Sigma NS/TS$

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NHW generation intensity (Specific NHW generation) (per net value added)	per per P or T or NVA	NI=ΣN/NVA	NIS=ΣNS/NVAS
Increase or decrease in total NHW generation	kg or tonne	ΣN-ΣNS	
Relative change of increase or decrease in total NHW generation	%	100*(ΣN-ΣNS)/H	
NHW Reycling	kg or tonne	NHWR=ΣH*ROR/100	NHWRS=ΣHS*ROR/100
Share of recycled NHW	%	100*Recycled N/Total N	100*Recycled NS/Total N
Relative change of NHW recycling	%	100*(NHWR-NHWRS)/NHWR	
Change in solid waste generation intensity	%	100*(NI-NIS)/NI	

2.2.2 Economic Indicators

Economic KPIs are aimed to be used in FISSAC Platform analysis modules in order to evaluate and score the economic impacts of the processes before and after the industrial symbiosis network. These economic indicators give the decision makers insights about the economic sustainability, particularly the change of costs, turnover and net value added. In accordance with this idea, selected KPIs are of operational costs (OPEX), capital costs (NPV) and production quantities.

In order to monitor the economic performance of a system model, facility or a network, following indicators are implemented to FISSAC IS platform. (Table 9)

Table 9 Economic KPIs Implemented in FISSAC Software Platform

Subject	Indicators	Classes
ECONOMIC INDICATORS	**Product Quantity** **(See Annex I for Sample Calculation)**	-
	Turnover **(See Annex I for Sample Calculation)**	-
	Net Value Added **(See Annex I for Sample Calculation)**	-
	OPEX **(See Annex I for Sample Calculation)**	• Material cost • Water cost • Energy cost • Land use cost • Labor cost • Maintenance cost • Environmental cost savings • Revenues as a result of IS activities

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Subject	Indicators	Classes
	CAPEX **(See Annex I for Sample Calculation)**	-

Net Present Value (NPV)

Definition

By discounting whole expenses during the system scope to the nowadays, WLC is calculated as a net present value (NPV). Distinctive systems and investments are compared where the prices diverge at some point of the calculation period thanks to this methodology. Following formulas are used to calculate NPV.

Formula

Discount rates =>

$$r = \frac{1+d}{1+i} - 1$$

d corresponds to the interest rate and i corresponds to the inflation rate.

Net present value=>

$$NPV = \sum_{t=0}^{t=T} \frac{C_t}{(1+r)^t}$$

t (0,..,T) is the project or assessment period, C_t is the cash flow occurring in year t, and r is the discount rate.

OPEX

Definition

OPEX stands for an abbreviation of operational costs of a facility. Considering the content of the OPEX, it includes both internal and external costs and possible revenues as well. Internal costs as material costs, water cost, energy costs, land use cost, labour costs and maintenance costs can be used. Moreover, external costs include environmental costs and savings regarding waste, emissions and treatment costs as well as avoided regulatory fines among them.

Formula

Table 10 illustrates the OPEX KPIs and their formulas that will further be used in the FISSAC Platform,

Table 10 FISSAC Platform KPIs regarding internal operational costs

Material Cost		Calculation Before IS	Calculation After IS
Total material cost	€	TMC=Cost*C+Cost*FA+Cost*CA+Cost*W	TMCS=Cost*CS+Cost*FAS+Cost*CAS+Cost*WS
Specific material cost	€	SMC=TMC/P or T or NVA	SMCS=TMCS/PS or TS or NVAS
Increase or decrease in total material cost	€	TMC-TMCS	
Relative change of increase or decrease in total material cost	%	100*(TMC-TMCS)/TMC	

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Relative change in specific material cost	%	100*(SMC-SMCS)/SMC	
Water Cost		**Calculation Before IS**	**Calculation After IS**
Total water cost	€	Cost*W	Cost*WS
Specific water cost	€	SWC=Cost*W/P or T or NVA	SWCS=Cost*WS/PS or TS or NVAS
Increase or decrease in total water cost	€	Cost*W-Cost*WS	
Relative change of increase or decrease in total water cost	%	100*(Cost*W-Cost*WS)/(Cost*W)	
Relative change in specific water cost	%	100*(SWC-SWCS)/SWC	
Energy Cost		**Calculation Before IS**	**Calculation After IS**
Total energy cost	€	Cost*E	Cost*ES
Specific energy cost	€	SEC=Cost*E/P or T or NVA	SECS=Cost*ES/PS or TS or NVAS
Increase or decrease in total energy cost	€	Cost*E-Cost*ES	
Relative change of increase or decrease in total energy cost	%	100*(Cost*E-Cost*ES)/(Cost*E)	
Relative change in specific energy cost	%	100*(SEC-SECS)/SEC	
Land Use Cost		**Calculation Before IS**	**Calculation After IS**
Total land use cost	€	L	LS
Specific land use cost	€	SLU=L/P or T or NVA	SLUS=LS/PS or TS or NVAS
Increase or decrease in total land use cost	€	L-LS	
Relative change of increase or decrease in total land use cost	%	100*(L-LS)/(L)	
Relative change in specific land use cost	%	100*(SLU-SLUS)/SLU	
Labour Cost		**Calculation Before IS**	**Calculation After IS**
Total labour cost	€	LA	LAS
Specific labour cost	€	SLC=LA/P or T or NVA	SLCS=LAS/PS or TS or NVAS
Increase or decrease in total labour cost	€	LA-LAS	
Relative change of increase or decrease in total labour cost	%	100*(LA-LAS)/(LA)	
Relative change in specific labour cost	%	100*(SLC-SLCS)/SLC	
Maintenance Cost		**Calculation Before IS**	**Calculation After IS**
Total maintenance cost	€	M	MS
Specific maintenance cost	€	SM=M/P or T or NVA	SMS=MS/PS or TS or NVAS
Increase or decrease in total maintenance cost	€	M-MS	
Relative change of increase or decrease in total maintenance cost	%	100*(M-MS)/(M)	
Relative change in specific maintenance cost	%	100*(SM-SMS)/SM	
Total Operational Cost (OPEX)		**Calculation Before IS**	**Calculation After IS**
Total operational cost	€	TOC=Specific Cost*(C+FA+CA+W+E+L+LA+M+A)	TOCS=Specific Cost*(CS+FAS+CAS+WS+ES+LS+LAS+MS+AS)

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Specific operational cost	€	SO=TOC/P or T or NVA	SOS=TOCS/PS or TS or NVAS
Increase or decrease in total operational cost	€	TOC-TOCS	
Relative change of increase or decrease in total operational cost	%	100*(TOC-TOCS)/TOC	
Relative change in specific operational cost	%	100*(SO-SOS)/SO	

TURNOVER and NET VALUE ADDED

Formula

Furthermore, product quantity, turnover and net value added (NVA) KPIs are also included in OPEX indicators and their formulas are given in the Table 11.

Table 11 Economic KPIs used in the Platform

Product Quantity		Calculation Before IS	Calculation After IS
Total product quantity	tonne	P	PS
Increase or decrease in total product quantity	tonne	P-PS	
Relative change of increase or decrease in total product quantity	%	100*(P-PS)/P	
Turnover		**Calculation Before IS**	**Calculation After IS**
Total turnover	€	T	TS
Increase or decrease in total turnover	€	T-TS	
Relative change of increase or decrease in total turnover	%	100*(T-TS)/T	
Net Value Added		**Calculation Before IS**	**Calculation After IS**
Total net value added	€	NVA	NVAS
Increase or decrease in total net value added	€	NVA-NVAS	
Relative change of increase or decrease in total net value added	%	100*(NVA-NVAS)/NVA	

2.2.3 Network Indicators

Formation and evolution of IS networks has been investigated in the literature for IS where resource savings and emission reductions in IS systems were quantified. Researches focused on defining IS system, specification of IS boundaries and impacts of implementation of the system during evaluation of IS network. Social factors are adopted and applied as networks indicators. Network indicators were examined in FISSAC in order to understand organization framework of IS networks. By using network indicators, network structure and relationships among the nodes are analysed [5]. In this section, network indicators related to positioning and directional relations are explained. Brief description of relevant indicators is given in the section.

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2.2.3.1 Basic Terminology

Node are the units or actors in a network

Edges (Arcs) are connections between nodes

Path is a sequence of arcs, in which the initial node of each arc is the same as the terminal node of preceding arc in the sequence.

2.2.3.2 Centrality

Centralization indicators are used as metrics for analyzing industrial symbiosis structural attributes [6]. In network analysis, centrality is the core indicator since characteristics of nodes can be described by centrality indicators [7]. Degree centralization, betweenness centralization and closeness centralization are measures of centralization in the network [6].

2.2.3.3 Degree Centrality

Degree centrality is described as the direct total relations of one node and others [8]. The number of neighbours for the vertex in the graph is degree centrality of a vertex. Degree centrality can be calculated by counting number of edges incident on the vertex [9]. Ability of the firm itself in the exchanging of wastes is reflected by degree centrality. However, the centrality does not reflect the ability to control others [8]. A node with high degree centrality means that it is connected by many edges in the network.

Degree centrality (DC) is calculated and expressed as [8]:

$$DC_i = \frac{\sum_{j=1}^{N} x_{ij}}{N-1} \quad , i \neq j$$

Where

N = number of nodes

X_{ij} = relations from node i to node j

Node with high DC value shows that the highest input waste flows to the node and output waste flows from the node. In other words, there is close relationship of the node with other nodes in terms of waste exchange. Therefore, when a node has higher DC value, it means that importance of the node is higher in IS network compared to other nodes. Also, vulnerability of the IS system is determined according to DC value of nodes.

2.2.3.4 Betweenness Centrality

Global importance of the node v in the IS network is identified by the betweenness centrality. The ratio of number of shortest paths between node s and t passing through v ($б_{st}$) over the total number of shortest paths between s and t in the network ($б_{st}$) is specified by betweenness centrality. A node with high betweenness centrality means that the node has global importance within the network due to the relationship it has with other nodes. The equations are given in the following for calculation of the centrality [5].

$$C_B(v) = \sum_{s \in V} \sum_{t \in V} \delta_{st}(v)$$

where

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$$\delta_{st}(v) = \frac{\sigma_{st}(v)}{\sigma_{st}}$$

$\delta_{st}(v)$ = ratio of $\sigma_{st}(v)$ over the total number of shortest paths between nodes s and t in the network

2.2.3.5 Closeness Centrality

The minimal path from a given node to another is quantified by closeness centrality. The following equation is used for determining the closeness centrality of node I in the network [8].

$$CC_i = \frac{N-1}{\sum_{j=1}^{N} d_{ij}} \quad ,i \neq j$$

where

N: number of nodes

d_{ij} = the minimal length from node i to node j

A node/facility with high closeness centrality means that it is the most influenced facility by other facilities in the IS network. If there is extent of the facility, other facilities can be influenced in an IS network.

2.2.3.6 Reciprocity

The indicator shows mutually beneficial exchanges between nodes. Total network is evaluated by this indicator. Reciprocated weight between node i and j is defined as below [10]:

$$w_{\underset{ij}{\leftrightarrow}} \equiv \min[w_{ij}, w_{ji}] = w_{\underset{ji}{\leftrightarrow}}$$

Total reciprocated weight is defined as below [10]:

$$\overset{\leftrightarrow}{W} = \sum_{i} \sum_{j \neq i} w_{\underset{ij}{\leftrightarrow}} = \sum_{i} s_{\underset{i}{\leftrightarrow}}$$

Total weight of network is defined as below [10]:

$$W \equiv \sum_{i} \sum_{j \neq i} w_{ij}$$

For network wide measurement, weighted reciprocity of weighted network is obtained from following equation [10].

$$r \equiv \frac{\overset{\leftrightarrow}{W}}{W}$$

If there are vice versa waste exchange between two facility, it means that there is reciprocity in the IS network. The higher reciprocity value is, the higher mutual waste exchanges between facilities are. If all nodes are perfectly reciprocated, r is equal to 1. If reciprocation is absence, r is equal to 0.

2.2.4 MIPS Indicator

Material Intensity per Unit Service (MIPS), illustrates the consumed material covering the direct and indirect consumptions per unit service defined. In other words, MIPS includes the input materials for a given service from cradle to grave, for instance, if 1 kg copper is consumed, it also brings 500 kg/kg “ecological rucksack” for the extraction of 1 kg copper to the MIPS evaluation. [12]

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The term “ecological rucksack” can be defined as the embedded consumed materials from “cradle-to-grave” for the unit raw material used in a process. In other words, considering the “copper” example, using 1 kg copper in a process can also bring much more consumed materials from the extraction and transport of that copper in MIPS evaluation. With this “cradle to grave” approach, MIPS can be useful and in harmony with life cycle approaches. In addition, the term “service unit” has quite similar meaning with the “functional unit” in life cycle assessment studies. Considering FISSAC IS structure and defined constructional processes, MIPS will be beneficial for the decision makers to represent both direct and indirect material consumption in a sustainability frame.

In MIPS evaluation, material inputs are divided into 5 categories; [12]

- Abiotic raw materials
- Biotic raw materials
- Earth movements
- Water
- Air

Table 12 Resource categories in MIPS methodology

Resource Category	Definition
Abiotic Raw Materials	Mineral raw materials, fossil fuels, spoils (from mining activities and/or excavations)
Biotic Raw Materials	Plant biomass from cultivation, biomass from uncultivated areas counted as fresh mass (meat is reduced from plant biomass if it is not from wild animals)
Earth Movements	Mechanically moved soil (ploughing) or soil erosion
Water	Surface, ground and deep ground water (process or cooling water excluded)
Air	Oxygen molecules bonded in combustion, or chemical/physical transformation

MIPS also defines a number of “MI Factors” that can be used to evaluate the material inputs from earlier life cycle stages of a particular input, i.e. “ecological rucksack”. These factors are developed by Wuppertal Institute and cover majority of material types. Considering FISSAC processes, all MIPS resource categories are highly relevant due to the high amount of material consumption in construction works. Moreover, MIPS can be used to illustrate the difference of the material consumptions before and after the IS network generation both combining both direct and indirect consumptions (i.e., ecological rucksack).

Evaluation of MIPS includes 7 stages as below[11];

- Stage 1: Definition of aim, object and “service unit”
- Stage 2: Representation of the process chain
- Stage 3: Compiling of data
- Stage 4: Material input from cradle to product
- Stage 5: Material input from cradle to grave

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- Stage 6: Material input per unit service evaluation
- Stage 7: Interpretation of the results

Table 13 MIPS Calculation sheet

MIPS Calculation												
For process X												
			Abiotic Material		**Biotic Material**		**Earth movements**		**Water**		**Air**	
Name			MI-Factor	kg/unit	MI-Factor	kg/unit	MI-Factor	kg/unit	MI-Factor	kg/unit	MI-Factor	kg/unit
Substance/pre-product	Unit	Amount	kg/unit	Main product	kg/unit	Main product	kg/unit	Main product	kg/unit	Main product	kg/unit	Main product
Input A		A	MIa(A)	A * MIa(A)	MIb(A)	A * MIb(A)	MIe(A)	A * MIe(A)	MIw(A)	A * MIw(A)	MIair(A)	A * MIair(A)
Input B		B	MIa(B)	B * MIa(B)	MIb(B)	B * MIb(B)	MIe(B)	B * MIe(B)	MIw(B)	B * MIw(B)	MIair(B)	B * MIair(B)
Input C		C	MIa(C)	C * MIa(C)	MIb(C)	C * MIb(C)	MIe(C)	C * MIe(A)	MIw(C)	C * MIw(C)	MIair(C)	C * MIair(C)
∑ MIPS Value (kg/unit)				0,00		0,00		0,00		0,00		0,00

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3 EVALUATION SCOPE and OBJECTIVES

3.1 Scope of the Evaluation

The scope of the evaluation consists of testing platform features including modules validation, visual checks, key performance indicator calculation results covering all the functional and required tests for the fulfilment of end user expectations. During Task 6.5 based on the user tests, in addition to the available features, new features are added to enhance the usability and the flexibility of the platform.

In order to evaluate all of the items described above, a testing strategy involving different use case (scenarios) was prepared for a smooth assessment period. In that respect, as it can be seen from the figure below, general overview of testing activities is divided into three categories identifying the responsible team (who execute the test) in each step of testing activities.

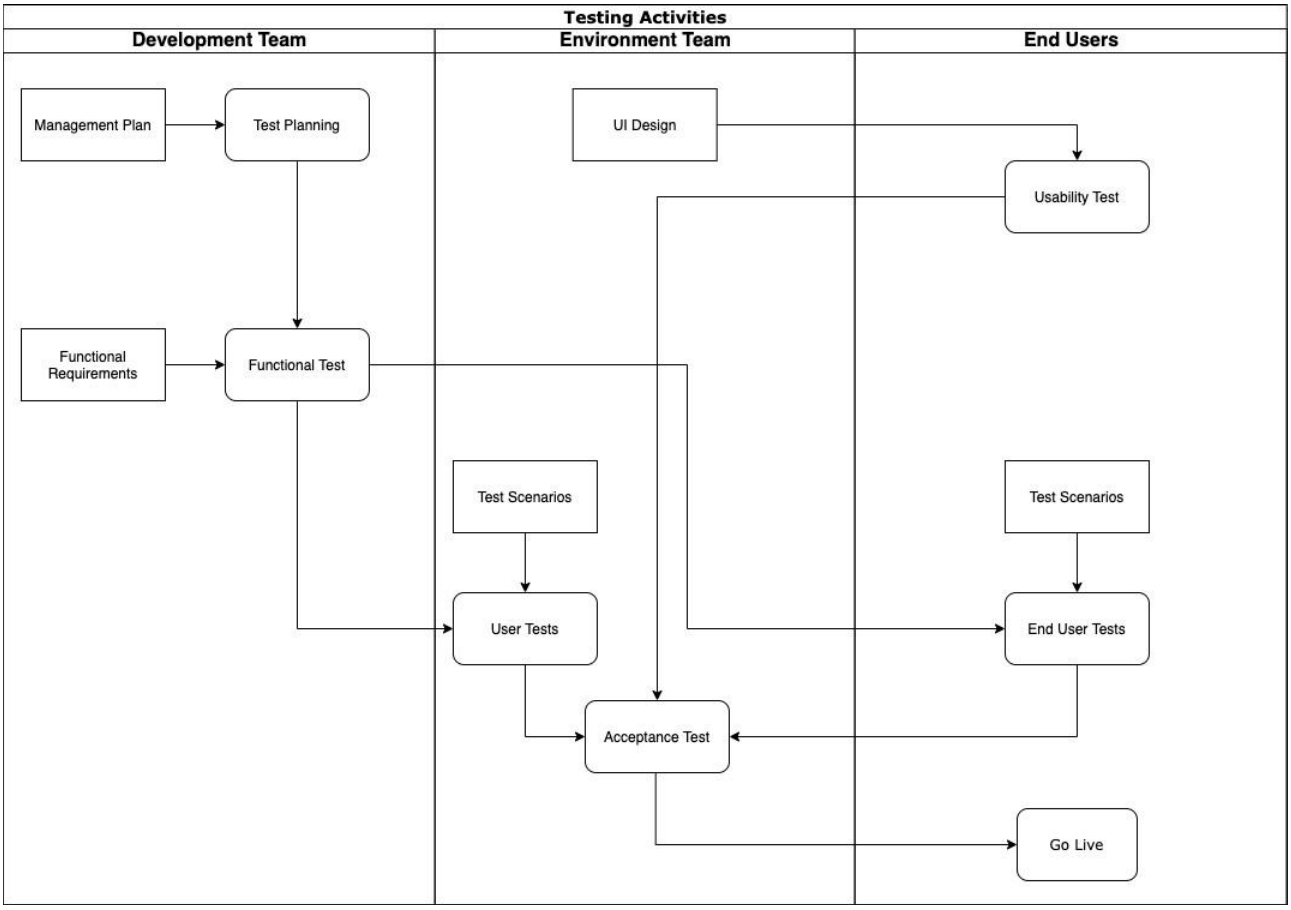

Figure 5 Testing Activities Flowchart

3.1.1 End User Tests

For the user tests we prepared a set of use cases that represent typical conditions under which the system should operate. These tests were performed with both internal and external testers. The reason that we have included our internal environment team is that it is important for testers to be familiar with both functional and non-functional requirements so they can better evaluate the system.

Beginning with the FISSAC IS Platform online test sessions, platform environmental analysis feature is validated throughout different steps. These steps include nine different scenarios to show the platform features and its application respecting bottom-up approach. The main objective of this online sessions is to

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capture different comments/feedbacks and evaluate the software modules and features from a different perspective.

There are seven external partners from FISSAC consortium selected according to their relevancy to the subject together with eleven internal domain experts. All the external users joined to private online session specific to each partner. Sessions have one-hour duration and completed by user on their own. The following information (Figure 6,Figure 7, Table 14 and Table 15) for Environmental KPIs Assessment were shared before the testing session to let the user familiar with the testing steps. In addition to that, all the internal and external testers were assisted during the online session.

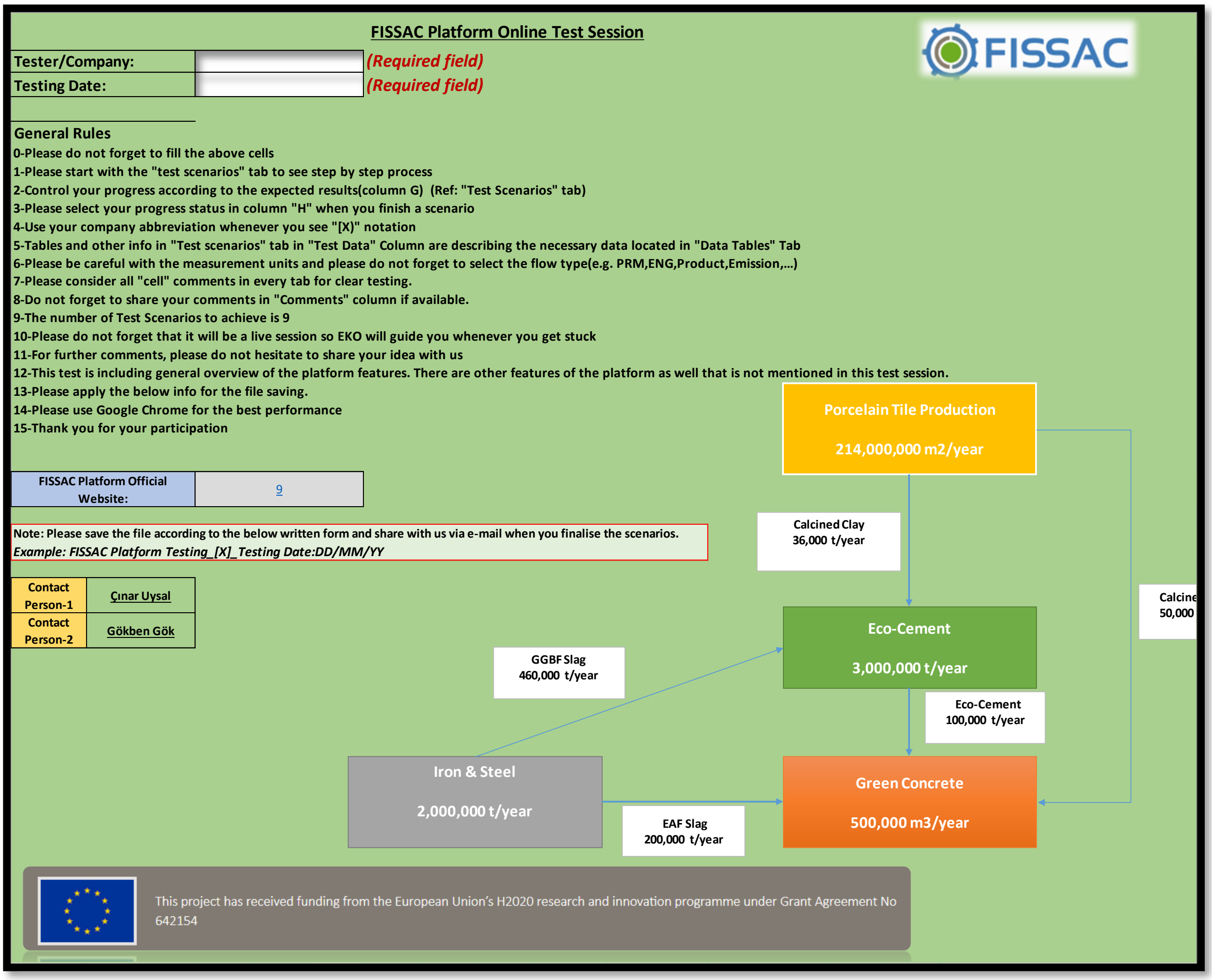

Figure 6 Online Test Session General Rules (Screenshot)

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Test Scenario ID	Test Scenario Name	Description	Location in the Platform	Test Steps	Test Data	Expected Results	Success(S) or Fail(F)	Comments
1	Login and Workspace	Login to Platform and Learn to Create New Work Space	-	1.Login to Fissac platform 2.Click Change Project 3.Click on add new workspace button(This is the "+" sign 4.Fill the all the required fields and click save button 5.Now you can see your newly created workspace 6.Click on newly created workspace(in Step 5) and continue with test scenario 2	http://is.fissacproject.eu/	Successful login and entering to the main page of the platform describing the FISSAC project coordinator, duration, framework and etc.	S F	
2	New Flow	Create a new Flow	Opportunity Assessment	1.Under opportunity assessment(Menu on the left), go to models-flows page 2.Click on Add new button (Plus sign "+") 3.Fill all required fields in General attributes(use test data:Column F) 4.Click on save button **(Only two flows will be added during the session. All other flows in Scenario 4 are already available in the FISSAC inventory so no need to add all flows in data tables tab)**	Table 1.1 "[X]_P_Tile" Flow and Table 1.2 - "[X]_GGBFS"	User should be able to see his/her flow added in flow list. (User can use advanced search or "my flows" filter option.)	S F	
3	Edit Flow	Addition of Unit Equivalency	Opportunity Assessment	Under Opportunity Assessment-Model-Flows Menu 1.Search for "[X]_P_Tile" in the advanced search field 2.Click on the flow then click the edit button to enter the edit screen 3.Add new unit equivalence(Use the Test data described in Column F) 4.Click on save button	Table 1.1 -Add Equivalence to "[X]_P_Tile" flow according to the comment stated in cell(G4)	User should be able to see "equivalent type" and "equivalent unit" inside the relevant flow.	S F	
4	Unit Process	Create a new Unit Process	Opportunity Assessment	1.Go to Opportunity Assessment-Models-Unit Processes Page 2.Click on the add new button ("+" sign) 3.Fill in all the required fields in general attributes window (Even NACE code are given) 4.Add all input and output described in test data from **FISSAC INVENTORY**. Do not forget to select functional unit as output flow. (Functional unit is the product of the process:e.g. in cement process, it is cement) 5.Click on save button(This saving option is only valid if the functional unit is entered)	Table 1.1/1.2/1.3/1.4	User should be able to see his/her unit process added in unit process list. (User can use advanced search or "my process" filter option.)	S F	
5	System Model	Create a new System Model	Opportunity Assessment	1.Go to Opportunity Assessment-Models-System Models Page 2.Click on the add new button ("+" Sign) 3.Fill in all the required fields in General Attributes 4.Add new Unit Process by using "+" sign according to the info in Table 2 of data tables tab of this excel 5.Select one of the outputs as functional output(scroll down and see the bottom of the screen to select the functional unit: it means the product) 6.Click on save button (	Table 2	User should be able to see his/her system model added in system model list. (User can use advanced search or "my models" filter option.)	S F	
6	Facility	Create a new Facility	Network Design and Assessment	1.Go to Network Design and Assessment-Assets-Facilities Page 2.Click on the add new button ("+" Sign) 3.Fill in all the required fields 4.Select System model (This is not Add System Model so you have to select your system model created in Scenario 5) 5.Click on save button (Now you are able to see the process flow overview of the facility) 6.Click Edit Button 7.Define the amount of production under "PRODUCTION" text 8.Click on save button again	Table 3	User should be able to see his/her facility in facility list. (User can use advanced search option.)	S F	
7	Network	Create a new Network	Network Design and Assessment	1.Go to Network Design and Assessment-Assets-Networks Page 2.Click on the add new button ("+" Sign) 3.Fill in all the required fields(Refer to Table 4) and press save button. 4.Click to edit button and Add Facilities (Refer to Table 4) 5.Define amounts for waste transfer under "Possible Waste Transfer Scenarios" with the help of "+" sign action button (Refer to Table 4) 6.Click on save button	Table 4	User should be able to see his/her network in network list. (User can use advanced search option.)	S F	
8	Analyses	Environmental KPI Evaluation	Analysis and Reports	1.Go to Analysis and Report-Analyses Page 2.Select System Model radio button 3.Select System Model Indicator Analyses Type 4.Select stated System Model(s) in Table 5 5.View the assessment results from the table below (In total, there are 5	Table 5 (Note:Please read carefully the description in cell "O31")	User should be able to see the selected KPI(s) result(s) as described in Table 5.	S F	
9	Analyses Verification	Validation of KPI results	-	1.Check all the results in Table 5(Cell N27 to N31) validating the the previous steps as correct 2.If your results match with ours, **CONGRATULATIONS! Now you are familiar with some of main features of FISSAC Platform.**	Table 5 and Other Result Tabs (Results1-Results2-Results3)	The user results obtained during Scenario 8 should match with the results stated in Table 5	S F	

Figure 7 Scenarios and Testing Steps (Screenshot)

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Table 14 Unit Process Data for Testing Session

Table 1.1:Porcelain Tile Production (Unit Process Name: [X]_Tile) (NACE:23.4)							
Input				**Output**			
Flow Name	**Type**	**Amount**	**Unit**	**Flow Name**	**Type**	**Amount**	**Unit**
Clay	PRM	22.6	kg	[X]_P_Tile	Product	1	m2
Glazing	PRM	0.73	kg	CO2	Emission	3.28	kg
Natural Gas	ENG	1.83	m3	CH4	Emission	0.0000001	kg
Electricity	ENG	1.97	kWh	HSW	Hazardous Solid Waste	0.00276	kg
				Calcined Clay	By-product	3	kg
Table 1.2:Eco Cement Production (Unit Process Name: [X]_Cement) (NACE:23.51)							
Input				**Output**			
Flow Name	**Type**	**Amount**	**Unit**	**Flow Name**	**Type**	**Amount**	**Unit**
Clinker	PRM	0.7	t	Cement	Product	1	t
Gypsum	PRM	0.04	t				
Calcined Clay	SRM	0.06	t				
[X]_GGBFS	SRM	0.2	t				
Table 1.3:Iron and Steel Production (Unit Process Name: [X]_Iron) (NACE:24.10)							
Input				**Output**			
Flow Name	Type	Amount	Unit	**Flow Name**	**Type**	**Amount**	**Unit**
Pig Iron	PRM	0.03	kg	Liquid Steel	Product	1	kg
Graphites Electrodes	PRM	0.004	kg	EAF Slag	By-product	0.152	kg
Scrap Iron	PRM	1.053	kg	[X]_GGBFS	By-product	0.229	kg
Energy	ENG	1.822	MJ	CO2	Emission	0.093	kg
Table 1.4:Green Concrete Production (Unit Process Name: [X]_Concrete) (NACE:23.63)							
Input				**Output**			
Flow Name	**Type**	**Amount**	**Unit**	**Flow Name**	**Type**	**Amount**	**Unit**
Cement	PRM	0.30	t	Concrete	Product	1	m3
Fine Aggregate	PRM	0.60	t	PM10	Emission	0.01925	kg
Coarse Aggregate	PRM	0.12	t	PM2.5	Emission	0.01925	kg
Water	PRM	0.145	t				
Electricity	ENG	321.86	kWh				
EAF Slag	SRM	1	t				
Calcined Clay	SRM	0.15	t				

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Table 15 Other Data Required for Testing Session (Screenshot)

Table 2:System Model	
System Model Name(To be Created)	Unit Process To be Used
[X]_SM1	[X]_Tile
[X]_SM2	[X]_Cement
[X]_SM3	[X]_Iron
[X]_SM4	[X]_Concrete

Abbreviations	
PRM	Primary Raw Material
SRM	Secondary Raw Material
ENG	Energy

Table 3:Facility			
Facility Name(To be Created)	System Model To be Used	Info	Production Amount
[X]_Fac1	[X]_SM1	Tile Producer	214,000,000 m2/year
[X]_Fac2	[X]_SM2	Eco-Cement Producer	250,000 t/month
[X]_Fac3	[X]_SM3	Iron and Steel Producer	2,000,000 t/year
[X]_Fac4	[X]_SM4	Green Concrete Producer	500,000 m3/year

Table 4:Network (Include:Fac1_Test, Fac2_Test, Fac3_Test, Fac4_Test)				
Network Name(To be Created)	Facility Relations	By-Product for Symbiosis	Amount of By-product Demand	
[X]_FISSAC ECOpark	[X]_Fac1 to [X]_Fac2	Calcined Clay	3,000 t/month	**Network Type:** Dependent **Data Sharing:** Yes
	[X]_Fac1 to [X]_Fac4	Calcined Clay	50,000 t/year	
	[X]_Fac2 to [X]_Fac4	Eco Cement	100,000 t/year	
	[X]_Fac3 to [X]_Fac2	[X]_GGBFS	460,000 t/year	
	[X]_Fac3 to [X]_Fac4	EAF Slag	200,000 t/year	

Table 5:Analyses					
Type	System Model Indicator Analyses	Indicator Name/KPI Name	System Model(s)	Result Obtained	Description
Environmental KPIs Assessment	Material Consumption	Primary Raw Material Intensity(per quantity)	[X]_SM4	1.17	Green Concrete Production
	Energy Consumption	Total Thermal Energy Consumption	[X]_SM1	19.45	Porcelain Tile Production
	Air Emissions	Total GHG Emissions	[X]_SM1	7.79	Porcelain Tile Production
	By-Products Generation	By-Products Generation Intensity(per quantity)	[X]_SM3	0.381	Iron and Steel Production
	Material Consumption	All Available	[X]_SM2 and Cement Production (Baseline)	See "Results" Tabs	**2 system models will be selected and compared accordingly**

Test scenarios were prepared in a way that user will find out how to apply in various modules of the platform after finishing all the steps. Table 16 is describing this strategy implemented for every scenario generated. In addition to that, general insight related to the applications of the platform like saving, requesting a data, searching, filtering, transition of the pages, user intentions/activities etc. were investigated by EKO during the online testing sessions.

Table 16 Objectives of Scenarios (in terms of Internal Testers Perspective)

Scenario No	Short Description	Main Ambition
1	Login to Platform and Learn to Create New Work Space	This scenario is for registered user that let the sign in to the platform and create a new private portfolio without any technical and visual problems (icons, colours, linkage, comprehensive visuals, etc.)
2	Create a new Flow	The primary concern is to let user understand how to create a flow and attribute equivalent unit .
3	Addition of Unit Equivalency	
4	Create a new Unit Process	This section is the building stone of the process design. User will capture how to add a unit process/system model together with type of input and output flows as well as selection of a functional unit, NACE and other platform terminologies.
5	Create a new System Model	
6	Create a new Facility	This is one of the crucial scenario enabling a producer company creation with the support of Scenario 4 and Scenario 5. In this module, user will learn how to add a facility allocated with its unique system model, its general attributes (like Address, year of establishment, etc.) and production amount in monthly or yearly based.
7	Create a new Network	This scenario is the last step of an eco-industrial park design combining the facilities that user created during the previous

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		steps. User is gathering all four facilities in one single environment (called Network). User is able to observe the matchmaking of the platform prompting different transfer scenarios between facilities.
8	Environmental KPI Evaluation	These scenarios are the ultimate tasks revealing the power of environmental analysis via KPIs evaluations whether user were succeeded during previous scenarios(entering the proper input/output value, etc.) and are able to check their results according to the outputs stated in Table 15.
9	Validation of KPI results	

Following table (Table 17) is arranged in order to describe the aim of the each screenshot used during online testing session:

Table 17 Testing Template Divisions and Their Descriptions

Figure/Table #	Description
Figure 6	This section is used for the announcement of general rules of the testing period including two required field entry such as "Name" and "Date". In this figure, the network that will be established during the session is shown at the bottom right of the screen which is relevant with FISSAC Use Cases in a way.
Figure 7	This figure is the second page(tab) of the testing guideline. In this section, testing steps are arranged according to the sequence order. Every scenario has its own data application which is mentioned in the steps list. The location in the software platform is also stated here to facilitate the flow of scenarios. The last two columns are used and filled by testers. Column 8 from left is prompting the success or fail status of the scenario which is validated according to the results written in Column 7. In addition to that, column 9 is used for any kind of comments or suggestions or feedback related to the respective scenario (same row)
Table 14	There are four tables describing four unit processes that will be used during the initial design stages of the four facilities. (These are Cement Producer, Porcelain Tile Producer, Concrete Producer, Iron and Steel Producer)
Table 15	This figure is describing the system models, facilities and network to be established. Moreover, there are 5 different KPIs analysis results including a comparison section to finalize the test scenarios. At last, the user can validate their results with the excel file results.

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In MIPS platform testing, a conceptual cement production system model (SM) has been selected to work on. MIPS indicator has been tested internally by EKO colleagues. In the test, user is directed to;

- Login and select system model conceptual "Cement Production"
- Check inputs as
  - Blast Furnace Slag
  - Calcined Clay
  - Gypsum
  - Clinker
- Select "Analysis" module and check "System model"
- Select "MIPS" on the dropdown menu
- Select pre-defined system model
- Pick appropriate MIPS Flow and MI Factors for every input
- Check the results of each MIPS category

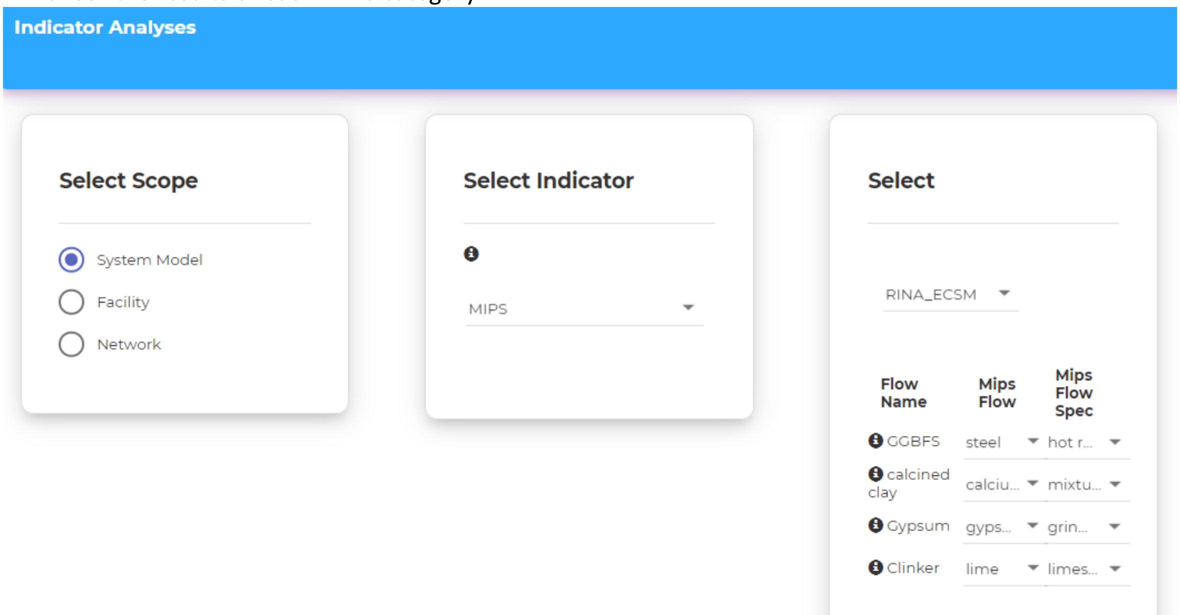

Figure 8: MIPS Analysis Platform Interface for testing

For economic indicators' testing, a conceptual facility has been created to work on. Economic KPIs consist of three major indicator set of product quantity, turnover and net value added.

Economic indicator has been tested internally by EKO colleagues. In the test, user is directed to;

- Login and select system model conceptual "facility"
- Check inputs from "facility costs" tab as
  - Turnover
  - Net value added
- Select "Analysis" module and check "facility"
- Select "Economic" on the dropdown menu
- Select pre-defined facility
- Check the results of each Economic indicator category

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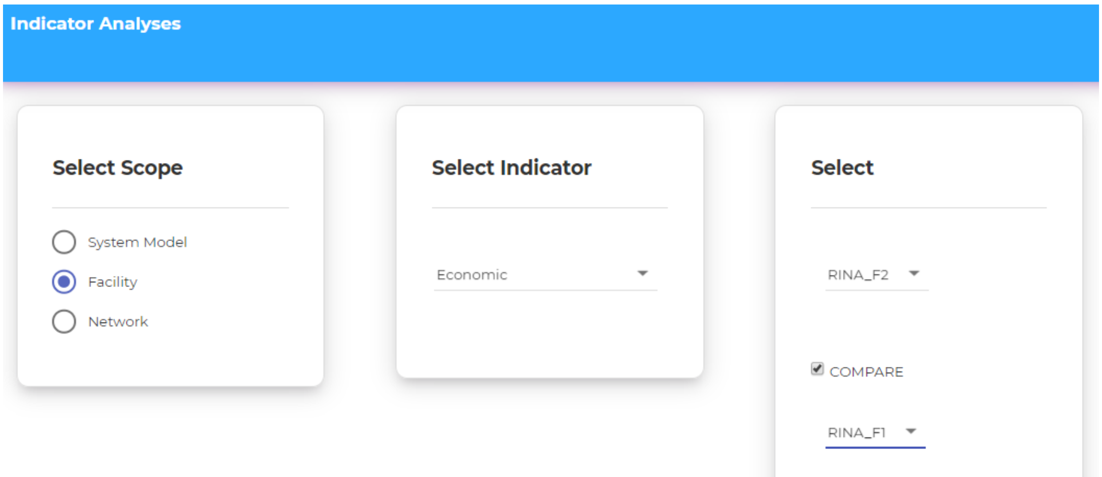
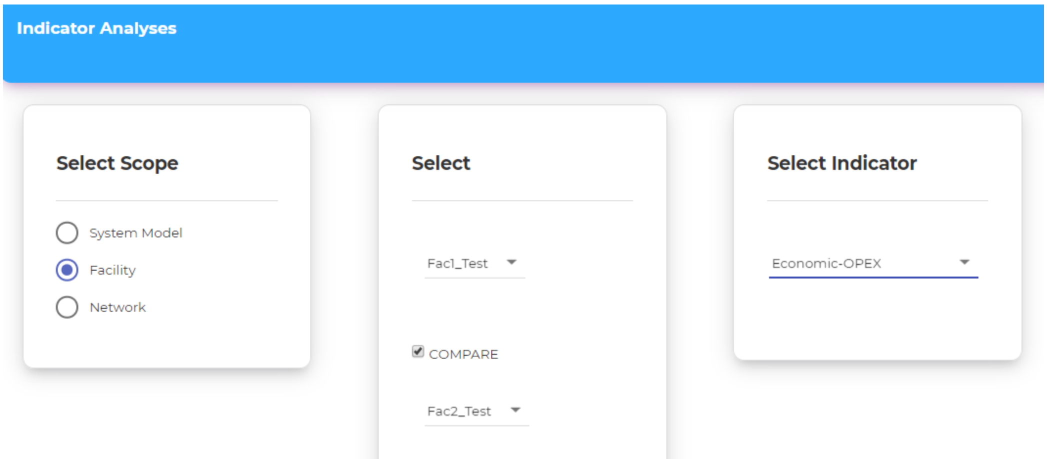


Figure 9: Economic Analysis Platform Interface for testing

For economic OPEX indicators' testing, a conceptual facility has been created to work on. Economic OPEX KPIs consist of a set of indicators including material cost, water cost, labour cost, energy cost, maintenance cost and land use cost.

Economic OPEX indicator has been tested internally by EKO colleagues. In the test, user is directed to;

- Login and select system model conceptual "facility"
- Check inputs from "facility costs" tab with regard to relevant cost items
- Select "Analysis" module and check "facility"
- Select "Economic OPEX" on the dropdown menu
- Select pre-defined facility
- Check the results of each Economic indicator category



For NPV indicator testing, a conceptual facility has been created to work on. NPV indicator has been tested internally by EKO colleagues. In the test, user is directed to;

- Login and select system model conceptual "facility"
- Check inputs from "facility costs" tab with respect to relevant cost items
- Select "Analysis" module and check "facility"
- Select "NPV" on the dropdown menu
- Select pre-defined facility
- Check the results of each NPV row and the graphical representation

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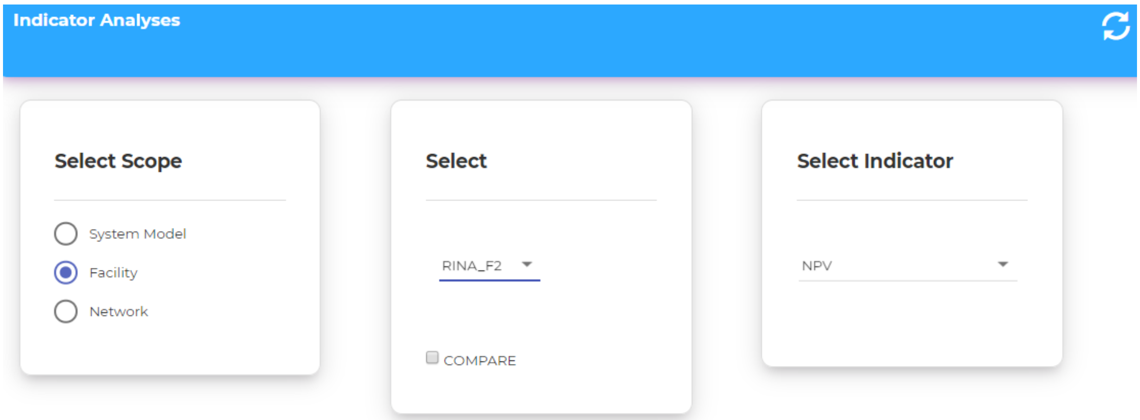

Figure 10: Economic OPEX Analysis Platform Interface for testing

3.1.2 Functional Test

The objective of performing functional test is to assure the quality of the main features of the platform. It simply tests the functions of the software. The test cases for these functional tests contains the following attributes. Test cases were prepared with respect to the requirements defined in deliverable 6.1, SRS Report. (Table 18)

Table 18 Attributes of the Test Cases

Attributes	Description
Name	Name of the scenario
Input	Input data
Oracle	Expected Test Results
Log	Output Produced by the Test

To briefly list, the items that are controlled during the functional testing period,

- User accessibility to all pages and functionalities
- Ease of Use (e.g. readable content, Colours used in the modules, Text Fonts, etc.)
- Error message screen (checking whether suitable error messages are prompted)
- General functionalities (e.g.)

In order to satisfy the list above, a manual testing approach was used to test the software against the specifications. The tests covered not only the main functions of the application but also measured the applicability of the software. Tests were prepared with respect to the requirements and the following methodology was used to validate them.

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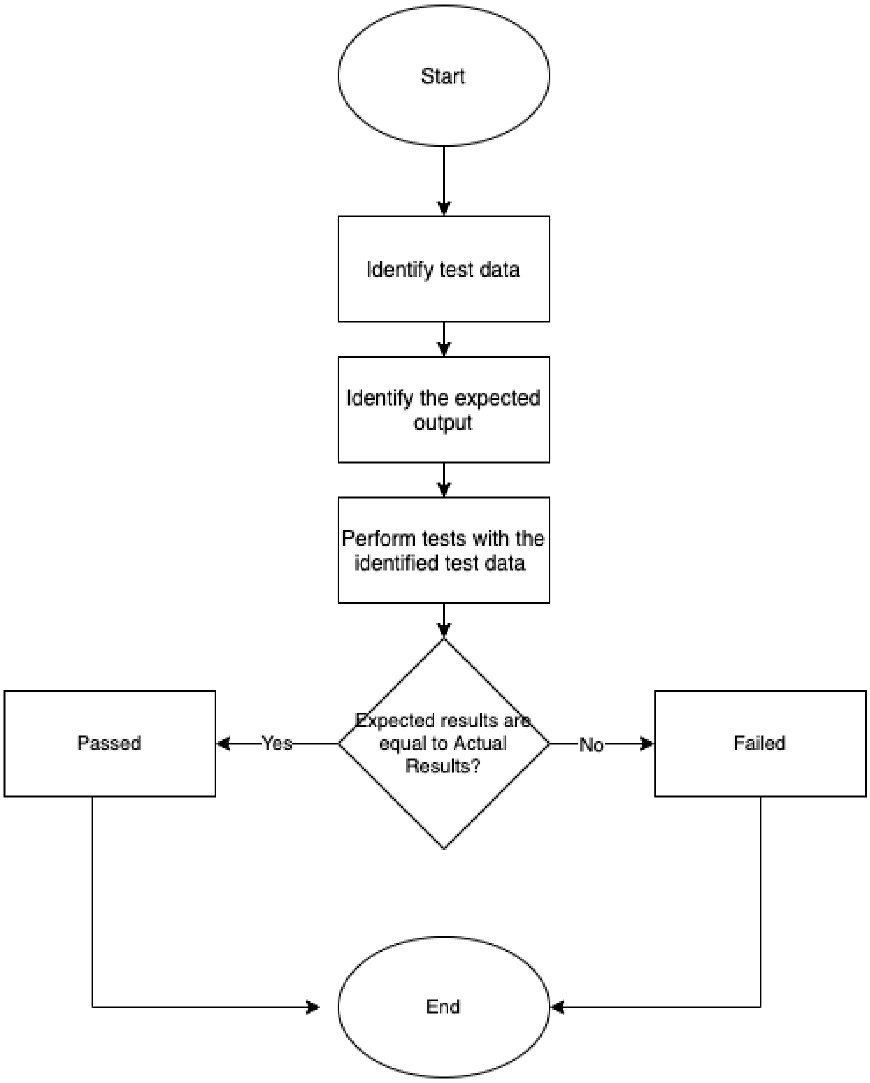

Figure 11 Manual Testing Methodology Flowchart

3.2 Evaluation Results

3.2.1 Environmental Test Outputs

During the different sessions of FISSAC Online Testing Session, there are 23 testers in total either internally or externally evaluating the platform with respect to the testing scenarios. The detailed information on these scenarios is already provided in section 3.1.1. Evaluation results were collected with the help of Figure 7 and minutes were taken during live sessions. Arguments and comments acquired during this period are quite vital to elaborate the status of the platform both technically and visually.

Table 19 is describing the information (the number of person involved and other details as well.) about the external testers who attend to the online testing sessions.

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Table 19 Online Test Sessions Info for Environmental KPIs

Tester Abbreviation	# of Person Involved	Received Feedback Status	Testing Date
ACC	2	-	20.12.2019
RINA	1	✓	20.12.2019
SYM	1	✓	10.01.2020
TEC	2	✓	10.01.2020
GEO	1	✓	23.01.2020
GTS	2	✓	23.01.2020
RISE	1	-	23.01.2020
TCMA	2	✓	24.01.2020
EKO	11	✓	December 2019-January 2020

Apart from EKO, which is considered as "Internal Tester", all the other firms are considered as "External Tester". Following tables shows the rate of completion as well as the success amount along 9 scenarios operated during the sessions. (see Table 20 and Table 21) During the online testing sessions, major issues together with new items for the sake of platform advancement are revealed and stated in Table 22.

Table 20 Internal Tester Success and Completion Rates

User No	Completed	Success	Complete Ratio	Overall Success*
1	+	+	9/9	Yes
2	+	+	9/9	Yes
3	+	-	7/9	No
4	+	+	9/9	Yes
5	+	+	9/9	Yes
6	+	+	9/9	Yes
7	+	+	9/9	Yes
8	+	-	8/9	No
9	+	+	9/9	Yes
10	+	+	9/9	Yes
11	+	+	9/9	Yes

*Overall success means that testers are completed the test scenarios without having any issues

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Table 21 External Tester Success and Completion Rates

User No	Completed	Success	Complete Ratio	Overall Success
1	+	+	9/9	Yes
2	+	+	9/9	Yes
3	+	+	9/9	Yes
4	+	+	9/9	Yes
5	+	+	9/9	Yes
6	+	+	9/9	Yes
7	+	?	8/9	Incomplete
8	+	?	8/9	Incomplete

Table 22 Major Findings during Testing Sessions

No	Problem Category	Problem Definition
1	New Request	Tutorial videos has been prepared and linked with platform help section
2	Visual	Some of the generic functionalities (e.g. Workspace, Menu Transition, GUI, etc.) has been modified for more user-friendly screens
3	Visual	Process flow diagram schemes are updated
4	Visual	Unused buttons and links are removed
5	Logic	Some of the mathematical notations are updated
6	Bug	User is now able to delete his/her own facility
7	New Request	Searching and filtering options are improved
8	New Request	Platform data loading period is shorten
9	Visual	“Required field” option are added to all relevant screen
10	New Request	Creation of symbiosis relation customization in network module is improved
11	Logic	External validation of environmental KPIs are initiated (on-going activity)
12	Logic	User permission-role matrix is re-arranged.
13	Visual	So many minor but useful corrections are made.
14	New Request	Dictionary has been prepared and linked with top bar.
15	New Request	Dashboard is made main page.
16	New Request	Survey has been prepared and linked with top bar.
17	New Request	How to use page is added and linked with platform help section.
18	New Request	About page is prepared and added to the side bar.
19	Visual	Buttons and switches on Facility, System Model, Flow Processes, Unit Processes and Networks pages are designed.
20	New Request	Facility analysis is added.

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3.2.2 Economic Test Outputs

In this section economic test results will be represented. Economic tests have been completed internally by producing conceptual system models and facilities within the platform.

Economic test results is shown as below,

	RINA_TSM	RINA_ECSM
Product Quantity		
Total product quantity	5000000m2	3000000ton
Increase or decrease in total product quantity	2000000.00	
Relative change of increase or decrease in total product quantity	%	
Turnover		
Total turnover	47 €	50 €
Increase or decrease in total turnover	-3.00	
Relative change of increase or decrease in total turnover	-6.38 %	
Net Value Added		
Total net value added	35 €	38 €
Increase or decrease in total net value added	-3.00	
Relative change of increase or decrease in total net value added	-8.57 %	

Figure 12: Economic Testing results

Economic OPEX test results is shown as below,

Figure 13: Economic OPEX Analysis Platform Interface for testing

Indicator	SM1	SM2
Material Cost		
Total material cost	0 €	25.4816 €
Specific material cost	0 €	0.73 €
Increase or decrease in total material cost	-0.73 €	
Relative change of increase or decrease in total material cost	-Infinity %	
Relative change in specific material cost	-Infinity %	
Water Cost		
Total water cost	0 €	0 €
Specific water cost	0 €	0 €
Increase or decrease in total water cost	0.00 €	
Relative change of increase or decrease in total water cost	NaN %	
Relative change in specific water cost	NaN %	

Figure 14: Economic OPEX Testing results

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Energy Cost		
Total energy cost	0.4925 €	0 €
Specific energy cost	0.01 €	0 €
Increase or decrease in total energy cost	0.49 €	
Relative change of increase or decrease in total energy cost	100 %	
Relative change in specific energy cost	100 %	
Land use Cost		
Total land use cost	NaN €	1222 €
Specific land use cost	0 €	34.91 €
Increase or decrease in total land use cost	NaN €	
Relative change of increase or decrease in total land use cost	-Infinity %	
Relative change in specific land use cost	-Infinity %	

Figure 15: Economic OPEX Testing results (Continued)

Total labour cost	NaN €	2000 €
Specific labour cost	0 €	57.14 €
Increase or decrease in total labour cost	NaN	
Relative change of increase or decrease in total labour cost	-Infinity %	
Relative change in specific labour cost	-Infinity %	
Maintenance Cost		
Total maintenance cost	NaN €	700 €
Specific maintenance cost	0 €	20 €
Increase or decrease in total maintenance cost	NaN	
Relative change of increase or decrease in total maintenance cost	-Infinity %	
Relative change in specific maintenance cost	-Infinity %	
Total Operational Cost (OPEX)		
Total operational cost	3.4925 €	28.4816 €
Specific operational cost	0.09 €	0.81 €
Increase or decrease in total operational cost	-24.99	
Relative change of increase or decrease in total operational cost	-715.51 %	

Figure 16: Economic OPEX Testing results (Continued)

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NPV test results is shown as below

NPV Calculation

Year	TOTAL	Discount Factor	NPV	NPV(Yearly)
0	€ -8600.00	€ 1.00	€ -8600.00	€ -8600
1	€ 2650.00	€ 0.98	€ 2585.37	€ -6014.63
2	€ 2650.00	€ 0.95	€ 2522.31	€ -3492.33
3	€ 2650.00	€ 0.93	€ 2460.79	€ -1031.54
4	€ 2650.00	€ 0.91	€ 2400.77	€ 1369.23
5	€ 2800.00	€ 0.88	€ 2474.79	€ 3844.02
TOTAL NPV: € 3844.02				

Figure 17: NPV Testing results

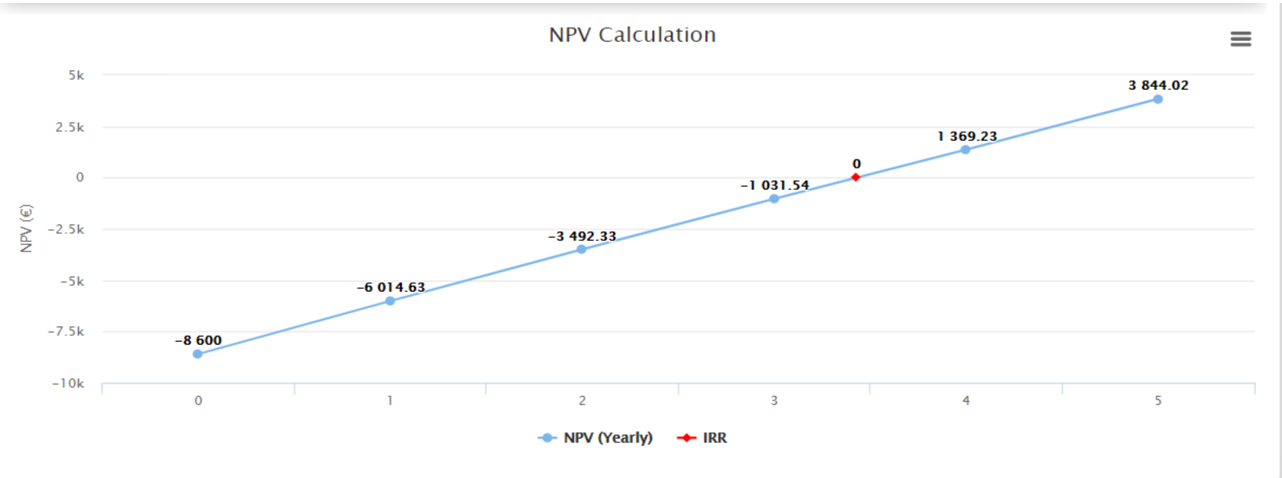

Figure 18: NPV graphical representation

3.2.3 Network Test Outputs

In the test processes, an established network was analysed to see wheter platform can quantify the network indicators. According to the results compared to pre-calculated values, only one minor issue were identified in calculating of network indicators. This minor problem sourced from betweenness centrality calculation and is fixed, tested and validated respectively.

3.2.4 MIPS Test Outputs

After selecting relevant MIPS flows with required MI Factors, the platform will automatically evaluate the MIPS results below the selection pane. The results of the sample MIPS analysis will be as follows,

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MIPS Calculation

Name	Abiotic Material	Biotic Material	Earth movements	Water	Air
GGBFS	1.702	0	0	14.962000000000002	0.098
calcined clay	0.32880000000000004	0	0	2.355	0.1314
Gypsum	0.0732	0	0	0.41200000000000003	0.0024
Clinker	1.722	0	0	8.155	0.063
Total:	3.826	0	0	25.884	0.2948

Figure 19: MIPS Testing results

3.2.5 Functional Test Results

We have used the following requirement traceability matrix to validate that all requirements are tested during the tests and to ensure no functionality is left unchecked.

- FSC=FISSAC
- M=Module
- SM=Sub module
- FR=Functional Requirements

Table 23 Requirements Traceability Table

Requirement ID	Requirement Description	Test Results
FSC.M1.SM1.FR1	Creating New Network	**Pass**
FSC.M1.SM1.FR2	Deleting Existing Network	**Pass**
FSC.M1.SM1.FR3	Editing Existing Network	**Pass**
FSC.M1.SM1.FR4	Changing Network Type	**Pass**
FSC.M1.SM1.FR5	Changing Data Sharing Preferences of Network	**Pass**
FSC.M1.SM1.FR6	Assigning Network Manager	**Pass**
FSC.M1.SM1.FR7	Assigning Symbiosis Experts	**Pass**
FSC.M1.SM1.FR8	Validating Assigned Experts	**Pass**
FSC.M1.SM2.FR1	Creating New User	**Pass**
FSC.M1.SM2.FR2	Deleting Existing User	**Pass**
FSC.M1.SM2.FR3	Editing Existing User	**Pass**
FSC.M2.SM1.FR1	Enabling data inputting section in an appropriate format	**Pass**
FSC.M2.SM1.FR2	Inputting data using appropriate screens	**Pass**
FSC.M2.SM1.FR3	Validation of quality and format according to format standard defined by platform	**Pass**
FSC.M2.SM2.FR1	Changing security options from provided interfaces	**Pass**
FSC.M3.SM1.FR1	Listing symbiosis models	**Pass**
FSC.M3.SM1.FR2	Creating required symbiosis models	**Pass**
FSC.M3.SM1.FR3	Viewing details of selected symbiosis model	**Pass**
FSC.M3.SM1.FR4	Updating details of selected symbiosis model	**Pass**
FSC.M3.SM1.FR5	Managing system models and inner symbiosis models of selected symbiosis model	**Pass**
FSC.M3.SM1.FR6	Saving design work as a design in platform data inventory	**Pass**
FSC.M3.SM2.FR1	Listing assembly models	**Pass**

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FSC.M3.SM2.FR2	Creating required assembly models	**Pass**
FSC.M3.SM2.FR3	Viewing details of selected assembly model	**Pass**
FSC.M3.SM2.FR4	Updating details of selected assembly model	**Pass**
FSC.M3.SM2.FR5	Managing unit processes of selected assembly model	**Pass**
FSC.M3.SM2.FR6	Saving design work as a design in shared inventory	**Pass**
FSC.M3.SM3.FR1	Listing flows	**Pass**
FSC.M3.SM3.FR2	Creating new flows according to inventory permissions	**Pass**
FSC.M3.SM3.FR3	Deleting selected flows according to inventory permissions	**Pass**
FSC.M3.SM3.FR4	Filtering huge amount of flows by location, flow type etc. rapidly	**Pass**
FSC.M3.SM3.FR5	Viewing details of selected flow	**Pass**
FSC.M3.SM3.FR6	Updating details of selected flow according to inventory permissions or saving as a new flow	**Pass**
FSC.M3.SM3.FR7	Manage equivalent quantities for selected flow. It means replaceable amount, unit pairs for flow definition	**Pass**
FSC.M3.SM4.FR1	Listing processes	**Pass**
FSC.M3.SM4.FR2	Creating new processes according to inventory permissions	**Pass**
FSC.M3.SM4.FR3	Deleting selected process according to inventory permissions	**Pass**
FSC.M3.SM4.FR4	Viewing details of selected process	**Pass**
FSC.M3.SM4.FR5	Updating details of selected process according to inventory permissions or saving as a new process	**Pass**
FSC.M3.SM4.FR6	Managing input and output flows and their amount to model something more appropriately	**Pass**
FSC.M3.SM5.FR1	Listing measurement units	**Pass**
FSC.M3.SM5.FR2	Creating new unit	**Pass**
FSC.M3.SM5.FR3	Deleting units	**Pass**
FSC.M3.SM5.FR4	Viewing details of selected unit	**Pass**
FSC.M3.SM5.FR5	Updating details of selected unit including conversions	**Pass**
FSC.M4.SM1.FR1	List opportunity models	**Pass**
FSC.M4.SM1.FR2	Looking for a new opportunity model	**Pass**
FSC.M4.SM1.FR3	View opportunity model	**Pass**
FSC.M4.SM1.FR4	Create an opportunity model	**Pass**
FSC.M4.SM1.FR5	Update an opportunity model	**Pass**
FSC.M4.SM1.FR6	Delete an opportunity model	**Pass**
FSC.M4.SM1.FR7	Identifying matching among facilities according to the facility typology	**Pass**
FSC.M4.SM1.FR8	Analyse matching	**Pass**
FSC.M4.SM1.FR9	Identify relevant norms, guidelines, standards, barriers related to the identified matching opportunities in terms of technological / non technological issues	**Fail (not implemented)**
FSC.M4.SM1.FR10	Identify relevant norms, guidelines, standards, barriers related to location of identified facilities	**Fail (not implemented)**
FSC.M4.SM1.FR11	Suggest proper price	**Fail (not implemented)**
FSC.M4.SM1.FR12	Sharing opportunity model for feedback	**Fail (data not available)**
FSC.M4.SM1.FR13	Giving feedback about the opportunity model	**Fail (data not available)**
FSC.M4.SM1.FR14	Confirm the opportunity model	**Pass**

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FSC.M4.SM1.FR15	Publishing result reports	**Fail (not implemented)**
FSC.M4.SM1.FR16	Notify matching opportunities identified	**Pass**
FSC.M4.SM2.FR1	View notifications	**Pass**
FSC.M4.SM2.FR2	List matching opportunities	**Pass**
FSC.M4.SM2.FR3	Select a matching opportunity from the list	**Pass**
FSC.M4.SM2.FR4	Remove an opportunity from the list	**Fail (not implemented)**
FSC.M4.SM2.FR5	Refine a matching opportunity	**Pass**
FSC.M4.SM2.FR6	Using a confidential messaging system for communicating with selected facility	**Pass**
FSC.M4.SM2.FR7	Confirm the engagement	**Failed (Obsolete)**
FSC.M4.SM2.FR8	Transaction	**Failed (Obsolete)**
FSC.M4.SM2.FR9	View the engagement	**Failed (Obsolete)**
FSC.M4.SM2.FR10	View the transaction	**Failed (Obsolete)**
FSC.M5.SM1.FR1	Viewing KPIs and sustainability metrics	**Pass**
FSC.M5.SM2.FR1	Comparing and benchmarking assembly / symbiosis models according to KPIs and metrics	**Pass**
FSC.M5.SM2.FR2	Performances are needed to be measured before IS and after IS. Using different symbiosis models for each. It will provide meaningful results for decisions of IS model defined in FISSAC	**Pass**
FSC.M5.SM3.FR1	Publishing reports	**Failed (Obsolete)***
FSC.M5.SM3.FR2	Sharing reports	**Failed (Obsolete)***
FSC.M5.SM3.FR3	Viewing published reports	**Failed (Obsolete)***
FSC.M5.SM3.FR4	Viewing published and shared if shared with user	**Failed (Obsolete)***

*Functional requirements involved in FSC.M5.SM4 features are no longer available since platform itself can prompt and allow every authorized data to be ready to evaluate in “Analysis” section freely. In that respect, all the outputs can be seen as real-time based so report publishing and/or sharing options are no longer needed. Due to this reason, all the previously identified functional requirements cancels out respectively.

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4 IS NETWORK VALIDATION with FISSAC PLATFORM

In this section, FISSAC platform analysis abilities have been implemented on FISSAC IS network and the results are represented. All figures in this section are taken from FISSAC IS Platform. Real case studies in FISSAC industrial network are;

- Porcelain Tiles
- Eco-cement production
- Ready mix concrete production
- Salt slag recovery
- Natural stone
- Iron and Steel

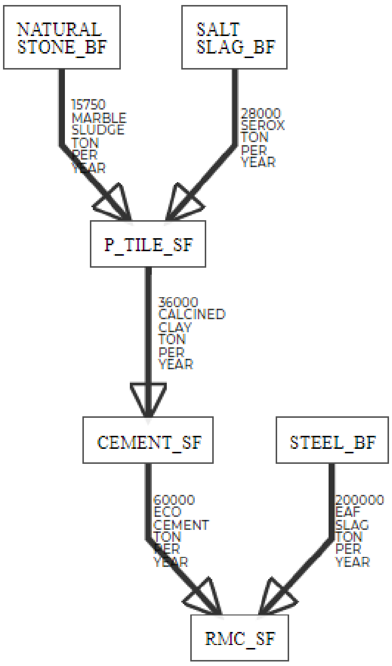

Figure 20: FISSAC IS Network flowchart

Environmental analysis results of the scenarios;

Primary Raw Materials (PRM) **(Yearly Based)**	**P_Tile_SS**
Total PRM consumption	293520000.00 kg/year
PRM intensity (Specific PRM consumption)(per quantity)	24.46 kg/kg

Figure 21: PRM Results of Porcelain tile production

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Secondary Raw Materials (SRM) (Yearly Based)	
Total SRM consumption	22560000.00 kg/year
SRM intensity (Specific SRM consumption)(per quantity)	1.88 kg/kg
SRM intensity (Specific SRM consumption)(per turnover)	22560000.00 kg/€
SRM intensity (Specific SRM consumption)(per net value added)	22560000.00 kg/€

Figure 22: SRM Results of Porcelain tile production

THERMAL ENERGY	
Total thermal energy consumption	288600000.00 kWh
Thermal energy intensity (Specific thermal energy utilization) (per quantity)	24.05 kWh/m2

Figure 23: Thermal Energy Consumption Results of Porcelain tile production

ELECTRICITY	
Total electricity consumption	35160000.00 kWh
Electricity intensity (Specific electricity consumption) (per quantity)	2.93 kWh/m2

Figure 24: Electricity Consumption Results of Porcelain tile production

By-products (Yearly Based)	Steel_BS
Total by-product generation	285 kg /year
By-product generation intensity (per quantity)	0
By-product generation intensity (per turnover)	0.04071 kg/€
By-product generation intensity (per net added value)	0.0475 kg/€

Figure 25: By Products results of Iron and Steel production

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Primary Raw Materials (PRM) **(Yearly Based)**	**RMC_SS**	**RMC_BS**
Total PRM consumption	253680.00 ton/year	463000.00 ton/year
PRM intensity (Specific PRM consumption)(per quantity)	1.27 ton/ton	2.31 ton/ton
PRM intensity (Specific PRM consumption)(per turnover)	10.15 ton/€	23.15 ton/€
PRM intensity (Specific PRM consumption)(per net value added)	12.68 ton/€	25.72 ton/€
Increase or decrease in total PRM consumption	209320.00 ton	
Absolute change in PRM substitution	209320.00 ton	
Relative change of PRM substitution	82.51 %	
PRM efficiency	182.51 %	

Figure 26: Is scenario comparison PRM results of Ready Mix Concrete

GHG(Greenhouse Gases) Emissions **(Yearly Based)**	**P_Tile_SS**
Total GHG(Greenhouse Gases) emissions	80004000 kgC02Eq
GHG(Greenhouse Gases) emissions from electricity consumed and purchased	10404000 kgC02Eq

Figure 27: GHG emissions results of porcelain tile production

Solid Waste Generation **(Yearly Based)**	**P_Tile_BS**
Hazardous Solid Wastes (HW)	
Total HW generation	33120 kg
HW generation intensity (Specific HW generation) (per quantity)	0.0028 kg/m2

Figure 28: Solid waste generation of porcelain tile production

Economic analysis results of the scenarios;

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Turnover			
Total turnover	25000 €		20000 €
Increase or decrease in total turnover		5000.00	
Relative change of increase or decrease in total turnover		20.00 %	
Net Value Added			
Total net value added	20000 €		18000 €
Increase or decrease in total net value added		2000.00	
Relative change of increase or decrease in total net value added		10.00 %	

Figure 29: Turnover and NVA results of Ready mix concrete scenarios

NPV Analysis results

Year	TOTAL	Discount Factor	NPV	NPV(Yearly)
0	€ -15920.00	€ 1.00	€ -15920.00	€ -15920
1	€ 14650.00	€ 0.98	€ 14292.68	€ -1627.32
2	€ 14650.00	€ 0.95	€ 13944.08	€ 12316.76
3	€ 14650.00	€ 0.93	€ 13603.98	€ 25920.75
4	€ 14650.00	€ 0.91	€ 13272.18	€ 39192.92
5	€ 14800.00	€ 0.88	€ 13081.04	€ 52273.97
TOTAL NPV: € 52273.97				

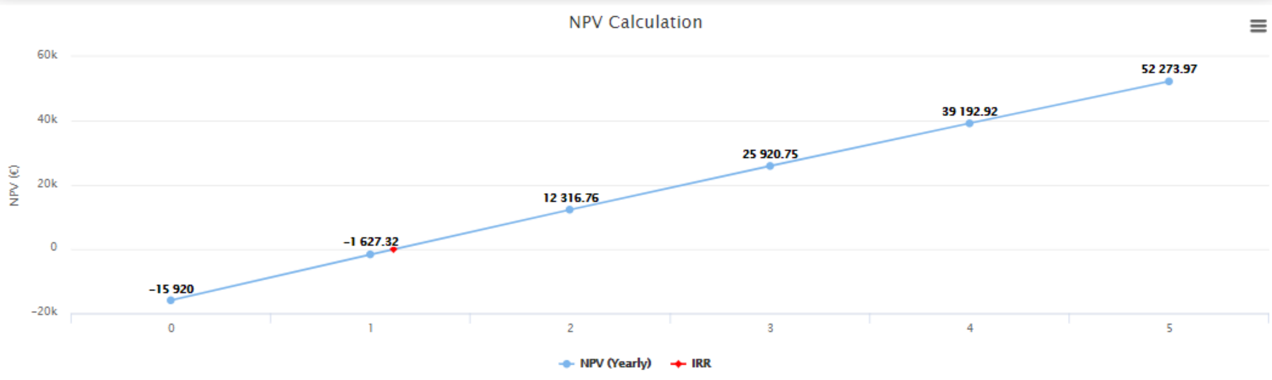

Figure 30: NPV results of Ready mix Concrete production

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Network analysis results of the scenarios;

NAME	NODE DEGREE	INPUT NODE DEGREE	OUTPUT DEGREE	NORMALIZED DEGREE
Natural Stone_BF	1	0	1	0.2
Cement_SF	2	1	1	0.4
RMC_SF	2	2	0	0.4
Steel_BF	1	0	1	0.2
Salt Slag_BF	1	0	1	0.2
P_Tile_SF	3	2	1	0.6

Figure 31: Degree Centrality results of FISSAC IS Network

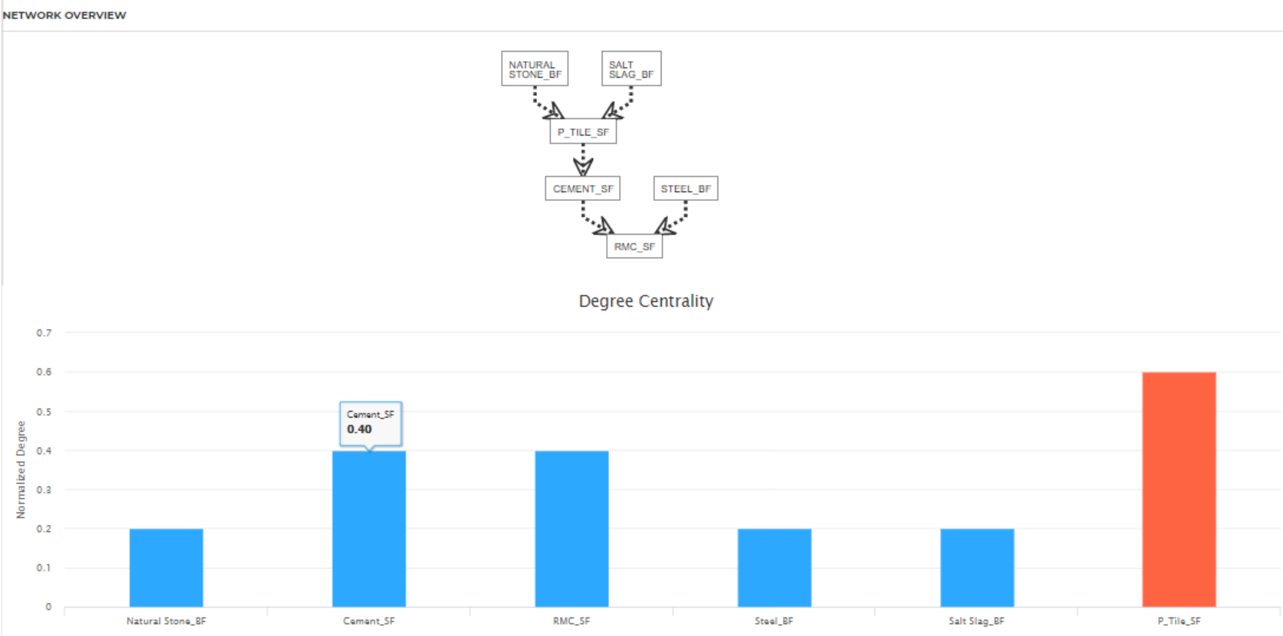

Figure 32: Degree Centrality graphical results of FISSAC IS Network

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5 USER SUPPORT

Nowadays, every software developer defines the action for user supports and prepare documentation before launching the software. The reason behind this practice is the substantial influence of the user needs from a software on the decision of the user to register (sign up and stay) or buy or not. This is directly related with the success of the software in concern.

For this purpose, in order to establish a robust baseline for the overall success of the platform, user support is the key feature used for the simplification and the smoothness of user experiences. In FISSAC IS Platform, a well-structured self-service support system is implemented. This system is all about enabling user to reach on their own to supporting documents together with tutorial medias. This is an automated methodology in which user mostly find it quick and simple with respect to help desk or call center.

For this purpose, by considering the user support system of FISSAC IS Platform, several tools/medias were developed that lead the way for a holistic coverage throughout the application of the platform. These items can be listed as below;

1. User Guide
2. Tutorial Videos
3. Survey
4. Dictionary
5. Infographic

5.1 User Guide

For the ease of FISSAC Platform application, it is essential to have a booklet or an instruction document so called “user guide” in order to represent all the modules in a simple and comprehensive manner to protect user interest. This document has a specific purpose to support technical and non-technical users and solve problems without expert guidance. It helps managing the technical knowledge. As time is one of the essential parameter in human life, FISSAC IS Platform User Guide were prepared for the identification of the operation flows in the platform together with the key terminologies used in.

In that respect, following chapters were integrated throughout this technical document;

- ***Chapter 1 FISSAC Platform***
- ***Chapter 2 Glossary***
- ***Chapter 3 Getting Started***
    - ***3.1 General Features***
    - ***3.2 Platform Features***
- ***Chapter 4 Platform Modules***

It is possible to access Chapter 2 as an integrated text in web module called as “Dictionary” feature found at the top and right corner of the platform page.

5.2 Tutorial Videos

In order to facilitate the user approach to the platform and help them to capture the application of different features, short tutorial videos were prepared according to the different modules of the platform. The names of the tutorial videos are listed as below.

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1. General platform application (in progress)
2. Create a new flow (https://youtu.be/OzsBSuhhvOA)
3. How to edit a flow (https://youtu.be/Q_JWNuqMOT0)
4. How to add a unit process (https://youtu.be/0fdyNdbI5BE)
5. How to add a system model (https://youtu.be/15sgq_yRglg)
6. How to add a facility (https://youtu.be/JCkXPq2oIB8)
7. How to add a network (https://youtu.be/oJCLcqHLx_E)
8. How to use analysis module (https://youtu.be/QvWtpX91JtI)

General platform tutorial video will cover a holistic scenario starting from unit process to analysis section in one single video. In addition to that, all other short tutorial videos are already uploaded to Youtube (Links are stated above) and it is possible to access these videos via "Help and Support" section of the FISSAC IS Platform. The screenshot of the tutorial video section can be found in ANNEX II.

5.3 Survey

Although it is mainly intended to prepare a well-documented user guide or straightforward tutorial videos that allows user to understand the modules crystal clear, there are always some lack of information necessary to fulfil for the best user experiences. In order to understand the user perspective from different sectors, a simple survey is prepared. In that respect, it is possible to obtain various information by asking for different values of the platform as well as user expectations from different modules or in general. For this reason, a survey system that only appear for long term user is implemented to the platform. In addition to that, a survey icon at the top of the every page will be present to allow all the user to participate accordingly. Questions and related choices can be found in ANNEX II.

5.4 Dictionary

This section is also called as "Glossary" that defines the main parameters used in the platform. This platform mainly consists of material flow analysis terminology together with various types of key performance indicators and platform basic features. To support the comprehension of the user in terms of the definitions lies behind each technical and non-technical terms, a dictionary module is added to the platform. The screenshot of this section can be found in ANNEX II.

5.5 Infographic

It is quite useful to exploit the advantages of visualization considered as nutrients for human perception. FISSAC IS Platform is a free web-based software that is open to all kind of users so it is important to communicate with this wider audience by facilitating and arranging the features of the platform into a simple format. It is called an "Infographic" which is a powerful tool with minimal use of text and in our case, maps the linkage between different sections of the platform.

In this context;

To identify the stream covering the flow of FISSAC IS Platform application beginning from process design phase and end up with opportunity analysis, an Infographic is prepared and embedded into "Help and Support" section.(Figure 33)

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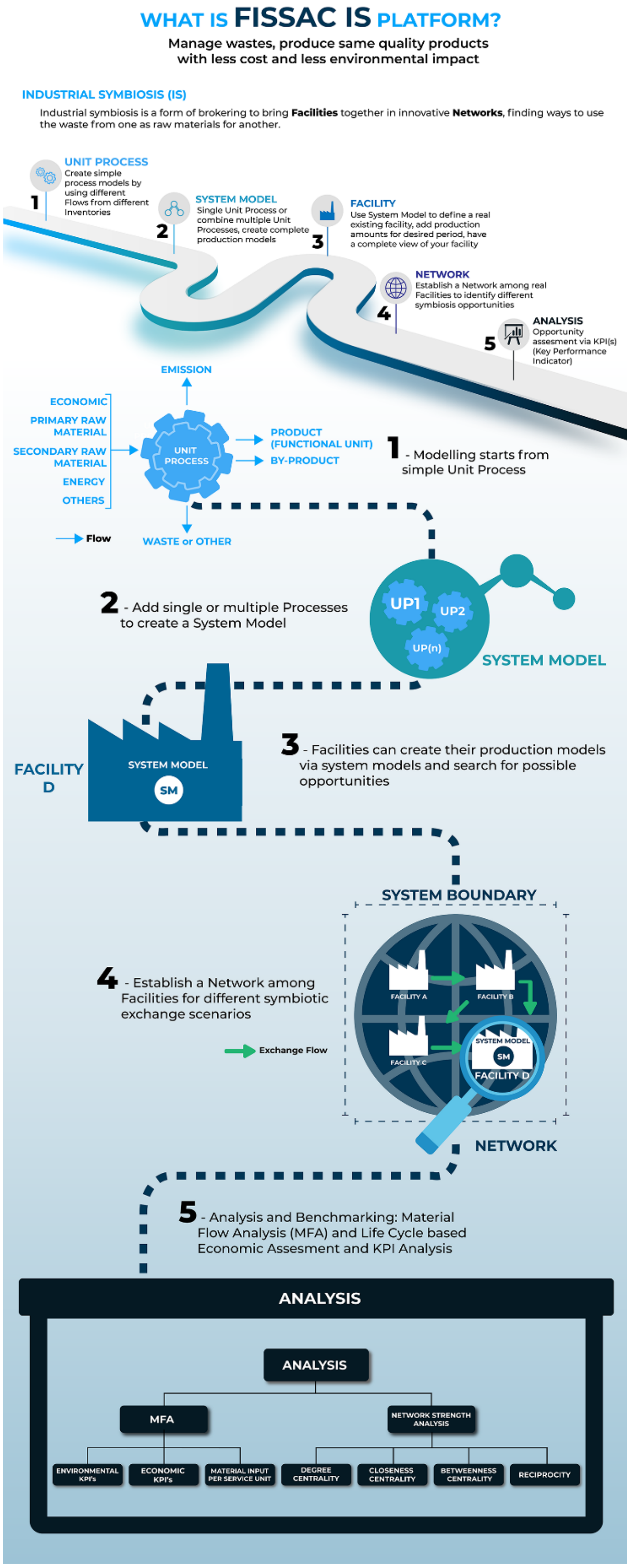

Figure 33 Infographic for "How to Use"

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6 FISSAC IS COMMUNITY CREATION

In addition to the work outlined in the DoA, efforts were made to introduce the Platform to selected target users within the professional network of the FISSAC consortium members. The main activities undertaken includes:

1. Presentation of the FISSAC IS Platform in the project final event on January 29th in Brussels.
2. A dedicated webinar on FISSAC IS Platform held on February 26th.
3. Dissemination of launch of the Platform through professional networking channels and project website.
4. Meetings with high influence target users.

The final event aiming for a participative and dynamic manner hosted the official launch of the FISSAC Platform with a live session to encourage the interested participants engage in the FISSAC IS Community and to receive feedback to improve the Platform on the final period of T6.3. Before the live session, a brief introduction of the Platform was made to present the most captivating features for the users as shown in Figure 34 and the FISSAC Platform Video [3].

In order to leverage the professional outreach of the FISSAC consortium members, a visual set was prepared by EKO and shared with the entire consortium for easy dissemination of the Platform. A sample visual can be seen in Figure 35. Following the official launch of the Platform in the final event, continuous dissemination over the networking channels and website is being carried out by the key partners (Figure 36).

The 4th and final webinar of the project is also allocated to the FISSAC IS Platform, held on February 26th.

[3] http://fissacproject.eu/en/

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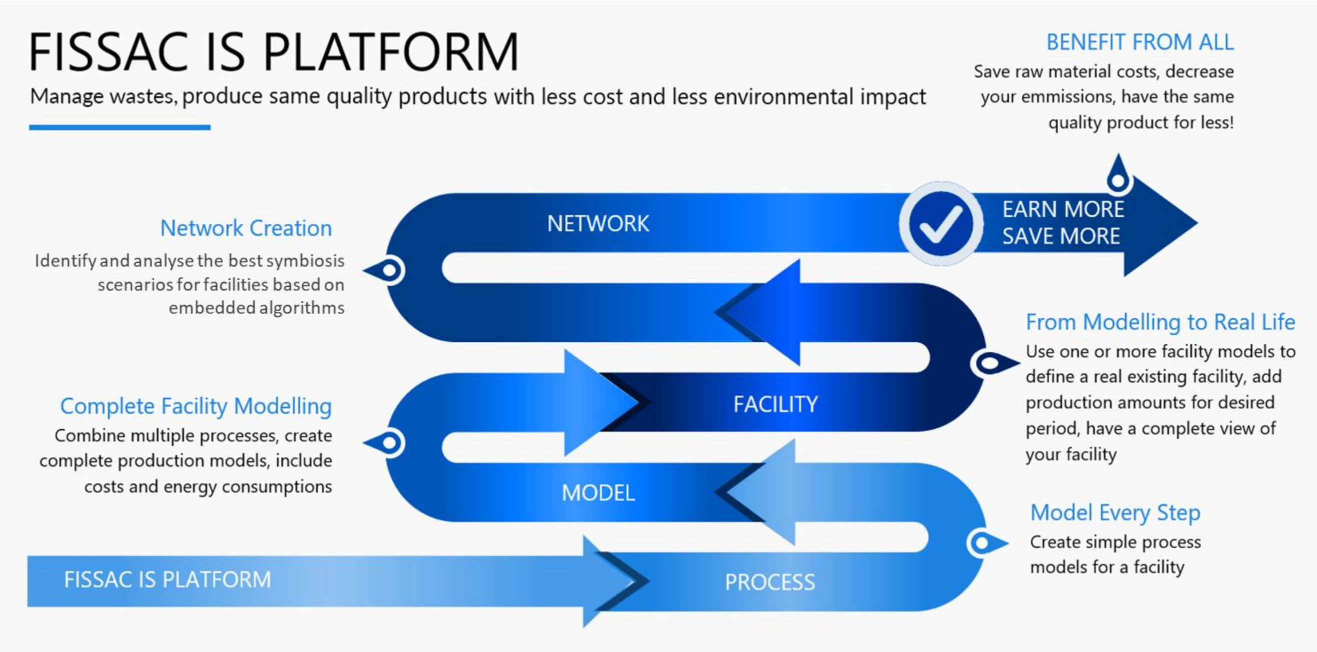

Figure 34 Slides from the introductory presentation of the FISSAC IS Platform at the project final event

Figure 35 A sample visual from the tool set prepared for dissemination of the FISSAC IS Platform by the partners

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Figure 36 Dissemination example

The 4th FISSAC webinar(FISSAC-A New Industrial Symbiosis Platform) lasted 1 hour and 20 minutes with 22 attendees(Table 24) from different companies.

Table 24 Webinar Attendees Table

Patricia Astrain	Elena Rocco	Luis Enriquez	Roberto Orejana
Raquel Casado	Claudio Sulew	Edith Guadella	Antonio Palomeque
Andrea Casas	Carmen Valache	Daniel Hiniesto	Debora Paolini
Vicente Diaz-Tejeire Montero	Mårten Wiktor	Christian Leroy	Clémence Pricken
Sinem Duman	Marta Alonso	Giulia Marrazzo	
Clas Mellby	Milian Nelzen	Asier Oleaga	

Following agenda is applied in the 4th Webinar. It mainly targets the application of the FISSAC platform covering different modules. During the session, a top to bottom approach were utilized to explain different features of the platform with an industrial symbiosis scenario including some of the FISSAC value chains.

1. Introduction to FISSAC Project
2. Introduction of the FISSAC Platform
3. Platform Tutorial-Opportunity Identification
4. Platform Tutorial-Process Design & Opportunity Assessment
5. Questions & Answers

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Table 25 presents the list of activities undertaken by the project partners to create interest in the FISSAC Platform from select group of stakeholders that has the ability to engage more platform users and initiate new IS related projects within their industrial community.

Table 25 The summary of activities carried our partners to disseminate the FISSAC IS Platform to target audience

Target stakeholder	Possible outcome	Type of the activity	Partner responsible
Turkish Ministry of Industry and Technology (MoiT)	MoiT is the main regulating agency responsible for overseeing the resource efficiency and industrial symbiosis activities in Turkey. They have strong outreach to industrial establishments and organized industrial zones (OIZs) nation -wide. The most important outcomes of the contact with the Ministry include: 1) Further dissemination opportunities through Regional Development Agencies discussed 2) Utilization of the platform as a nation-wide industrial symbiosis tool discussed, idea needs to be developed further 3) Organization of local workshops through Regional Development Agencies proposed by the Ministry Upon the meeting, EKO received a joint invitation from MoiT and British Embassy in Ankara to participate in a steering committee meeting of an IS related project carried out in Turkey supported by the Prosperity Fund [4] to discuss future synergies with upcoming projects of the Ministry. Particular lead to be followed is the possibility of the FISSAC IS Platform to be used as a model for a national IS platform to serve not only to industrial users and network managers but also for regulating bodies like MoiT.	Meeting and live demonstration	EKO
Turkish Ministry of Environment and Urbanization	MoEU is also another regulating body focusing on the resource efficiency and IS in the industrial framework in order to ensure the necessary environmental performance is achieved, in particular within the framework of integrated pollution prevention and control. A meeting with the relevant Branch Manager was held, with the participation of the Team Leader for Networking and Partnership from the Regional Activity Centre for Sustainable Consumption and Production (SCP/RAC). The main theme was the development of a new funding opportunity for the MoEU from SCP/RAC in construction	Meeting and live demonstration	EKO

[4] The Prosperity Fund is active in Turkey since 2011 and aims to support the broad-based and inclusive growth in Turkey in partnership with key interlocutors of the country. The fund covers a number of sectors, including improving the Business Environment and increasing Trade and Investment opportunities, promoting Financial Services and Financial Markets; and developing Future Cities and the transition to a Low Carbon economy. (https://www.gov.uk/guidance/uk-prosperity-fund-turkey)

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	sector and how the FISSAC IS Platform can aid the project concept. Further, meetings are planned for elaboration of the project concept between MoEU and EKO.		
İzmir Development Agency (İZKA)	İZKA is one of the 26 development agencies (DAs) established for the Turkey's accession period to EU Membership in order to decrease inter-regional disparities and income differences in Turkey. 2020 has been selected as the year of "resource efficiency" for all DAs nation-wide. Among the 26 DAs, İZKA is one the most active agencies supporting many IS projects within their geographical area of coverage. Upon a live presentation of the Platform, İZKA expressed interest to co-organize follow-up tutorial session for the industrial representatives in İzmir region.	Live demonstration	EKO
OSTIM Organized Industrial Zone (Their "Letter of Interest" can be found in Annex II as **Figure 42**)	OSTIM is one of the OIZs in Ankara, currently hosting more than 6.200 facilities active under 17 industrial sectors, a majority of which is SMEs. As part of its technopark, OSTİM has created 7 clusters on renewable energy and environmental technologies, construction equipment, medical sector, aviation, rubber technologies and rail systems. Two sessions were organized with OSTIM, a remote live demonstration of the Platform and a face-to-face meeting. A number of opportunities were discussed including: • Use of the IS Platform initially by the energy efficiency section of the OIZ Management to track the energy consumption of the facilities in the OIZ where the energy consumption data is currently being collected but not being managed efficiently. • Application for an industrial symbiosis demo project to Ankara DA, in which EKO provides the FISSAC IS Platform as an enabling tool for OSTIM.	Meeting and live demonstration	EKO
Cimko Narlı Cement Plant	Live demonstration of the platform as well as the main ambition of FISSAC project together with IS model were shared with Ms. Rukiye Aslan(environmental engineer)	Online demonstration	EKO
Votorantim Ankara Cement Plant	Live demonstration of the platform as well as the main ambition of FISSAC project together with IS model were shared with Mr. Okan Güven (Director of Sustainability) and Ms. Betül Öztürk (Environmental Manager)	Online demonstration (in March the 3rd of 2020)	EKO
M.S. Thesis	FISSAC IS Platform will be utilized as a validation tool within the context of the on-going M.S. thesis work of Mrs. Pınar Yalman Akcengiz who is also the Renewable Energy and Clean Technologies Cluster Manager.		EKO
AIB (Associazione Industraile Bresciana) and ATECAP	Following the FISSAC IS Platform webinar, the dissemination activities will be initiated over emails and phone.	Contact over phone and emails.	RINA
Living Lab	FISSAC IS Platform will be introduced in Hungary to industry (construction, construction material and recycling), professional bodies, research and academia, as well as policy makers.		GEO

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British Glass Environment and Energy Committee	GTS will introduce the platform to the UK glass industry through the British Glass Environment and Energy Committee.		GTS
Transforming Foundation Industries	Transforming Foundation Industries group is being set up in the UK currently that the sister organisation of GTS, Glass Futures, is a major part of, where Transforming Foundation Industries is trying to set up symbiosis projects across all the major intensive industries in the UK.		GTS

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7 CONCLUSIONS

WP 6 is basically devoted to developing the final version of FISSAC model for Industrial Symbiosis. To reach that target, an integrated Industrial Symbiosis Management Software tool namely **FISSAC IS Platform** is defined and developed accordingly.

The put in a nutshell, the philosophy behind the IS is to bring about cross-sectorial businesses together to generate synergies among them. This is achieved via FISSAC IS Platform that needs high amounts of data flow to evaluate the opportunities and their design phases respectively. This platform is a decision support tool combining MFA and industrial clustering with the help of bottom-up approach leading to designing and analysing functions.

The work presented in this document has tackled the validation of the FISSAC IS platform with internal and external user tests as well as the FISSAC IS Community Creation activities to disseminate and ensure the usefulness of the Platform. Following the previous works under WP6, Task 6.3 delivered:

- Detailed KPI assessment methodology as implemented in the Platform
- Introduction of MIPS as an alternative life cycle-based material efficiency indicator
- Evaluation methodology to evaluate technical and non-technical functionalities of the IS platform via internal and external user tests
- Functional and user test results
- Platform validation
- FISSAC IS Community Creation and user support activities

The implementation of this evaluation strategy is done with the creation of a stepwise testing scenarios including different modules of the platform starting from registration and unit process creation to KPIs analysis. In addition to that, functional requirements checklist was generated and reviewed via binary logic including "Pass" or "Fail" options.

Hence, major point considered in this deliverable is to test and validate pre-calculated outputs of different key performance indicators such as; Economic, Environmental, Network and MIPS indicators with the platform results. Additionally, every steps defined in testing scenarios are aimed to control various functional requirements in each module of the platform. Ultimately, all of these evaluation tests were conducted and finalized smoothly with the commitment of internal and external users so that FISSAC IS Platform is now exploitable for all registered user freely seeking user privacy.

A summary on platform test results:

During the online testing for Environmental KPIs applications, a real-like scenario covering some of the FISSAC Industries (Cement, Concrete, Steel and Tile Producers) were utilized along the sessions with internal and external users. According to the comments and outputs of these tests, permanent improvements were applied against main findings or feedbacks respectively. For the Economic, MIPS and Network performance indicators, only internal testing were realized since they are mostly just click & monitor based outputs so there is no need to stepwise test with various users for such a straight forward assessment. Network Strength KPIs test is especially related with the scenario arranged for environmental KPIs since it already includes an established network ready to be assessed. To sum up, most of the issues found during these tests were basically visuals and typos located both in front-end and back-end of the platform. In order to finalize the evaluation period, all the relevant findings were regenerated and set for best performance.

Within the scope of Task 6.3, additional work to DoA was undertaken for directed dissemination of the Platform to key and influential stakeholders. Results of these activities show promising level of interest from

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these stakeholder but continuous efforts need to be ensured to engage users to the Platform after the completion of the Project at least until a certain concentration of users can be involved with the Platform.

To use the FISSAC IS platform, user can follow the link below and register at their own discretion.

http://is.fissacproject.eu/

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ANNEX I

Sample Calculation for Material Consumption KPIs

Following example is illustrating an ordinary portland cement manufacturing process inputs and outputs including a replacement of semi-product, clinker, with calcined clay that is available as output of ceramic tile production process.

In order to show the deviation between before and after symbiosis scenario, baseline production line also includes a secondary raw material from glass industry.

Table 26 Scenarios for Material Consumption KPIs Calculation

Cement Production (Baseline Scenario)							
Code	**Input**	**Value**	**Unit**	**Code**	**Output**	**Value**	**Unit**
PRM1	Clinker	0.93	t	P	Cement	1	t
B	Finish Grinding	41.9	kWh	E	Particulate Matter (PM10)-Cement Mill Grinding	0.019	kg
PRM2	Gypsum	0.05	t	F	Particulate Matter (PM2.5)-Cement Mill Grinding	0.019	kg
SRM1	Glass	0.02	t	T	Turnover	47	€
				NVA	Net Value Added	35	€
Cement Production (Symbiosis Scenario)							
Code	**Input**	**Value**	**Unit**	**Code**	**Output**	**Value**	**Unit**
PRMS1	Clinker	0.91	t	PS	Cement	1	t
BS	Finish Grinding	41.9	kWh	ES	Particulate Matter (PM10)-Cement Mill Grinding	0.019	kg
PRMS2	Gypsum	0.03	t	FS	Particulate Matter (PM2.5)-Cement Mill Grinding	0.019	kg
SRMS1	Calcined Clay	0.06	t	TS	Turnover	50	€
				NVAS	Net Value Added	38	€

Note: Turnover and Net Value Added values are shown as output value however they are entered in Facility Costs Tab of Facilities Module

Several KPIs are calculated according to the identified formula and their results are astated in below table. (Table 27)

Table 27 Sample KPIs Outputs for Material Consumption

Primary Raw Materials (PRM)	**Result Before Industrial Symbiosis**	**Result After Industrial Symbiosis**
Total PRM consumption	0.98 t	0.94 t
PRM intensity (Specific PRM consumption) (per quantity)	0.98 t	0.94 t
Increase or decrease in total PRM consumption	-0.04t	
PRM efficiency	95.9 %	
Secondary Raw Materials (SRM)	**Result Before Industrial Symbiosis**	**Result After Industrial Symbiosis**
Total SRM consumption	0.02 t	0.06 t
SRM valorisation (substitution)	0.04 t	

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Relative change of SRM Valorisation	200 %	
SRM efficiency	300 %	
Raw Materials (RM)	**Result Before Industrial Symbiosis**	**Result After Industrial Symbiosis**
RM intensity (Specific RM consumption) (per turnover)	0.02 t/€	0.02 t/€
RM intensity (Specific RM consumption) (per net value added)	0.03 t/€	0.03 t/€

Sample Calculation for Energy Consumption KPIs

In order to demonstrate Energy Consumption based indicator calculations, Aerated Autoclaved Concrete Production Unit Process is selected. 50 % replacement of primary raw material, in this case "cement", by Eco Cement shows the great material exchange potential of this process. For this huge reduction in resource usage leads to a decrease in energy consumption of different types observed in symbiosis scenario.

Table 28 Scenarios for Energy Consumption KPIs Calculation

AAC Production (Baseline Scenario)							
Code	**Input**	**Value**	**Unit**	**Code**	**Output**	**Value**	**Unit**
	Cement	0.092	t	P	AAC	1	m3
	Limestone	0.032	t		PM10	0.01925	kg
	Aluminium	0.57	kg		PM2.5	0.01925	kg
	Quartzite	0.183	t	T	Turnover	35	€
	Gypsum	0.01	t	NVA	Net Value Added	25	€
	Water	0.434	t				
NG	Natural gas	5.85	m3				
E	Electricity	5.89	kWh				
F	Diesel	0.248	L				
RE	Solar Energy	7	kWh				

Note: Turnover and Net Value Added values are shown as output value however they are entered in Facility Costs Tab of Facilities Module

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AAC Production (Symbiosis Scenario)							
Code	**Input**	**Value**	**Unit**	**Code**	**Output**	**Value**	**Unit**
	Cement	0.046	t	PS	AAC	1	m3
	Eco Cement	0.046	t		PM10	0.01925	kg
	Limestone	0.032	t		PM2.5	0.01925	kg
	Aluminium	0.57	kg		Turnover	38	€
	Quartzite	0.0732	t	NVAS	Net Value Added	28	€
	Gypsum	0.01	t				
	Water	0.434	t				
NGS	Natural gas	5	m3				
ES	Electricity	4.89	kWh				
FS	Diesel	0.225	lt				
RES	Solar Energy	7	kWh				
	EAF Slag	0.0366	t				
	LF Slag	0.0366	t				
	Ceramic Waste	0.0366	t				

Note: Turnover and Net Value Added values are shown as output value however they are entered in Facility Costs Tab of Facilities Module

Several KPIs are calculated according to the identified formula and their results are stated in below table. (Table 29)

Table 29 Sample KPIs Outputs for Energy Consumption

FUEL	Result Before Industrial Symbiosis	Result After Industrial Symbiosis
Total fuel consumption	2.65 kWh	2.41 kWh
Fuel intensity (Specific fuel consumption) (per quantity)	2.65 kWh/m3	2.41 kWh/m3
Fuel intensity (Specific fuel consumption) (per turnover)	0.08 kWh/€	0.06 kWh/€
Fuel intensity (Specific fuel consumption) (per net value added)	0.11 kWh/€	0.00 kWh/€
Increase or decrease in total fuel consumption	-0.2 kWh	
Relative change of increase or decrease in total fuel consumption	-9.3 %	
Fuel substitution	-0.25 kWh	
Relative change of fuel substitution	-9.3 %	
Fuel efficiency	90.7 %	

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Sample Calculation for By-Product Generation

Following example is showing same production facility however in two different time period. The second table

Table 30 Scenarios for By-product Generation KPIs Calculation

Steel Production (Baseline Process Scenario)							
Code	**Input**	**Value**	**Unit**	**Code**	**Output**	**Value**	**Unit**
	DRI Iron	0.030	kg	P	Liquid Steel	1.000	kg
	Pig Iron	0.030	kg		Argon	0.001	kg
	Scrap Iron	1.053	kg		Nitrogen Oxides	0.000	kg
	Carbon Steel	0.012	kg		Steam	0.253	kg
	High Alloy and Stainless Steel	0.030	kg		Carbon Monoxide	0.001	kg
	Graphite Electrodes	0.004	kg		Carbon Dioxide	0.093	kg
	Refractory Lining	0.020	kg		TOC	0.000	kg
	Hard Coal	0.010	kg		Dust	0.034	kg
	Lime/Dolomite	0.081	kg		Sulphur Dioxide	0.000	kg
	Nitrogen	0.001	kg		Waste Refractories	0.020	kg
	Argon	0.001	kg	BP1	EAF Slag	0.152	kg
	Oxygen	0.066	kg	BP2	LF Slag	0.040	kg
	Natural Gas	0.022	kg	T	Turnover	346	€
	Energy	1.822	MJ	NVA	Net Value Added	50	€
	Steam	0.749	MJ				
	Water	0.030	m3				

Note: Turnover and Net Value Added values are shown as output value however they are entered in Facility Costs Tab of Facilities Module

Steel Production (Modified Process Scenario)							
Code	**Input**	**Value**	**Unit**	**Code**	**Output**	**Value**	**Unit**
	DRI Iron	0.03	kg	PM	Liquid Steel	1	kg
	Pig Iron	0.03	kg		Argon	0.001	kg
	Scrap Iron	1.052	kg		Nitrogen Oxides	0.0001	kg
	Carbon Steel	0.012	kg		Steam	0.253	kg
	High Alloy and Stainless Steel	0.030	kg		Carbon Monoxide	0.001	kg
	Graphite Electrodes	0.004	kg		Carbon Dioxide	0.093	kg
	Refractory Lining	0.020	kg		TOC	0.0003	kg
	Hard Coal	0.010	kg		Dust	0.034	kg
	Lime/Dolomite	0.081	kg		Sulphur Dioxide	0.0001	kg
	Nitrogen	0.0010	kg		Waste Refractories	0.02	kg
	Argon	0.0010	kg	BPM1	EAF Slag	0.16	kg
	Oxygen	0.0663	kg	BPM2	LF Slag	0.025	kg

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	Natural Gas	0.0224	kg	TM	Turnover	360	€
	Energy	1.822	MJ	NVAM	Net Value Added	55	€
	Steam	0.749	MJ				
	Water	0.030	m3				

Table 31 Sample KPIs Outputs for By-product Generation

By-products	Result Baseline Process Scenario	Result Modified Process Scenario
Total by-product generation	0.192 kg	0.185 kg
By-product generation intensity (per quantity)	0.19	0.19
By-product generation intensity (per net added value)	0.004 kg/€	0.003 kg/€
Increase or decrease in total by-product generation	-0.007 kg	
Relative change of increase or decrease in total by-product generation	-3.646 %	

Sample Calculation for GHG Emission KPIs

In this example, the main purpose is the usage of Soda Lime Silica Scrap Glass in porcelain tiles production as a substitute of clay. (Table 32)

Table 32 Scenarios for GHG Emission KPIs Calculation

Porcelain Tiles Production (Baseline Scenario)							
Code	**Input**	**Value**	**Unit**	**Code**	**Output**	**Value**	**Unit**
	Clay	22.6	kg		Dust	0.00535	kg
	Glazing	0.73	kg	G1	Sulphur dioxide	0.0312	kg
	Printing Ink	0.0691	kg		Fluorine	0.000808	kg
F1	Natural Gas	1.83	m3	G2	CO	0.0649	kg
F2	Diesel	0.014	kg	G3	CO2	3.28	kg
F3	Petroleum	0.00141	kg	G4	NOx	0.00692	kg
	Packaging Film	0.011	kg	G5	CH4	0.0000001	kg
	Polystrene	0.01	kg		NHSW	3.15	kg
	Cardboard	0.135	kg		HSW	0.00276	kg
	Water	9.37	kg	P	Porcelain Tile	1	m2
	Lubricating Oil	0.00141	kg	T	Turnover	30	€
E	Electricity	1.97	kWh	NVA	Net Value Added	20	€

Porcelain Tiles Production (Symbiosis Scenario)							
Code	**Input**	**Value**	**Unit**	**Code**	**Output**	**Value**	**Unit**
	Clay	19	kg		Dust	0.00535	kg
	Soda Lime Silica Scrap Glass	3.6	kg	GS1	Sulphur dioxide	0.0312	kg

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	Glazing	0.73	kg		Fluorine	0.000808	kg
	Printing Ink	0.0691	kg	GS2	CO	0.0649	kg
FM1	Natural Gas	1.78	m3	GS3	CO2	2	kg
FM2	Diesel	0.014	kg	GS4	NOx	0.00692	kg
FM3	Petroleum	0.00141	kg	GS5	CH4	0.0000001	kg
	Packaging Film	0.011	kg		NHSW	3.15	kg
	Polystrene	0.01	kg		HSW	0.00276	kg
	Cardboard	0.135	kg	PS	Porcelain Tile	1	m2
	Water	9.37	kg	TS	Turnover	32	€
	Lubricating Oil	0.00141	kg	NVAS	Net Value Added	21	€
ES	Electricity	1.9	kWh				

Table 33 Sample KPIs Outputs for GHG Emission

Greenhouse Gas (GHG) Emissions	Result Before Industrial Symbiosis	Result After Industrial Symbiosis
Total GHG emissions	7.839 kg $CO_{2\text{-}eq}$	6.431 kg $CO_{2\text{-}eq}$
GHG emissions from electricity consumed and purchased	0.583 kg $CO_{2\text{-}eq}$	0.562 kg $CO_{2\text{-}eq}$
GHG emissions from fuel consumption	3.976088 kg $CO_{2\text{-}eq}$	3.869 kg $CO_{2\text{-}eq}$
GHG emission intensity (Specific GHG emissions) (per quantity)	7.84 kg $CO_{2\text{-}eq}$/m2	6.43 kg $CO_{2\text{-}eq}$/m2

Sample Calculation for Solid Waste KPIs

In this example, it is intended to consider only the output section of the process. (Table 34)

Table 34 Scenarios for Solid Waste KPIs Calculation

Porcelain Tiles Production(Baseline Process Scenario)							
Code	**Input**	**Value**	**Unit**	**Code**	**Output**	**Value**	**Unit**
	Clay	22.6	kg		Dust	0.00535	kg
	Glazing	0.73	kg		Sulphur dioxide	0.0312	kg
	Printing Ink	0.0691	kg		Fluorine	0.000808	kg
	Natural Gas	1.83	m3		CO	0.0649	kg
	Diesel	0.014	kg		CO2	3.28	kg
	Petroleum	0.00141	kg		NOx	0.00692	kg
	Packaging Film	0.011	kg		CH4	1E-07	kg
	Polystrene	0.01	kg	N	NHSW	3.15	kg
	Cardboard	0.135	kg	H	HSW	0.00276	kg
	Water	9.37	kg	P	Porcelain Tile	1	m2
	Lubricating Oil	0.00141	kg	T	Turnover	30	€
	Electricity	1.97	kWh	NVA	Net Value Added	20	€

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Porcelain Tiles Production (Modified Process Scenario)							
Code	**Input**	**Value**	**Unit**	**Code**	**Output**	**Value**	**Unit**
	Clay	22.6	kg		Dust	0.00535	kg
	Glazing	0.73	kg		Sulphur dioxide	0.0312	kg
	Printing Ink	0.0691	kg		Fluorine	0.000808	kg
	Natural Gas	1.83	m3		CO	0.0649	kg
	Diesel	0.014	kg		CO2	3.28	kg
	Petroleum	0.00141	kg		NOx	0.00692	kg
	Packaging Film	0.011	kg		CH4	1E-07	kg
	Polystrene	0.01	kg	NS	NHSW	3.1	kg
	Cardboard	0.135	kg	HS	HSW	0.002	kg
	Water	9.37	kg	PS	Porcelain Tile	1	m2
	Lubricating Oil	0.00141	kg	TS	Turnover	31	€
	Electricity	1.97	kWh	NVAS	Net Value Added	21	€

Note: Turnover and Net Value Added values are shown as output value however they are entered in Facility Costs Tab of Facilities Module

Table 35 Sample KPIs Outputs for Solid Waste

Hazardous Solid Wastes (HW)	Result Baseline Process Scenario	Result Modified Process Scenario
Total HW generation	0.0028 kg	0.0020 kg
HW generation intensity (Specific HW generation) (per quantity)	0.0028 kg/m2	0.0020 kg/m2
Increase or decrease in total HW generation	0.0008 kg	
Relative change of increase or decrease in total HW generation	27.5 %	
HW recycling	0.0003 kg	0.0004 kg

Sample Calculation for NPV

As an example to NPV calculation in the platform, on “facility” module there is “facility costs” part to be filled with economic inventories.

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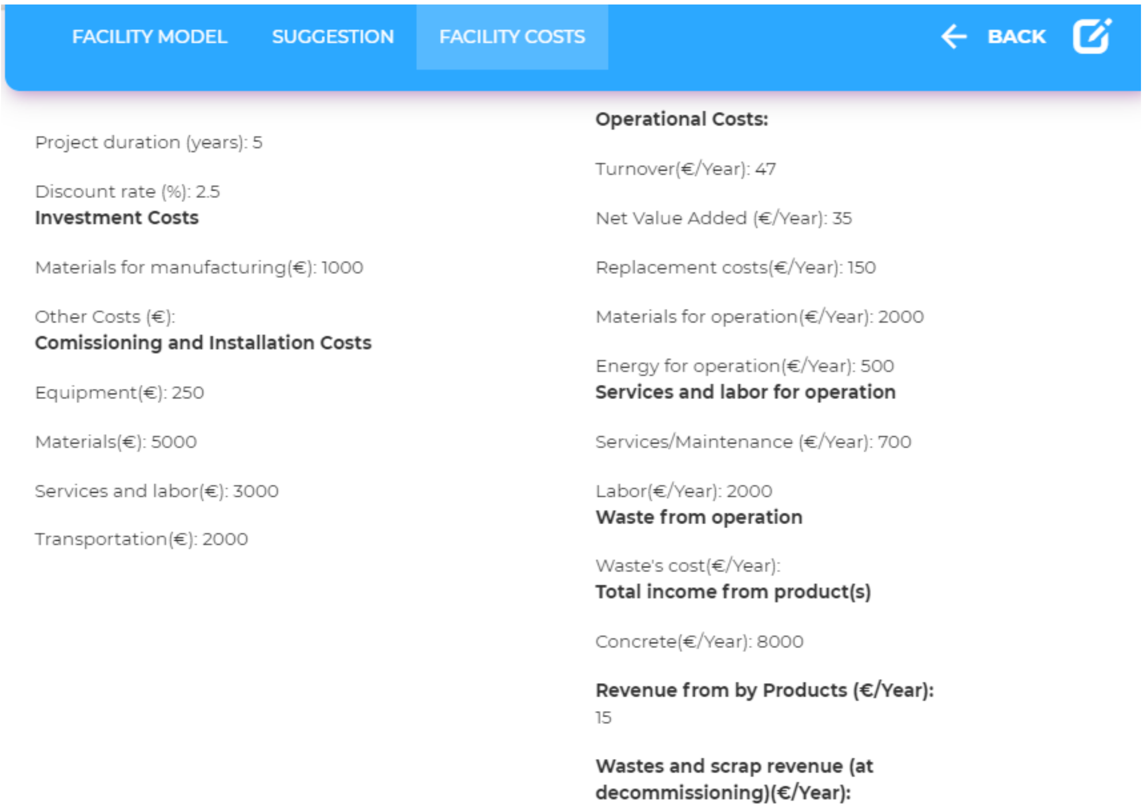

Figure 37 An Example of Facility Cost Inventory for NPV Analysis

After entering the cost items to the relevant fields on facility module, the platform will be able to analyse the NPV of that facility within the "analysis" tab. The results of NPV analysis will be illustrated in both tabulated and graphical forms below;

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NPV Calculation

Year	TOTAL	Discount Factor	NPV	NPV(Yearly)
0	€ -8600.00	€ 1.00	€ -8600.00	€ -8600
1	€ 2650.00	€ 0.98	€ 2585.37	€ -6014.63
2	€ 2650.00	€ 0.95	€ 2522.31	€ -3492.33
3	€ 2650.00	€ 0.93	€ 2460.79	€ -1031.54
4	€ 2650.00	€ 0.91	€ 2400.77	€ 1369.23
5	€ 2800.00	€ 0.88	€ 2474.79	€ 3844.02

TOTAL NPV: € 3844.02

Figure 38 Platform Results of NPV Analysis in tabulated form

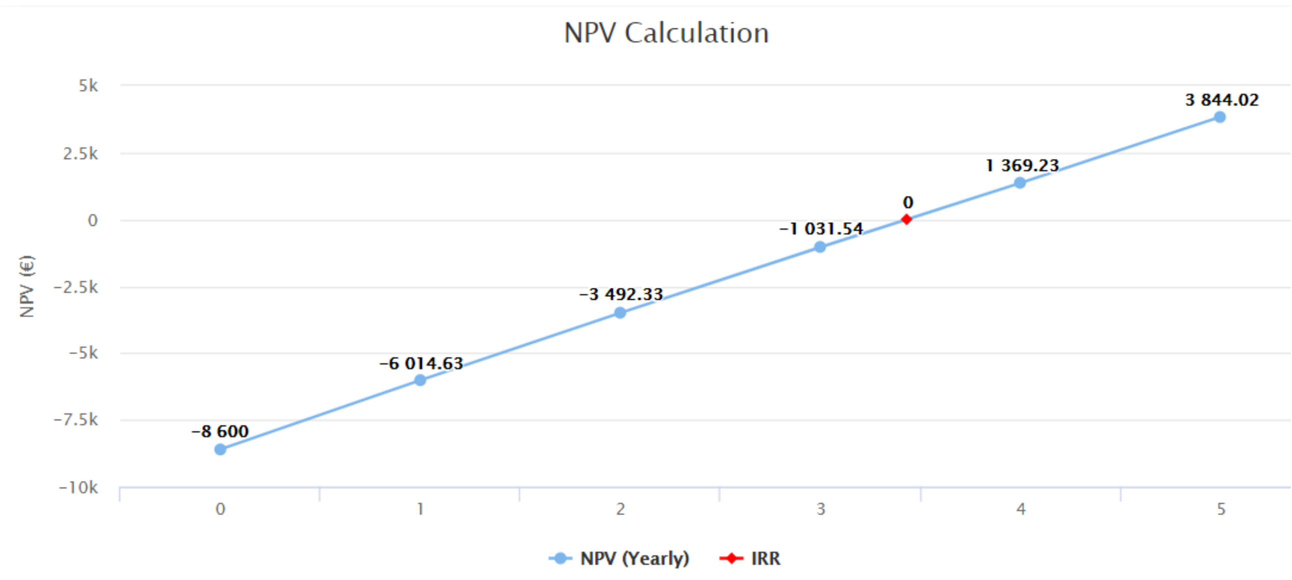

Figure 39 Platform Results of NPV Analysis in graphical form

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Sample Calculation for OPEX

Sample process data for related KPIs are stated as below. (Table 36)

Table 36 Example to the Economic OPEX analysis

Baseline Scenario for Ready Mixed Concrete Production									
Code	**Input**	**Value**	**Unit**	**Unit cost €**	**Code**	**Output**	**Value**	**Unit**	**Unit cost €**
C	Cement	0.3	t	150	**P**	Concrete	1	m3	150
FA	Fine aggregate	0.75	t	50		PM10	0.01925	kg	
CA	Coarse aggregate	1.12	t	50		PM2.5	0.01925	kg	
W	Water	0.145	t	15	**T**	Turnover	300	Euro	300
E	Electricity	321.86	kWh	0.25	**NVA**	Net Value Added		Euro	500
Symbiosis Scenario for Ready Mixed Concrete Production									
Code	**Input**	**Value**	**Unit**	**Unit cost €**	**Code**	**Output**	**Value**	**Unit**	**Unit cost €**
CS	Cement	0.3	t	150	**PS**	Concrete	1	m3	
FAS	Fine aggregate	0.75	t	50		PM10	0.01925	kg	
CAS	Coarse aggregate	0.11	t	50		PM2.5	0.01925	kg	
WS	Water	0.145	t	15	**TS**	Turnover		Euro	300
ES	Electricity	321.86	kWh	0,25	**NVAS**	Net Value Added		Euro	500
	EAF Slag	1.01	t	0					

Note: Turnover and Net Value Added values are shown as output value however, they are entered in Facility Costs Tab of Facilities Module. Moreover, labour costs, land use costs, maintenance costs and auxiliary costs are taken from the "facility costs" under facility module in the platform.

The KPI analysis results for the given inventory is illustrated in below table. (Table 37**Error! Reference source not found.**)

Table 37 Results of the Example to the Economic OPEX analysis

Material Cost		**Calculation Before IS**	**Calculation After IS**
Total material cost	€	140.68	90.18
Specific material cost	€	0.28	0.180
Increase or decrease in total material cost	€	0.101	
Relative change of increase or decrease in total material cost	%	3590%	
Relative change in specific material cost	%	3590%	
Water Cost		**Calculation Before IS**	**Calculation After IS**
Total water cost	€	2.18	2.18
Specific water cost	€	0.00435	0.00435
Increase or decrease in total water cost	€	0	

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Relative change of increase or decrease in total water cost	%	0	
Relative change in specific water cost	%	0	
Energy Cost		**Calculation Before IS**	**Calculation After IS**
Total energy cost	€	80.5	80.5
Specific energy cost	€	0.16	0.16
Increase or decrease in total energy cost	€	0	
Relative change of increase or decrease in total energy cost	%	0	
Relative change in specific energy cost	%	0	
Land Use Cost		**Calculation Before IS**	**Calculation After IS**
Total land use cost	€	1000	1000
Specific land use cost	€	2	2
Increase or decrease in total land use cost	€	0	
Relative change of increase or decrease in total land use cost	%	0	
Relative change in specific land use cost	%	0	
Labour Cost		**Calculation Before IS**	**Calculation After IS**
Total labour cost	€	30000	30000
Specific labour cost	€	60	60
Increase or decrease in total labour cost	€	0	
Relative change of increase or decrease in total labour cost	%	0	
Relative change in specific labour cost	%	0	
Maintenance Cost		**Calculation Before IS**	**Calculation After IS**
Total maintenance cost	€	5000	5000
Specific maintenance cost	€	10	10
Increase or decrease in total maintenance cost	€	0	
Relative change of increase or decrease in total maintenance cost	%	0	
Relative change in specific maintenance cost	%	0	
Total Operational Cost (OPEX)		**Calculation Before IS**	**Calculation After IS**
Total operational cost	€	36223.32	36172.82
Specific operational cost	€	72.45	72.35
Increase or decrease in total operational cost	€	50.5	
Relative change of increase or decrease in total operational cost	%	0.101	
Relative change in specific operational cost	%	0.14	

Sample Calculation for Turnover and Net Value Added

As an example to the KPI results given in Table 38, the cement production process is given as per below in Table 38.

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Table 38 Example of Economic KPIs Analysis

Baseline Scenario for Cement Production							
Code	**Input**	**Value**	**Unit**	**Code**	**Output**	**Value**	**Unit**
	Clinker	0.95	t	P	Cement	1	t
	Finish Grinding	41.9	kWh		PM10-Cement Grind.	0.019	kg
	Gypsum	0.05	t		PM2,5-Cement Grind.	0.019	kg
	[name of SRM]	0	[unit]	T	Turnover	47	M Euro
				NVA	Net Value Added	35	M Euro
Symbiosis Scenario for Cement Production							
Code	**Input**	**Value**	**Unit**	**Code**	**Output**	**Value**	**Unit**
	Clinker	0.91	t	PS	Cement	1	t
	Finish Grinding	41.9	kWh		PM10-Cement Grind.	0.019	kg
	Gypsum	0.03	t		PM2,5-Cement Grind.	0.019	kg
	Calcined Clay	0.06	t	TS	Turnover	50	M Euro
				NVAS	Net Value Added	38	M Euro

Note: Turnover and Net Value Added values are shown as output value however they are entered in Facility Costs Tab of Facilities Module

Results of the cement production process given in Table 38 in terms of product quantity, turnover and NVA are shown in Table 39.

Table 39 Results of Economic KPIs Analysis

Product Quantity		**Calculation Before IS**	**Calculation After IS**	**Calculation Before IS**	**Calculation After IS**
Total product quantity	tonne	P	PS	1	1
Increase or decrease in total product quantity	tonne	P-PS		0	
Relative change of increase or decrease in total product quantity	%	100*(P-PS)/P		0%	
Turnover		**Calculation Before IS**	**Calculation After IS**	**Calculation Before IS**	**Calculation After IS**
Total turnover	€	T	TS	47	50
Increase or decrease in total turnover	€	T-TS		-3	
Relative change of increase or decrease in total turnover	%	100*(T-TS)/T		-6.38%	
Net Value Added		**Calculation Before IS**	**Calculation After IS**	**Calculation Before IS**	**Calculation After IS**
Total net value added	€	NVA	NVAS	35	38
Increase or decrease in total net value added	€	NVA-NVAS		-3	
Relative change of increase or decrease in total net value added	%	100*(NVA-NVAS)/NVA		-8.57%	

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ANNEX II

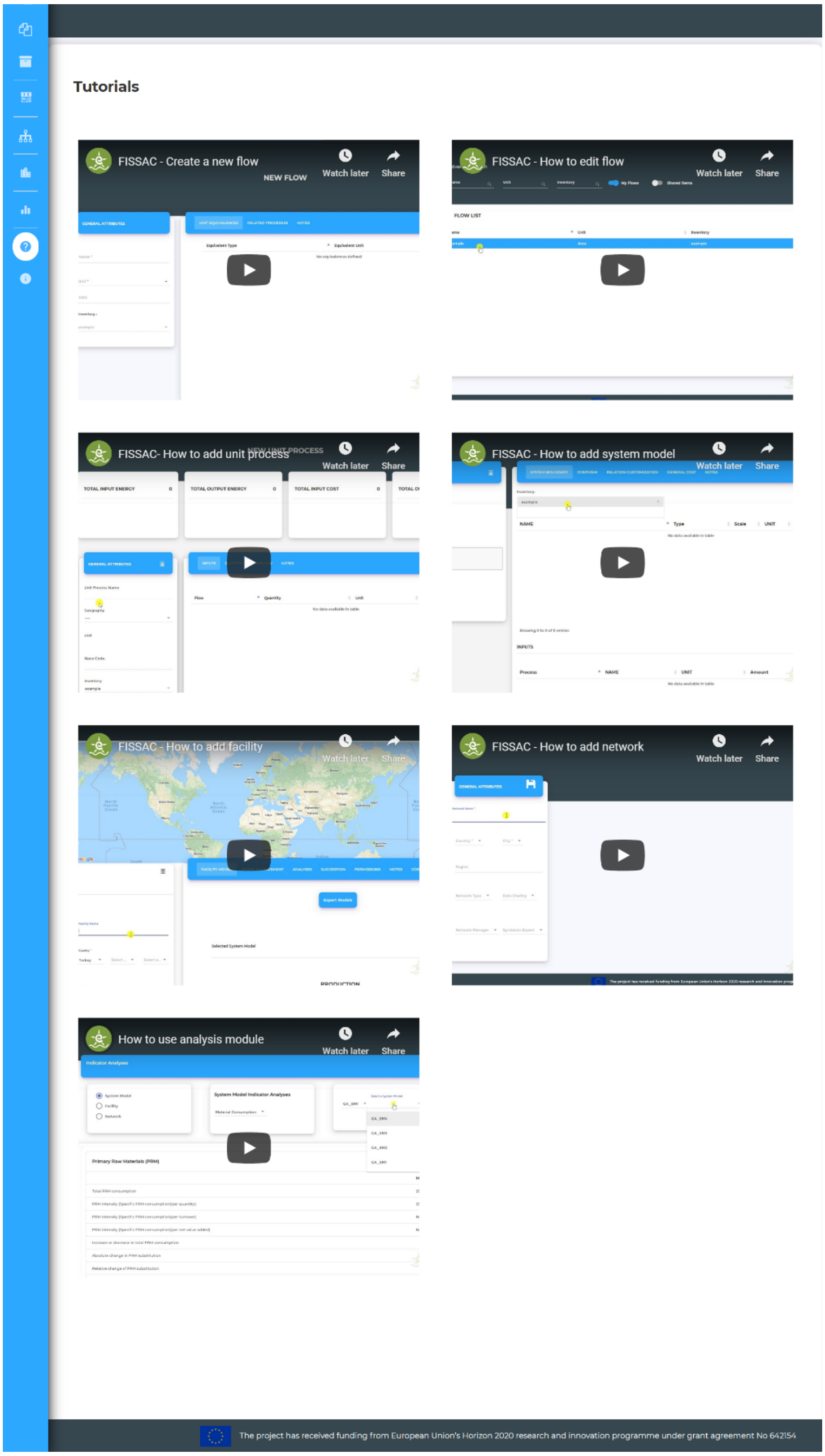

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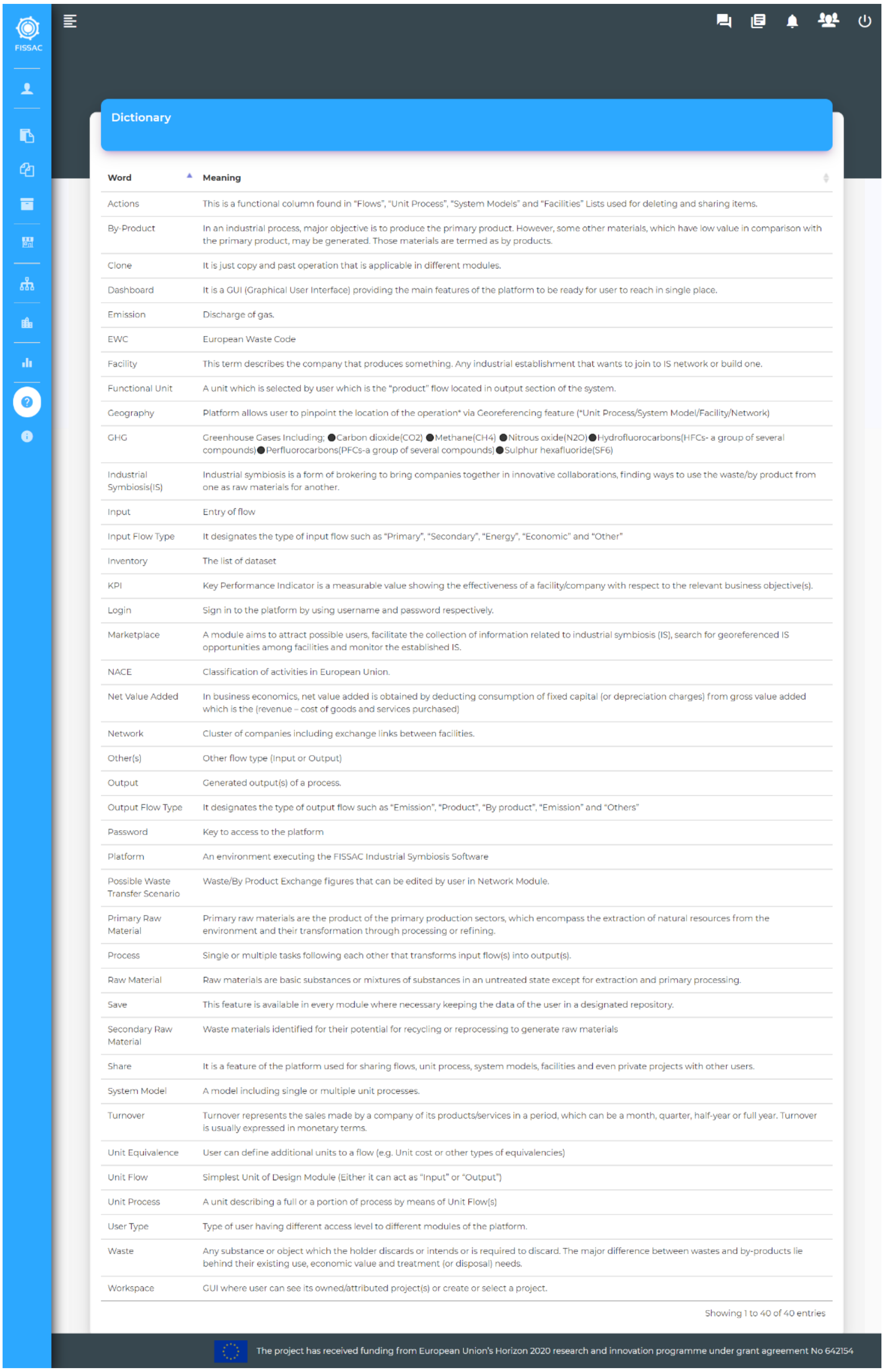
Figure 40 Tutorial Videos (Screenshot taken from FISSAC IS Platform)



Dictionary

Word	Meaning
Actions	This is a functional column found in “Flows”, “Unit Process”, “System Models” and “Facilities” Lists used for deleting and sharing items.
By-Product	In an industrial process, major objective is to produce the primary product. However, some other materials, which have low value in comparison with the primary product, may be generated. Those materials are termed as by products.
Clone	It is just copy and past operation that is applicable in different modules.
Dashboard	It is a GUI (Graphical User Interface) providing the main features of the platform to be ready for user to reach in single place.
Emission	Discharge of gas.
EWC	European Waste Code
Facility	This term describes the company that produces something. Any industrial establishment that wants to join to IS network or build one.
Functional Unit	A unit which is selected by user which is the “product” flow located in output section of the system.
Geography	Platform allows user to pinpoint the location of the operation* via Georeferencing feature (*Unit Process/System Model/Facility/Network)
GHG	Greenhouse Gases Including; ●Carbon dioxide(CO_2) ●Methane(CH_4) ●Nitrous oxide(N_2O)●Hydrofluorocarbons(HFCs- a group of several compounds)●Perfluorocarbons(PFCs-a group of several compounds)●Sulphur hexafluoride(SF_6)
Industrial Symbiosis(IS)	Industrial symbiosis is a form of brokering to bring companies together in innovative collaborations, finding ways to use the waste/by product from one as raw materials for another.
Input	Entry of flow
Input Flow Type	It designates the type of input flow such as “Primary”, “Secondary”, “Energy”, “Economic” and “Other”
Inventory	The list of dataset
KPI	Key Performance Indicator is a measurable value showing the effectiveness of a facility/company with respect to the relevant business objective(s).
Login	Sign in to the platform by using username and password respectively.
Marketplace	A module aims to attract possible users, facilitate the collection of information related to industrial symbiosis (IS), search for georeferenced IS opportunities among facilities and monitor the established IS.
NACE	Classification of activities in European Union.
Net Value Added	In business economics, net value added is obtained by deducting consumption of fixed capital (or depreciation charges) from gross value added which is the (revenue – cost of goods and services purchased)
Network	Cluster of companies including exchange links between facilities.
Other(s)	Other flow type (Input or Output)
Output	Generated output(s) of a process.
Output Flow Type	It designates the type of output flow such as “Emission”, “Product”, “By product”, “Emission” and “Others”
Password	Key to access to the platform
Platform	An environment executing the FISSAC Industrial Symbiosis Software
Possible Waste Transfer Scenario	Waste/By Product Exchange figures that can be edited by user in Network Module.
Primary Raw Material	Primary raw materials are the product of the primary production sectors, which encompass the extraction of natural resources from the environment and their transformation through processing or refining.
Process	Single or multiple tasks following each other that transforms input flow(s) into output(s).
Raw Material	Raw materials are basic substances or mixtures of substances in an untreated state except for extraction and primary processing.
Save	This feature is available in every module where necessary keeping the data of the user in a designated repository.
Secondary Raw Material	Waste materials identified for their potential for recycling or reprocessing to generate raw materials
Share	It is a feature of the platform used for sharing flows, unit process, system models, facilities and even private projects with other users.
System Model	A model including single or multiple unit processes.
Turnover	Turnover represents the sales made by a company of its products/services in a period, which can be a month, quarter, half-year or full year. Turnover is usually expressed in monetary terms.
Unit Equivalence	User can define additional units to a flow (e.g. Unit cost or other types of equivalencies)
Unit Flow	Simplest Unit of Design Module (Either it can act as “Input” or “Output”)
Unit Process	A unit describing a full or a portion of process by means of Unit Flow(s)
User Type	Type of user having different access level to different modules of the platform.
Waste	Any substance or object which the holder discards or intends or is required to discard. The major difference between wastes and by-products lie behind their existing use, economic value and treatment (or disposal) needs.
Workspace	GUI where user can see its owned/attributed project(s) or create or select a project.

Showing 1 to 40 of 40 entries

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Figure 41 Glossary (Screenshot taken from FISSAC IS Platform)

Project funded by the European Union's Horizon 2020 research and innovation programme under grant agreement Nº 642154.

Table 40 Survey Questions and Answers

#	Questions	Choice 1	Choice 2	Choice 3	Choice 4	Choice 5	Choice 6
1	Have you ever used a sofware specific to Industrial Symbiosis?	Yes(Please Specify)	No				
2	Have you ever been involved in an Industrial Symbiosis related project(s)?	Yes	No				
3	Which type of user did you choose during the registration to the FISSAC IS Platform?	Symbiosis Expert	Facility Owner	Network Manager	Technology/Solution Provider	Observer	
4	Do you find this platform useful?	Yes	No(*)				
5	How satisfied are you with this platform's ease of use?	Extremely Satisfied	Very Satisfied	Somewhat Satisfied	Not So Satisfied	Not at all Satisfied	
6	Which module(s) is more serviceable for you?	Opportunity Identification (Marketplace)	Process Design	Facility and Network Design	Opportunity Assessment		
7	Which sector are you involved currently?	Text only					
8	Do you have any thoughts on how to improve this platform?	Text only					
9	What is your purpose of using this software platform?	Sustainability Report Through KPIs	Finding Industrial Symbiosis Opportunities	Communicating with other companies	Monitoring the facilility performance	Evaluating Cleaner Production	Just Looking Around
10	Will you continue to use this tool in future?	Yes	No				

OSTİM
ORGANİZE SANAYİ BÖLGESİ

1132

Sayı: BM 1132 /2020 /02/2020
Konu: Ekodenge Hk.

Dear Madam/Sir,

OSTİM Organized Industrial Zone (OSTİM from hereon) is one of the pioneering industrial districts in Turkey, currently hosting more than 6.200 facilities active under 17 industrial sectors, a majority of which is SMEs. OSTİM has a strong commitment to sustainability and OSTİM management has supported its facilities with capacity building, technical assistance and R&D projects towards more efficient manufacturing practices over the years. In order to Ostim OIZs regional development strategy,, OSTİM has created 7 clusters on renewable energy and environmental technologies, construction machinery, medical sector, defence and aviation, rubber Technologies, rail systems and ICT.

OSTİM is always seeking new concepts and partnerships to improve the general environmental performance of the manufacturing activities in its boundaries. For this purpose, upon the introduction of the FISSAC IS Platform, OSTİM is exploring the possibility of utilizing FISSAC IS Platform as a network manager in order to monitor the energy efficiency of its facilities. Furthermore, the possibility of developing an industrial symbiosis demonstration project, in partnership with Ekodenge, in order to extend use of Platform to wider industrial audience will be explored.

Adem ARICI
Region Manager

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Figure 42 Ostim OIZ Letter of Interest for FISSAC IS Platform

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