HORIZON 2020

European Connected Factory Platform for Agile Manufacturing

European Factory Platform

WP9: Implementation of Embedded Pilots and Validations

D9.3: Implementation and Validation through Pilot-3

Vs: **1.0**

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Short Abstract

The deliverable describes the implementation and validation of developed solutions in the Circular Economy Pilot.

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History

See Annexe B: History

Status

This deliverable is subject to final acceptance by the European Commission.

Further Information

www.efpf.org

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Project Partners:

Executive Summary

The purpose of this document is to structure and document the actions carried out in the **Circular Economy (CE)** pilot with a particular focus on requirements validation, user value proposition and EFPF solutions usability.

Basis, therefore, are the already performed technology development tasks as well as the additional needed ones resulting from the feedback of the EU reviewers (official review on 02.09.2020), which reads as follows:

"Good overview and progress of the pilot applications are provided; however, these applications should be clearly linked with pilot requirements. The validation of requirements is not clearly visible. Also, it was not entirely clear how these applications will be used by the target users, e.g. on Cloud or in the premise."

"The workplace environment solutions (with Visual Analytics) received reviewers praise. A suggestion was to check whether compliance with any regulations can be achieved through this solution."

Therefore, this document will link the software tools and services developed in the EFPF project (in the following, generally referred to as solutions) to the existing requirements in the CE pilot. Additionally, for both existing and new user requirements, the validation strategies are defined, and practical validation activities are documented. Moreover, this deliverable describes how the digital solutions, which have been developed based on the pilot partners' requirements, can deliver value to the target users in the **circular economy domain.** Afterwards, each developed solution is evaluated with the help of a set of questions to assess the perceived usability and the essential features and benefits.

This document describes the existing and the additional **circular economy** user stories/requirements, which have been developed during the past months and were not part of the requirements document initially submitted to the EU in the early stage of the project. The new requirements use the predefined structure with relevant epics, user stories and activity diagrams; and are maintained in the JIRA repository.

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0 Introduction

0.1   EFPF Project Overview

EFPF – European Connected Factory Platform for Agile Manufacturing – is a project co-funded by the H2020 Framework Programme of the European Commission under Grant Agreement 825075 and conducted from January 2019 until December 2022. It engages 30 partners (End-Users, Technology Providers, Consultants and Research Institutes) from 11 countries with a total budget of circa 16M€. Further information can be found at www.efpf.org.

To foster the growth of a pan-European platform ecosystem that enables the transition from "analogue-first" mass production to "digital twins" and lot-size-one manufacturing, the EFPF project will design, build and operate a federated digital manufacturing platform. The platform will be bootstrapped by interlinking four base platforms from FoF-11-2016 cluster funded by the European Commission early on. This will inform the design of the EFPF Data Spine and the associated toolsets to fully connect the existing user communities of the four base platforms. The federated EFPF platform will also be offered to new users through a unified Portal with value-added features such as single sign-on (SSO), user access management functionalities to hide the complexity of dealing with different platform and solution providers.

0.2   Deliverable Purpose and Scope

The purpose of this deliverable, "D9.3 Implementation and Validation through Pilot-3", is to document the activities in the project with a particular focus on the **circular economy** pilot.

0.3   Target Audience

The deliverable is declared public, and therefore its content can be used to raise the awareness of the project among broader audiences.

0.4   Deliverable Context

This document is one of the cornerstones for achieving the project aims. Its relationship to other documents is as follows:

- **Description of Action (DOA):** Provides the foundation for the actual research and technological content of EFPF. Notably, the Description of Action includes a description of the overall project work plan.
- **D2.3 - Requirements of Embedded Pilot Scenarios:** Provides an overview of pilot requirements for digital manufacturing and innovative factory solutions that can address the lot-size-one and closed-loop manufacturing needs of companies in the different industrial domains.

0.5 Document Structure

This deliverable is broken down into the following sections:

- **Section 0: Introduction:** An introduction to this deliverable, including a general overview of the project, an outline of the purpose, scope, context, status, and target audience of the deliverable, is provided.
- **Section 1: Circular Economy Pilot:** An overview of the pilot, including the actors involved and describing the problems to address in the pilot environment.
- **Section 2: Methodology of Pilot Implementation:** How the pilot has been implemented and validated. User stories with specific parameters have always been defined considering their relationship with the tools offered by EFPF.
- **Section 3: User Stories (US):** The different user stories that make up the pilot are described in detail, indicating the corresponding requirements, value to end-users, the validation process and conclusions.
- **Section 4: Concluding Remarks**
- **Annexes:**
  - **Annexe A:** Questionnaires for Solution Evaluation
  - **Annexe B:** History

0.6 Document Status

This document is listed in the Description of Action as "public".

0.7 Document Dependencies

This document has no preceding documents or further iterations.

0.8 Glossary and Abbreviations

A definition of standard terms related to EFPF, as well as a list of abbreviations, is available at https://www.EFPF.org/glossary

0.9 External Annexes and Supporting Documents

Annexes and Supporting Documents:

- Mastos, T. D., Nizamis, A., Terzi, S., Gkortzis, D., Papadopoulos, A., Tsagkalidis, N., Ioannidis D., Votis K. & Tzovaras, D. (2021). Introducing an application of an industry 4.0 solution for circular supply chain management. *Journal of Cleaner Production*, 126886.

0.10 Reading Notes

- None

1   Circular Economy Pilot

1.1   Pilot Description

Life-Cycle Assessment (LCA) is a widely used technique to assess environmental impacts associated with all the stages of a product's life from raw material extraction through materials processing, manufacturing, distribution, use, repair and maintenance, and disposal or recycling. Compliance with LCA requires manufacturing companies to establish collaborations with different stakeholders in the waste management domain. Similarly, highly customised solutions and special projects in the waste management domain require agile supply chain networks to respond to dynamic customer demands. In the case of EFPF partner KLEEMANN (KLE), a global

Figure 1: CLSC scenario in EFPF pilot

manufacturer of Lift Systems, Escalators, Moving Walks and a specialist in lot-size-one projects such as anti-vandal lifts, oil rigs, marine solutions, requires agile relationships with different partners and suppliers in the waste management domain to be compliant with LCA regulations. KLE works with waste management companies, e.g. ELDIA (ELD), the largest waste management and recycling company in Greece, to dispose of solid waste. KLEEMANN's waste is screened to recover materials (paper, wood, plastics, metal, pallets, and glass) and then recycled for use in several industries from different sectors.

In this circular economy model, the value of products and materials is maintained for as long as possible, bringing significant economic benefits to innovation, growth and job creation. This pilot in the EFPF project focuses explicitly on realising closed-loop supply chains (CLSC) in the KLE ecosystem. The return processes and the manufacturers in the network intend to capture the additional value and further integrate all supply-chain activities.

The pilot scenarios address the agile supply network through circular economy activities involving KLE, ELD and other European companies from the business ecosystem of KLE. At present, the supply chain and business relationships in the KLE ecosystem lack the visibility and tracking of waste. The companies also face lag in material transition phases, and the ecosystem poses entry barriers for new innovative European companies to join the market. Therefore, the pilot realisation focuses on establishing Closed-Loop Supply Chains (CLSC) at the European level. The KLE intends to capture the additional value and further integrate supply-chain activities through return processes.

Moreover, the pilot also focuses on providing new business opportunities to European companies through their inclusion in the different levels of the waste management supply chain. The tools and services provided by EFPF will support the overall process to ensure risk management, regulatory and environmental compliance, and optimising the production and waste management processes. The EFPF tools and services will play a crucial role in designing, executing, monitoring, and optimising ad-hoc collaborative processes to deliver time, cost, and service improvement benefits.
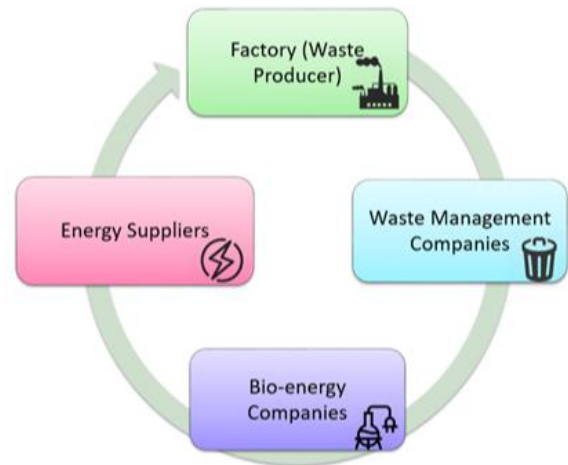
An overview of the Circular Economy Pilot stakeholders and the identification of challenges/problems is provided in the following table:

	Pilot: "Lot size 1 in Closed-Loop Supply Chain."
Problem description	• Lack of a marketplace for collecting and selling industrial waste in a closed-loop supply chain • Limited shop-floor automation and absence of real-time data or visibility in the supply chain • Complex collaboration procedures, rules and diversity of IT systems within the supply chain • Supply chain management (between KLE, ELD, MIL and other companies in the waste management ecosystem) lacks IT systems integration, leading to inefficiencies.
End-user	KLE, ELD, MIL
End-user type	Large Industry, SMEs
Product type	Industrial Waste (Steel, Scrap metal, Wood)
Expected Pilot Demonstrators for closed-loop supply chain	1. The EFPF platform will enable SMEs to take part in closed-loop supply chain activities of collecting, processing, and selling industrial recyclable materials through the marketplace (for cross border collaborations), governance rules and smart contracting 2. EFPF will enable the integration of IT systems (KLE, ELD, MIL and other companies) in the supply chain to bring more visibility across the distributed activities, to help in regulatory and compliance procedures and to support real-time decision support for the supply chain 3. EFPF will reduce the burden of finding relevant partners for lot-size-one tasks/jobs through automated matchmaking 4. EFPF platform will facilitate the improvement of resource efficiency through the design and monitoring of distributed processes, ensuring visibility of dependencies, conflicts and status

1.2 User Roles

The user roles in this pilot are derived from three different companies:

KLEEMANN:

- **Recycling management specialist for non-hazardous material:** This role is responsible for the recycling management of the company.
- **Purchasing Manager**: This role is responsible for the purchase of goods and services. Tasks, among others, include searching for the best quality products at competitive prices, seeking collaborations with reliable suppliers and negotiating contracts and prices.
- **Maintenance Manager**: This role is responsible for maintaining the shop floor's equipment/machine and its regular operation.

ELDIA:

- **Purchasing Manager**: This role is responsible for the purchase of goods and services.
- **Operations Manager:** This role is responsible for production management.
- **Managing Director**: This role is the head of the company and ultimate decision-maker.

MILOIL:

- **Purchasing manager:** This role is responsible for the acquisition of goods and services.

1.3   Problems to solve

The following problems are identified as the most important to be faced in the domain of the circular economy pilot:

- Use of traditional communication means
- Lack of automated waste tracking and tracing procedures
- Lack of shop-floor automation, including the absence of real-time data
- Lack of visibility throughout the entire supply chain
- Lack of a marketplace comprised of closed-loop supply chains
- Complex collaboration procedures and rules and diversity of IT systems
- Entry barriers due to limited awareness of business opportunities
- Lack of interoperability and integration of enterprise systems

2 Methodology of Pilot Implementation

During the requirements elicitation process, the pilot requirements were documented as epics, user stories and activity diagrams. In the context of the EFPF project, these terminologies mean the following:

- **User Story:** A user story is an informal, natural language description of one or more features needed of the EFPF platform and federated ecosystem.
- **Epic:** An epic is a big chunk of work with one common objective, e.g. a business function or business requirement. One epic can be broken down into several user stories
- **Activity Diagram:** An activity diagram is a way to describe a process by representing the flow from one step to another, where a step can relate to an operation either by a human, organisation or software. We use activity diagrams to represent user stories in more detail.

The documentation of requirements in the form of epics, user stories and activity diagrams allow technical teams to quickly understand the required features (e.g. new technology or enhancement in existing technology) from target users' perspective. The pilot requirements provide the basis for the definition of platform requirements (in D2.4), which describes what is needed to deliver the federated EFPF platform in several iterations.

2.1 User Stories

A user story is an informal, natural language description of a software system's features. User stories are written by and/or from the perspective of an end-user. The scope of the user stories is carefully defined to facilitate ease of understanding for the development teams and serve as a basis for communication.

In the EFPF project, a user story is composed of three parts:

- User role (Red)
- Desired action (Purple)
- Receive benefit (Green)

As an example:

As a <user_role>, I want <desired_action> so that <receive_benefit>

Each user story is completed by an 'Acceptance Criteria' to provide means for verifying and accepting the implemented features. The Acceptance criteria, which can also be referred to as "requirements, " reinforce the user story's scope and provide a clear indicator for completing the required functionality. Each user story must have one or more acceptance criteria, allowing the technical teams to test when the desired actions from the user story are implemented.

As an example:

Acceptance criteria:

- Capability to search for logistics services and retrieve results according to indicated parameters (i.e., origin, destination, delivery time, etc.)

2.2   Parameters of the User Stories

Each User Story includes the following seven parameters:

- **Short description:**
  Describes the User Story (US) in a comprehensive way
- **Requirements and acceptance criteria**
  Shows the criteria and their fulfilment in a comprehensive form
- **Fulfilment of US through EFPF:**
  Technical overview of the components involved in the implementation of the user story
- **Testing and evaluation:**
  Shows examples from the testing and evaluation process
- **User value proposition:**
  Describes how the specific applications gain value proposition to the end-users
- **Compliance with Standards and regulations:**
  If relevant compliances are secured to specific standards and regulations, they will be indicated here
- Lessons learned and Outlook

End-users describe their experience during implementation and list all issues/problems faced for each US and the consequent effects or response by the relevant project. The Technical Partners' questionnaires were also used to collect the feedback in a structured manner.

2.3   Links to EFPF Solutions

The table below shows the link between each user story from the EFPF CE pilot and the technology solutions developed in the project. As observed in the table, each user story can be considered as:

- **Fully covered**: the EFPF solutions have covered all (or the most relevant) requirements demanded in the user story.
- **Partially covered**: there are some relevant requirements that the EFPF solutions have not covered.
- **Not covered**: those use stories whose most relevant requirements have not been covered by the EFPF solutions provided.

	Epics and User Stories	Fully covered	Partially covered	Not covered	EFPF solution involved
Epic 1	Enable the Integration of IT systems and Blockchain technology in the Supply Chain to Bring More Visibility and Real-time Support Across Distributed Activities While Keeping Regulatory and Compliance Procedures				
US 1	Bins' fill level monitoring	☒	☐	☐	S 2
US 2	Blockchain verification to improve transportation security and reliability	☒	☐	☐	S 12
US 3	Blockchain traceability to improve closed-loop supply chain management	☒	☐	☐	S 12
US 4	Trusted and secured information flow across the CE partners	☒	☐	☐	S 14
Epic 2	Online Bidding Process for Circular Economy Enabled by Automated Matchmaking				
US 5	Online bidding for processed wastes	☒	☐	☐	S 13
Epic 3	Search for specialised products/services				
US 6	Search for new customers and market research for specialised product customers	☒	☐	☐	S 4

Epic 4	Data Analytics for the Optimization of Procedures Related to Circular Economy Activities				
US 7	Optimization of Planning Activities for Effective Waste Management through EFPF Platform	☒	☐	☐	S 11
US 8	Optimization of Planning Activities for Purchasing New Materials	☒	☐	☐	S 11
US 9	New predictive maintenance solution	☒	☐	☐	S 11

Table 1: Link between CE user stories and EFPF solutions

The table below enumerates the EFPF solutions to provide a quick reference. For more detailed descriptions of the solutions, please visit the EFPF website[1] and EFPF portal[2].

No	Solution	Relates to Pilot	EFPF Components Covered	Tools and Services Covered
S 1a	Solution 1a: Production Optimisation (Predictive Maintenance)	Furniture	EFPF Portal, Data Spine – Message Bus, Data Spine – Integration Flow Engine, EFPF Security Portal (EFS), Service Registry	Industreweb Collect Factory Connector, FCGMT, Anomaly Data Solution (ADS), Predictive Maintenance Tool, Deep Learning Toolkit (DLT), ROAM Risk Tool, Secure Data storage
S 1b	Solution 1b: Production Optimisation (Operator Error)	Furniture	Data Spine – Message Bus, EFPF Security Portal (EFS), Service Registry	Industreweb Collect Factory Connector, FCGMT, Industreweb Display
S 2	Solution 2: Bin Fill Level Monitoring	Furniture CE	EFPF Portal, Data Spine – Message Bus, Data Spine – Integration Flow Engine, EFPF Security Portal (EFS), Service Registry	Visual and Data Analytics Tool, Symphony HAL, Symphony Event Reactor

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[1] https://www.efpf.org/offering-2

[2] https://efpf-portal.ascora.eu/

S 3	Solution 3: Workflow and Service Automation Platform	Furniture; Aerospace	EFPF Portal, Data Spine – EFPF Security Portal (EFS), Service Registry	WASP
S 4	Solution 4: Matchmaking Service	Aerospace CE	EFPF Portal, Data Spine – EFPF Security Portal (EFS), Service Registry	Federated Search, Base platform Marketplaces, Catalogue Service, Business Opportunities,
S 5a	Solution 5a: Efficient Resources Management Solutions (Visual Detection)	Aerospace	Data Spine – Message Bus, Service Registry	Industreweb Collect Factory Connector, AI Vision Service (FC component), Secure Data storage
S 5b	Solution 5b: Efficient Resources Management Solutions (Stores Monitoring)	Aerospace	EFPF Portal, Data Spine – Message Bus, Service Registry	Industreweb Collect Factory Connector, ROAM Risk Tool
S 6	Solution 6: Workplace Environment Monitoring	Aerospace	EFPF Portal, Data Spine - Message Bus, Data Spine – Integration Flow Engine, EFPF Security Portal (EFS)	TSMatch Gateway Factory Connector, Symphony Platform
S 7	Solution 7: Tendering & Bid Management	All domains	EFPF Portal, Data Spine - EFPF Security Portal (EFS), Service Registry	Business Opportunities Service, Federated Search
S 8	Solution 8: Almende Risk Analysis & Management Tool	All domains	EFPF Portal, Data Spine – Message Bus, Data Spine – Integration Flow Engine, EFPF Security Portal (EFS), Service Registry	ROAM Risk Tool
S 9	Solution 9: Catalogue Service	All domains	EFPF Portal, Data Spine – EFPF	Product Catalogue Service

			Security Portal (EFS), Service Registry	
S 10	Solution 10: Business Network Intelligence	All domains	EFPF Portal, Data Spine - Message Bus, EFPF Security Portal (EFS)	iQluster, SDK Business Intelligence App
S 11	Solution 11: Data Analytics	CE	EFPF Portal, Data Spine – Message Bus, Integration Flow Engine, EFPF Security Portal (EFS), Service Registry	Visual and Data Analytics Tool, Deep Learning Toolkit
S 12	Solution 12: Blockchain Application	CE, Aerospace	EFPF Portal, Data Spine – EFPF Security Portal (EFS)	DAML, Blockchain DApp (web and mobile application)
S 13	Solution 13: Online Bidding Process	CE	EFPF Portal, Data Spine – Integration Flow Engine, EFPF Security Portal (EFS), Service Registry	Matchmaker, Agents, Marketplace
S 14	Solution 14: System Security Modeling	CE	EFPF Portal, Data Spine – EFPF Security Portal (EFS), Service Registry	SSM

Table 2: EFPF Solutions

3 User Stories (US)

3.1 US1: Bins' Fill Level Monitoring

3.1.1 Short Description

At KLEEMANN and ELDIA, the bin's fill-level monitoring is a crucial day-to-day activity that involves several employees responsible for detecting fill levels of scrap metal and recyclable waste bins. Based on their experience, the employees estimate specific times for pick-up bins and transportation to the containers. The involved stakeholders do not know the exact time the bins and containers are packed, and this causes problems such as waste bin overflows. For example, suppose the responsible employee collects scrap metal from the piston/ cylinder plant and transports it to the factory's open-top container, and the container is full. In that case, scrap metal will be disposed of in another place, causing space problems.

This procedure is not optimized because orders do not have the same volume daily, and different waste quantities are generated. As a result, fuel consumption and traffic within the factory increase.

Hence, a solution is needed to help both companies automatically monitor the bins' fill-level so that the involved stakeholders know immediately which bins need to be emptied.

Partners involved in this user story were from the user side KLEEMANN and ELDIA and the technical side, CERTH. It should be noted that technical partners from FIT, C2K, ASC and SRFG have provided their support regarding the standard components such as data spine, EFPF portal and SSO, which are horizontally used in all the following CE user stories. The following figures demonstrate how bins' fill level monitoring is implemented at KLEEMANN's premises.

Figure 2: Fill level monitoring through EFPF platform (inside the factory)

Figure 3: Checking the gateway

Figure 4: Fill level monitoring through EFPF platform (outside the factory)

3.1.2 Requirements / Acceptance Criteria

- Access fill level live data
- Monitor fill level
- Customise the fill level notification
- Receive a collection notification

3.1.3 Fulfilment of the US1 through EFPF

The technical solution applied in this user story is the "bin's fill-level monitoring". The bins' fill level monitoring is an advanced version of the solution that has been initially introduced in the COMPOSITION project. The solution is fully integrated into the EFPF platform. Customisation of fill level thresholds and notification alerts are added in the EFPF version. The user story is fulfilled by a series of tools and components participating in this case:

1. Fill Level Sensors: The available fill level sensors to KLEEMANN and ELDIA pilot sites contain the following sub-components

   - An MB 7380 Ultrasonic sensor enables the measurement of the fill level in the container. The sensor enables the raw distance measurements from the sensor to the bottom of the container. These values are processed and then translated to fill percentage according to bin type and sensor placement – for smaller bins in KLEEMANN's production line, IR sensors (vl53l0x) were used.
   - A controller board developed by CERTH to interface with MB 7380 Ultrasonic sensor.
   - An SX1272MB2xAS Lora communication module for open-top containers that are located outdoors. For smaller bins inside the production line, a Wi-Fi module was used for connectivity.

Figure 5 Assembled sensor in case

   - A script in which the raw measurements are processed and are translated to fill percentage according to bin type and sensor placement

2. Shop-floor connectivity mechanism to gather sensors data in real-time.
3. This connectivity mechanism is based on LoRa LPWAN Gateways available on both KLEEMANN and ELDIA premises.
4. Data Spine's Message Bus (MQTT Broker) is used to publish the data from the LoRa Gateway available to a server to be available to online tools providing analytics and monitoring.
5. A web-based UI for real-time monitoring of bins fill level is available to end-users to monitor real-time the fill level of the open-top containers.

6. An email notification mechanism is also provided for notifying the user if the fill level has surpassed a predefined threshold. The user can set this threshold through the interface.
7. A Trend Analysis approach for fill level data (part of Data Analytics solutions). Trend Analysis applied to create a profile for fill level trend and define if there is an aggressive trend in how a bin/open-top container is filling. In particular, the Slope Statistic Profile method is applied to the time series of recordings (percentages) of a fill level to enable the monitoring of fill level trend.
8. EFPF Portal is used as well. All the solution's interfaces are accessible through the EFPF Portal.
9. Security aspects from Data Spine are used as well. Access to the solution and corresponding data through the portal is permitted only to authorized users.

3.1.4   Testing and Evaluation

The testing and evaluation of fill level monitoring have been running for more than six months. Validation of the fill level monitoring is done from KLEEMANN and ELDIA. Scrap metal and recyclable waste data are continuously being generated and described as a percentage indicating the fill level of the scrap metal and recycling bins. Implementing the EFPF fill level monitoring solution provides early and automated detection of scrap metal and recyclable waste fill levels to empty the bins before they get full. The solution is deployed for more than six months in both companies. The pilots have measured the time spent and costs before and after deploying the solution. They have estimated clear time savings of 15% in waste collection procedures and a 5% reduction of operational costs. The figure below illustrates some examples of the EFPF fill level monitoring dashboard.
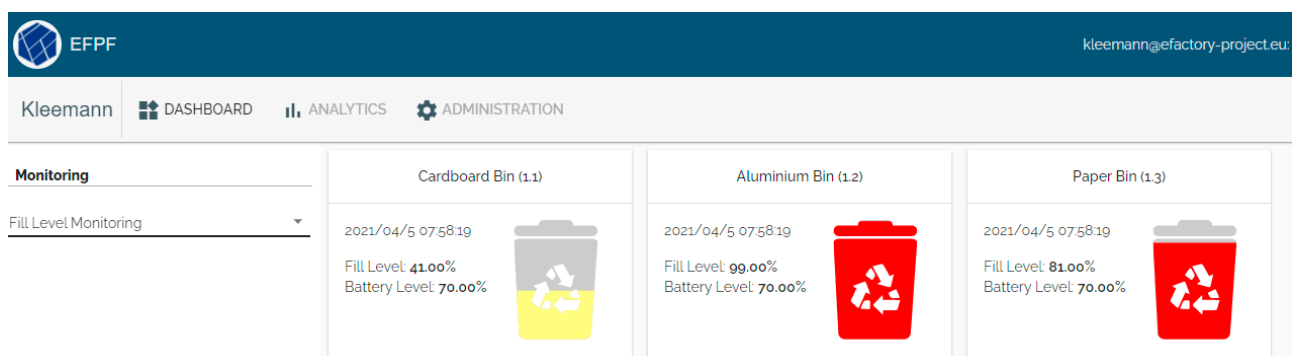
Figure 6: Fill level monitoring dashboard

The user requirements about waste collection optimisation and the corresponding acceptance criteria are:

- Access fill level live data

Figure 2, Figure 3 and Figure 4 demonstrate the way the fill level data are accessed

- Monitor fill level

Figure 6 presents a screenshot of fill level monitoring solution available to KLE and ELDIA users

- Customise the fill level notification

The end-user can set the threshold for receiving notifications related to bins fill level by using the available UI, as is depicted in the following picture
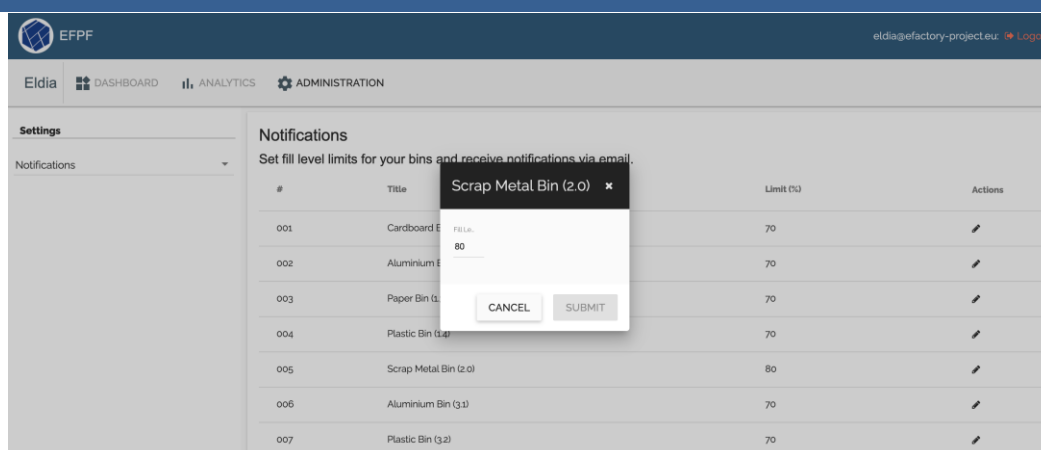
Figure 7: Set fill level threshold for receiving notifications

- Receive a collection notification

An email notification mechanism has been set up for KLE and ELDIA end-users to receive messages for the bins that need to be collected based on the threshold that has been set up

The entire identified user requirements are covered as indicated by the above descriptions of the available components. A web UI is available to the user (through the EFPF Portal) for real-time monitoring of bins' fill level, enabling the end-user to access the fill level data and monitor the bins/containers. Furthermore, warnings are available through the interface that provides different colours based on fill level percentage (green for low, yellow for medium and red for the high percentage) and the email notification mechanism. This last feature with email notification is newly added after a demand by end-users to receive emails and set up the threshold/percentage of the notification.

3.1.5   User value proposition

The proposed solution offers the following user value outcomes:

- Reduces the costs of unnecessary collections
- It keeps the site cleaner and reduces storage space
- Improves decision-making regarding waste collection management
- Enables the optimization of planning activities in waste management supply chains
- Improves safety conditions because manual fill level observations are minimised

3.1.6   Compliance with Standards and Regulations

- MQTT is used for sensors' data transmission. MQTT is an OASIS standard messaging protocol for the Internet of Things (IoT)
- The fill level measurements data descriptions are based on the ISO/OGC Observation and Measurement (O&M) model
- For the ELDIA case and the open-top container in their premises, an IDS Trusted Connector was used for data transmission over MQTT. The connector's implementation following the DIN Spec 27070 and ISO 62443-3 standards

3.1.7   Lessons Learned and Outlook

The bins' fill level monitoring solution was evaluated by target users KLE and ELDIA in real-world industrial scenarios. Based on the actual user-based evaluations of the functional and

non-functional aspects of the developed solution, the following lessons are learned. For detailed results or specific user evaluation comments/scores, please refer to Sections 5.2.1 and 5.3.1.

- The pilots feel confident with all measurements since the solution is tested for more than a year. The following statements confirm this:

> *The fill level monitoring tool has offered us tangible results, primarily through real-time notifications. Now I can use my department's resources more effectively, and I will budget an extension of the solution in all the bins within our factory next year.*

> *Waste Management Supervisor (KLEEMANN)*

> *The installation and operation of the fill level monitoring sensors will, in real-time, give a complete picture of the status of all our waste and recyclable containers located at our customers' premises, thus facilitating the planning of the routes of the Logistics Department.*

> *Managing Director (ELDIA)*

- ELDIA is also planning to extend the solution to their customers without using the LORA network
- It has been observed that in some rare cases, fill level sensors do not provide accurate measurements of open-top containers filling level.
- Real-time fill level monitoring enables optimisation of services and transport routes
- Cost minimisation due to the reduction of unnecessary collections can be achieved
- Carbon footprint reduction due to the reduction of pickups can be achieved

3.2 US2: Blockchain Verification to Improve Transportation Security and Reliability

3.2.1 Short Description

Transportation security and reliability play a critical role in all transport operations, especially in the waste management sector. Companies face significant challenges such as the lack of transparent and accurate data, which increase overall transportation costs. Reliance on paper transactions also increases processing and administration costs. Furthermore, matching shippers (the demand) with carriers (the supply) is another issue that companies need to face. The challenges above result in partial or empty truckloads. To address these challenges, a solution is needed to provide complete supply chain visibility to improve transportation security and reliability through updated, secure and reliable data for efficient decision making.

Partners involved in this user story were from the user side KLEEMANN, ELDIA and MILOIL and from the technical side CERTH and CNET.

3.2.2 Requirements / Acceptance Criteria

- Set up an order delivery/pick up (add info about stakeholders, date-time, material, photos, locations etc.)
- Secure handover with customers
- Secure and trusted notification (honest driver/company insert my place to provide order/pick up service)
- Record every stage of the pickup process in a verifiable and trusted way
- Explore details about the pickup process

3.2.3 Fulfilment of the US2 through EFPF

The technical solution applied in this user story is based on "blockchain technology". The solution ensures reliable data across the transportation operations. The main components are:

1. Blockchain-based mobile app available to the stakeholders of the transportation (i.e. drivers etc.)

2. Web application based on blockchain enables adding permissions to drivers, vehicles etc., that participate in a transportation process. Both mobile and web apps share a common blockchain back end in logging transportation information in the same blockchain instance.

3. Smart Contracts are used as a back-end part of the two DApps (web and mobile). Identity Smart Contracts, Supply Chain Smart Contracts, Logging Smart Contracts and Notification Smart Contracts are used.

4. EFPF Data Spine/Security and SSO are used for the delivery of the solution. After the registration through the EFPF SSO system, the users acquire a valid identity to interact with the BC system. For this to happen, an API resides at the Blockchain-as-a-Service platform from CERTH and communicates through the data spine with the EFPF.

5. EFPF Portal is used as well. The web application is accessible through the portal interfaces by the various stakeholders of the CE scenario. SSO is used here as well, alongside the role management services available to EFPF.
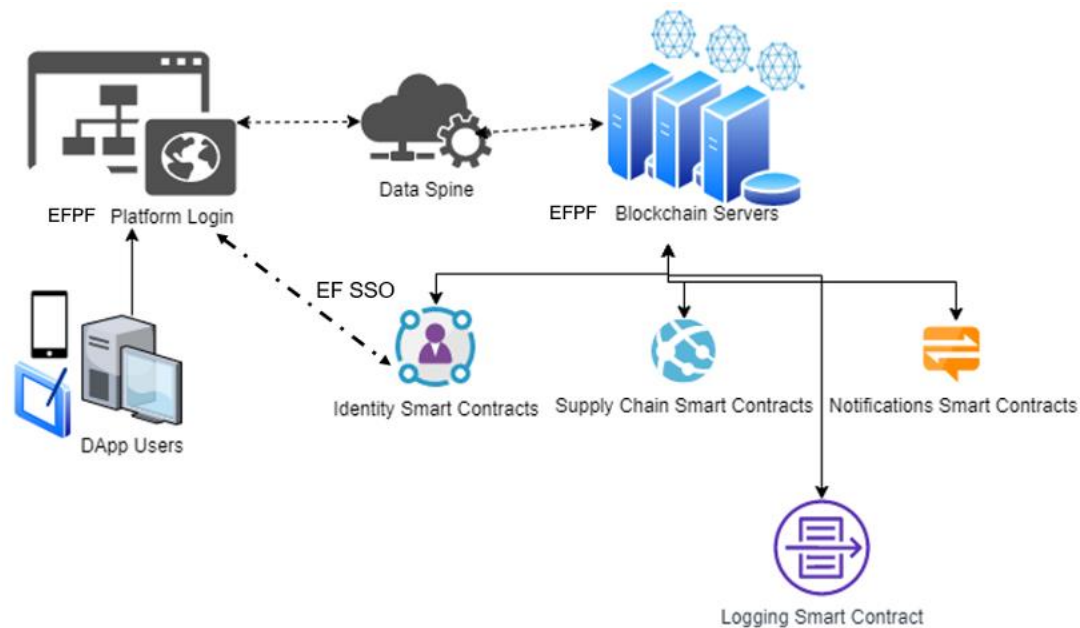

Figure 8: High-Level Architecture of the User Story 2

3.2.4 Testing and Evaluation

The three circular economy pilots (KLE, ELD and MIL) have been testing and evaluating the proposed solution for more than six months. The provided solution has satisfied the three pilots by offering clear transportation security and reliability functionalities. The information about the sender and receiver of every supply chain level, the involved drivers and trucks, as well as the type and details (pick up site, destination, driver, truck, times/dates etc.) about of the exchanged asset are logged as immutable transaction thus providing complete visibility. It should be mentioned that the testing is performed among the three companies and other dummy actors to check the functionalities in a closed-loop chain. Overall, the solution provides accurate transportation information for every supply chain stage.

The Blockchain as a Service (BaaS) solution is accessed through the EFPF platform. After the registration, the users interact with the system through their DApps which are web and mobile applications. The requirements for verifying the data for improving transparency, transportation security and reliability are fully met by the different SCs implemented and the recording of the transactions on the ledger and the user's digital signatures. The underlying cryptography and the IDM permissioning system guarantees security, non-repudiation, verifiability and transparency. The following figures illustrate how each of the requirements has been addressed by the BaaS solution.
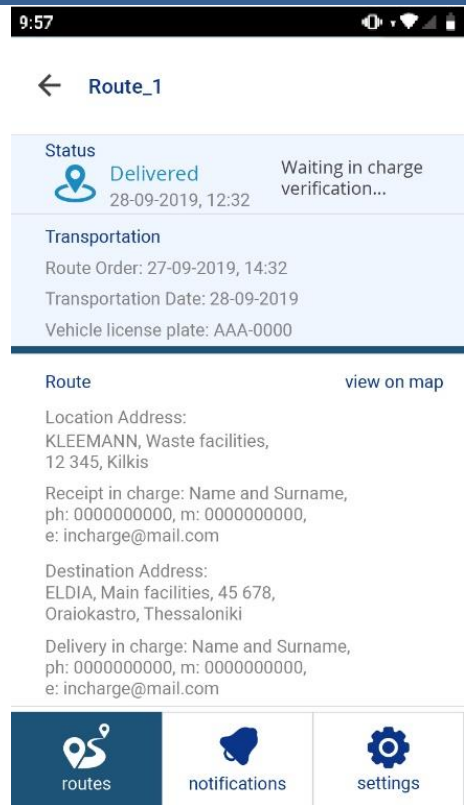
Figure 9: Set up an order delivery/pick up

- Set up an order delivery/pick up

The above figure demonstrates how the user can set up an order for delivery/pick up through the mobile application and fulfilling the corresponding requirement. It is worth mentioning that mobile and web applications share the same info logged in the blockchain. The mobile app is used by ELDIA drivers and the relevant staff in KLEEMANN and MILOIL responsible for loading and unloading the transported assets and confirming their receipt.

- Secure handover with customers

To enable a secure handover between the exchanging partners, the users can set authorized employees and vehicle details that can participate in specific transportation as presented in the following figure:
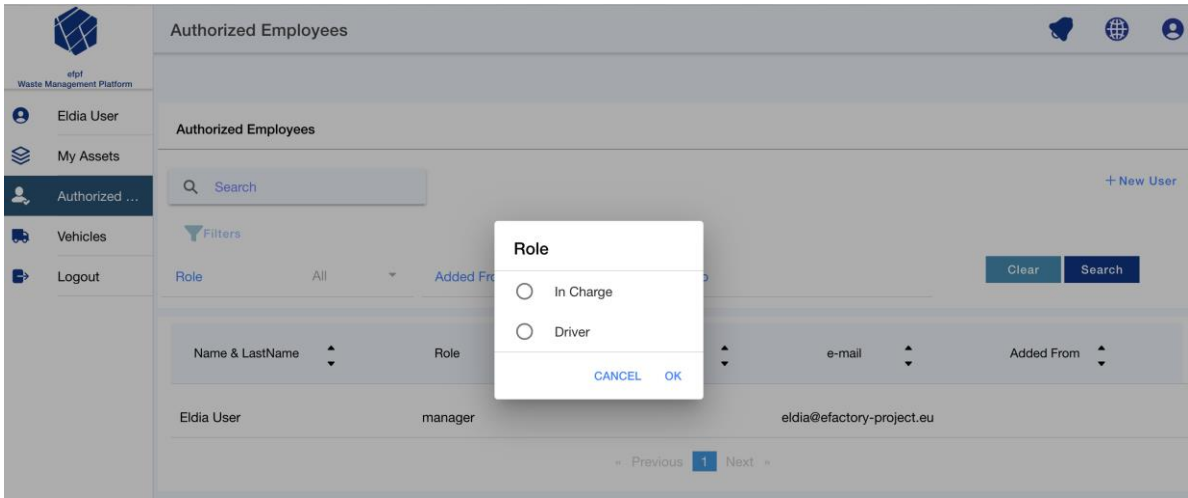
Figure 10: Secure handover with customers

- Secure and trusted notification

A notification for status changes during the transportation is available to authorized users through the mobile app interfaces as it is depicted below:
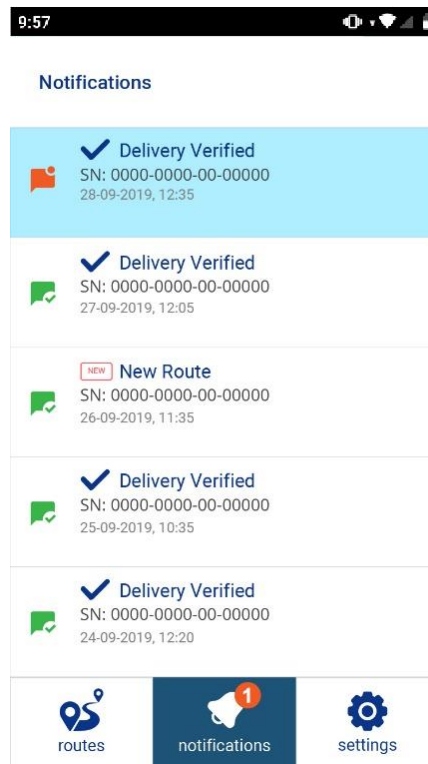
Figure 11: Secure and trusted notification

- Record every stage of the pickup process in a verifiable and trusted way

All the stages related to transportation and connected stakeholders actions are logged in the blockchain as immutable transactions. A conceptual scenario architecture about the information flaw that is recorded to blockchain and records the process in a verifiable and trusted way based on end-users requirements is available in the following figure:
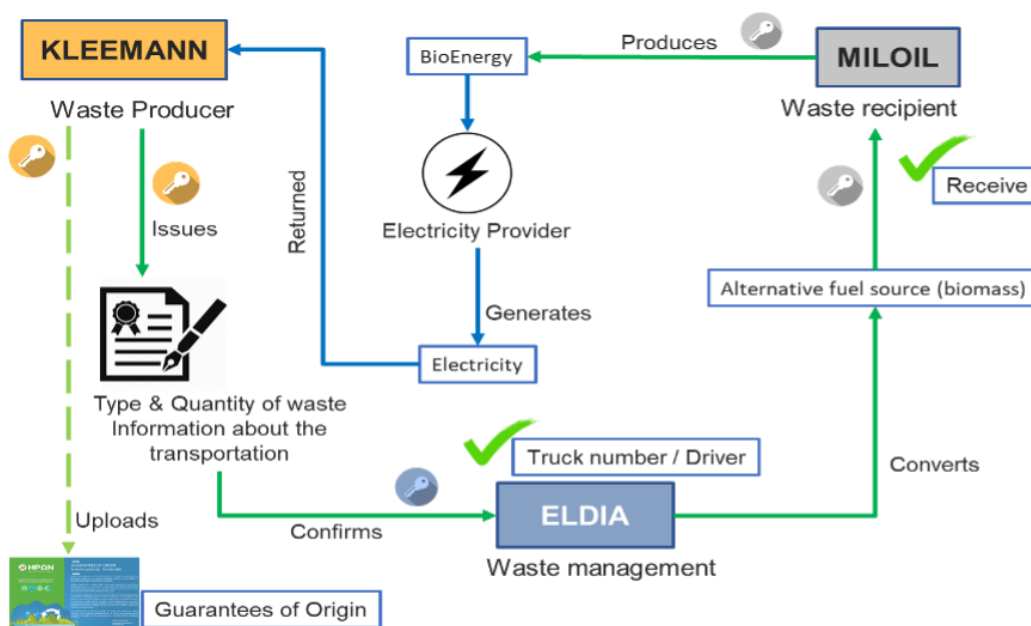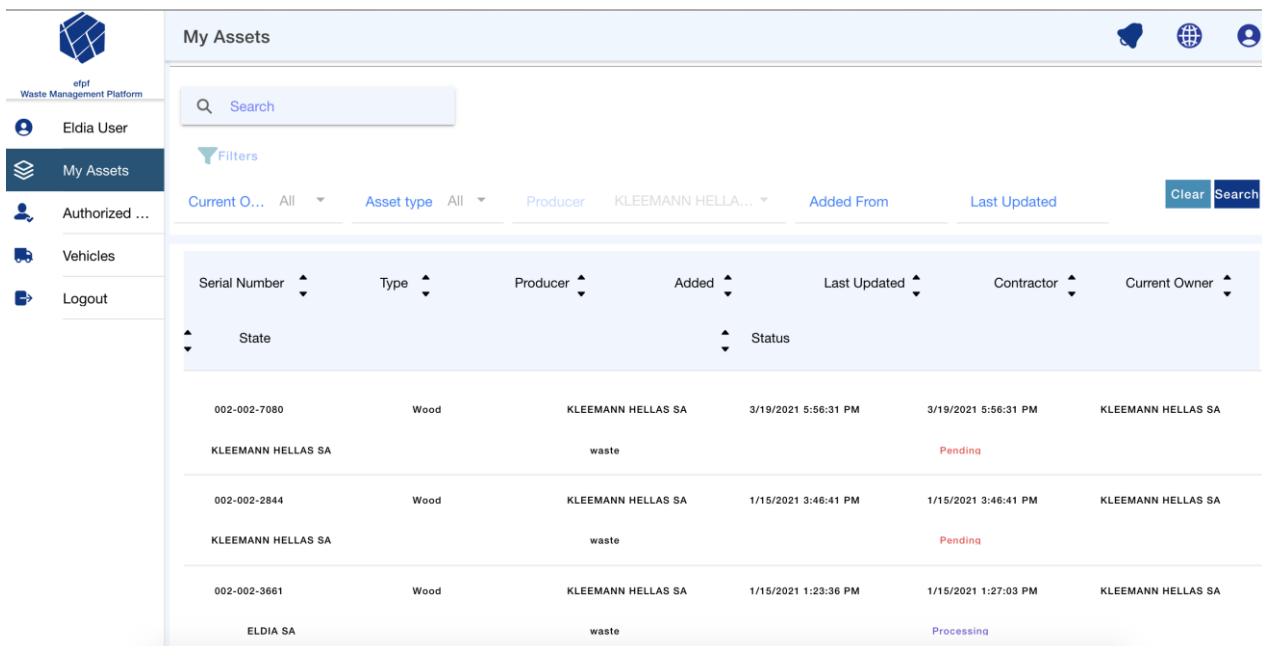
Figure 12: Record every stage of the pickup process in a verifiable and trusted way

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- Explore details about the pickup process
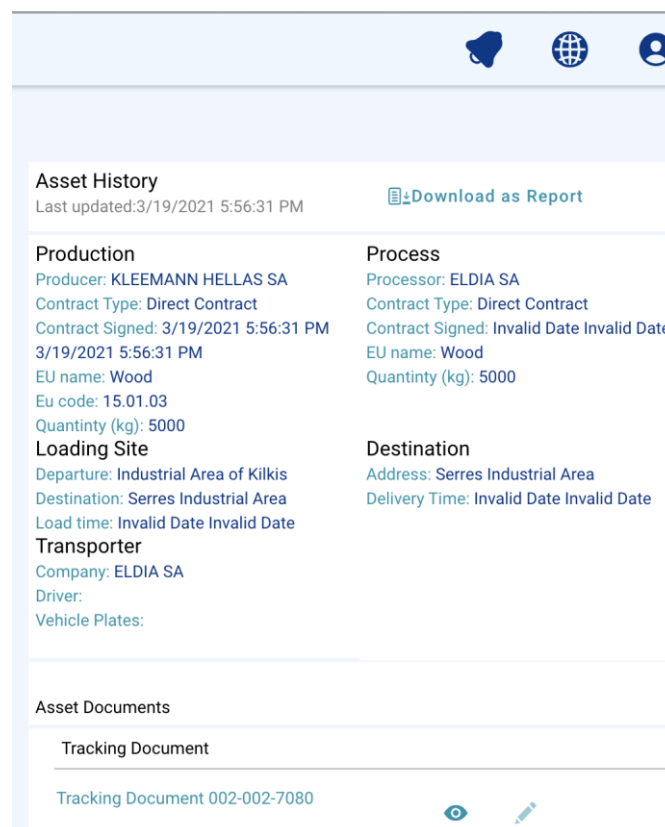
Through the web-based app, the user can explore all the available assets details that have been introduced to the application:

Figure 13: Explore details about all assets/pickup process

The authorized users are able also to see more details about specific asset transportation as depicted in the following figure containing test transportation between KLEEMANN and ELDIA:

Figure 14: Explore details about a specific asset/pickup process

3.2.5 User value proposition

The proposed solution offers the following user value outcomes:

- Supports and increases transparency in transport operations
- Ensures risk management, regulatory and environmental compliance
- Enables track and trace negotiation and delivery processes
- Reduces manual procedures related to transportation procedures
- Reduces transportations costs and use of resources
- Increases transport security and reliability in all customer services due to the complete information reports
- Enables the automatization and control of all routes executed by trucks

3.2.6 Compliance with Standards and Regulations

- **Hyperledger Grid[3] based on GS1**[4] standard was used in this user story. GS1 US assigned product identifiers are globally unique and accepted at major retailers, in e-commerce, and marketplaces worldwide. Every GS1 Global Trade Item Number (GTIN) and barcode identifies your company as the brand owner in the product data.

3.2.7 Lessons Learned

The blockchain solution was evaluated by target users KLE, ELDIA and MILOIL in their real-world industrial scenarios. Based on the actual user-based evaluations of the developed solution's functional and non-functional aspects, the following lessons are learned. For detailed results or specific user evaluation comments/scores, please refer to Sections 5.2.2 and 5.3.2.

- Transport information is shared among accredited users. The solution digitalizes the documents exchanged among the stakeholders during the different transportation phases.
- The solution offers a transparent and secure network for digital transactions.
- The solution offers complete visibility at all transportation steps, hence strengthening trust and security
- The solution is applied in three real-world companies, demonstrating that it can be extended to other companies.
- However, the solution has not run long enough to produce significant results. One factor contributing to this situation is the limited participation of companies and the limited time within the project's timeline.
- Some delays due to the COVID-19 pandemic were evident, and that has reduced the real-world iterations of the solution
- Continuous testing of the solution for the end-users to become more confident regarding its functionalities is needed

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[3] https://www.hyperledger.org/blog/2019/10/22/hyperledger-grid-and-gs1-standards-harmonizing-static-and-dynamic-data
[4] https://www.gs1us.org/b

3.3 US3: Blockchain Traceability to Improve Closed-Loop Supply Chain Management

3.3.1 Short Description

The lack of capability to track and trace assets and transactions throughout the entire supply chain is one of the critical challenges that the three companies face towards the circular economy. This lack of traceability hinders companies from quickly adapting, planning, and managing their assets effectively and optimised.

A solution is needed to help companies track and trace their assets at every supply chain stage and increase supply chain visibility without significantly increasing operational costs.

Partners involved in this user story were from the user side KLEEMANN, ELDIA and MILOIL and the technical side CERTH.

3.3.2 Requirements / Acceptance Criteria

- Record supply chain transactions in a verifiable and trusted way (Type & Quantity of waste Information about the transportation, requesters and suppliers details during bidding processes, uploaded guarantees or certification of origin etc.)
- Track waste/material/service at every supply chain stage
- Explore details about documents etc. from different supply chain stages
- Explore details that are connected with the pickup process

3.3.3 Fulfilment of the US3 through EFPF

The technical solution applied in this user story is based on the "blockchain technology" described for US2 in the previous sub-section. This user story aims to track and trace other aspects related to waste exchanged over this closed-loop supply chain besides the transportation part covered in the previous user story. However, as the two stories are connected, they are sharing standard components of EFPF. For this user story's fulfilment, the main components are:

1. Web-based DApp for track and trace of the wastes that are exchanged over this closed-loop circular scenario. Through this DApp, the digital document related to waste management is also exported.
2. EFPF portal as the solution is accessible through the project's portal.
3. Data Spine / Security functionalities such as SSO and Role Management are used

More details about the use of these components and the user story's architecture are available on US2. Therefore they are not explained further here.

3.3.4 Testing and Evaluation

The three companies have tested and positively evaluated the blockchain solution. The solution is displaying different information per user role and per organization/company role. For example, a manager of KLEEMANN who enters the system can update his/her profile, access a dashboard and manage all the company's assets that have been added and the contracts signed with other companies such as ELDIA, track the current position of each asset, retrieve specific information about the assets regarding their current state and if they

have been processed or delivered. Furthermore, in another case, a manager from ELDIA entered the system to manage legitimate drivers and vehicles for transportation and customise the transportation special requirements. ELDIA's drivers received the customized notification for new routes and assets that have to be transported. The actions mentioned above have been iteratively tested and evaluated by the three companies for more than six months.

The following paragraphs and figures illustrate how each of the requirements has been addressed by the solution

- • Record supply chain transactions in a verifiable and trusted way (Type & Quantity of waste Information about the transportation, requesters and suppliers details during bidding processes, uploaded guarantees or certification of origin etc.)

All the supply chain related to wastes exchanged in various phases of the circular economy scenario are logged as immutable transactions in blockchain applications developed.

The BaaS holistic solution takes advantage of the BC disruptive technology, specifically the Hyperledger Sawtooth HLS framework, to establish the underlying network configuration and build the necessary SCs. HLS has been chosen for the enterprise-oriented solution due to its unique characteristics that match the needs of the EFPF circular economy participants, such as the out of the box permission system and the lack of any fees upon usage. To this end, the BC is deployed as a service, which removes any need from the different parties to set up a complicated BC ecosystem on their own but instead fully automates their processes in an easy and smooth way

- • Track waste/material/service at every supply chain stage

Through the web-based interface, the end-users can track all the different stages in the transportation of an asset (waste/material). The users can see through a graphic representation the status/owner of the asset and in the same screen the full history details of the asset. The two parts mentioned above in the user interface are highlighted in the following figure: a screenshot from a test transaction between KLEEMANN and ELDIA on 19/03/2021.
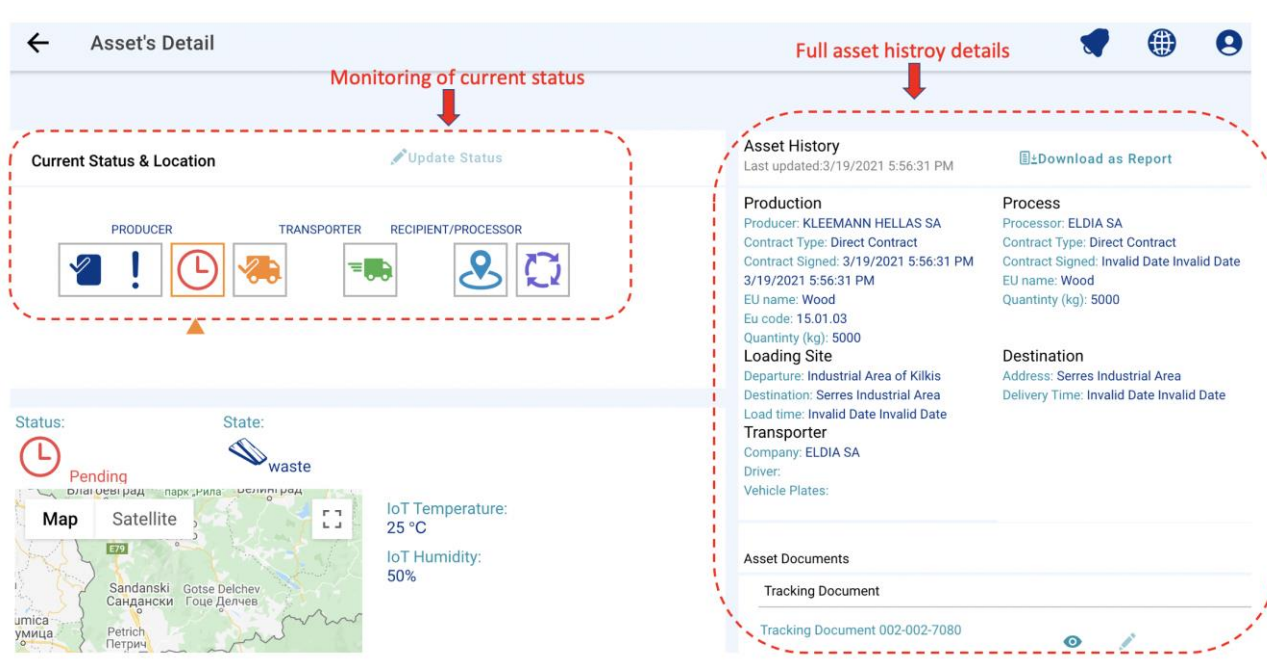
Figure 15: Track and trace interface for asset/waste

- Explore details about documents etc. from different supply chain stages

The solution enables issuing a digital certification document filled out by all the corresponding partners related to an asset and using digital signatures. Permission to edit the digital document is only available to users with the corresponding role (producer, transporter and processor) and only in the case that he/she currently possesses the asset. The following figures depict the online form that was filled out by MILOIL, which was the recipient of waste in a test between KLEEMANN (waste producer), ELDIA (transporter) and MILOIL (recipient/processor) conducted on 22/09/2020 and the exported digital document.

Figure 16: Tracking Document View

Figure 17: The Exported Tracking Document

- Explore details that are connected with the pickup process

This requirement is about the connection of mobile and web interfaces as the user should be able to monitor the pickup details (set on the mobile app) also through the web interface, something that is enabled by using the same blockchain nodes for logging information about a specific asset and its transportation as well. Figure 15 demonstrates that the information is also available to the web application.

3.3.5   User value proposition

The proposed solution offers the following user value outcomes:

- Increases customer loyalty
- Improves brand name
- Supports the overall CE processes and ensure risk management, regulatory and environmental compliance
- Enables track and trace negotiation and delivery processes
- Enables the optimisation of collaborative processes
- Reduces manual procedures
- Reduces costs and use of resources
- Provides trustworthiness of transactions and minimises risks
- All the exchanged documents, including asset tracking information among the stakeholders, are immutably logged on the blockchain

3.3.6   Compliance with Standards and Regulations

- **Hyperledger Grid[5] based on GS1**[6] standard was used in this user story. GS1 US assigned product identifiers are globally unique and accepted at major retailers, in e-commerce, and marketplaces worldwide. Every GS1 Global Trade Item Number (GTIN) and barcode identifies your company as the brand owner in the product data.

3.3.7   Lessons Learned

The blockchain solution was evaluated by target users KLE, ELDIA and MILOIL in their real-world industrial scenarios. Based on the actual user-based evaluations of the developed solution's functional and non-functional aspects, the following lessons are learned. For detailed results or specific user evaluation comments, please refer to Sections 5.2.2 and 5.3.2.

- Companies that apply blockchain technology can monitor the supply chain processes and view all the immutable historical and near real-time transactions written on the blockchain. That enables visibility and transparency and helps companies create closed-loop supply chains, one of the essential characteristics of the circular economy.
- The negotiations at every supply chain level are enabled by the automated bidding process (US 5) that improves and automates decision making as it is based on user preferences, historical data of the assessment of transactions and various ICT technologies
- The production of the certification of supply chain monitoring and eco-friendly processes is significant to improve customer loyalty
- Technology acceptance and use is still at early stages, and this constitutes an issue for all companies. However, the willingness to adopt the blockchain solution is evident.
- Confidence in this blockchain solution is one of the identified challenges that companies have reported, especially in the fields of corporate data and transactions/payments

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[5] https://www.hyperledger.org/blog/2019/10/22/hyperledger-grid-and-gs1-standards-harmonizing-static-and-dynamic-data
[6] https://www.gs1us.org/b

3.4   US4: Trusted and Secured Information Flow Across the CE Partners

3.4.1   Short Description

The large quantities of data flow among manufacturers and other organisations, including SMEs that participate in global supply chains, create an environment in which security and risk assessment are critical in all cyber-transactions. The deployment of cybersecurity solutions is an expensive process, especially for SMEs with limited knowledge and expertise in cybersecurity or risk assessment tools. This may cause a competitive disadvantage over larger organisations with dedicated resources to invest in developing and applying such solutions. The circular economy pilots also identify this challenge.

Hence, a solution is needed to help companies communicate more securely, identify existing and potential threats across the entire supply chain and mitigate their impact without increasing costs.

Partners involved in this user story were from the user side KLEEMANN and ELDIA, and from the technical side University of Southampton and CERTH.

3.4.2   Requirements / Acceptance Criteria

- Model the communication between the participating companies within the distance fill level monitoring scenario
- Definition of risks and threats to mitigate their impact

3.4.3   Fulfilment of the US4 through EFPF

The user story is fulfilled by using the System Security Modeler (SSM) tool available primarily through the EFPF Portal, connected to other core components of the EFPF platform. In particular, the realization of this user story involved the following:

1. SSM tool performs design-time ICT based risk-analysis and compliance check. It performs knowledge-based reasoning and pattern identification over system models defined by the end-users (see Figure 18). The asset models represent the topology of the physical (the infrastructure), logical (the processes) and dataflow (the data) layers.
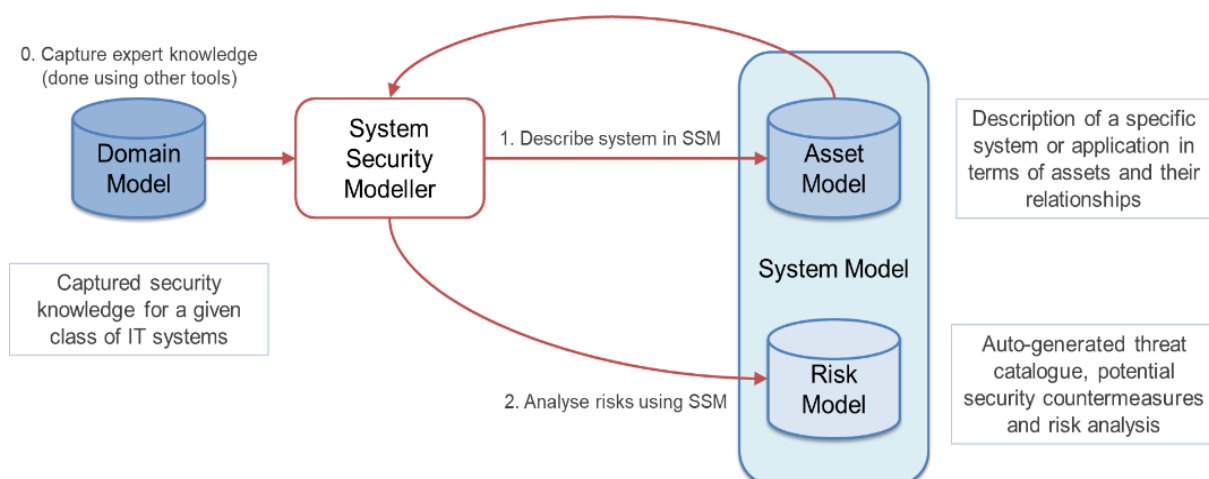

Figure 18: Overview of SSM Data Models

The main functions of the SSM tool are:

- System model management and system model construction.
- System analysis and threat identification. This includes potential regulatory compliance issues (compliance threats)
- Risk level analysis
- Navigation of attack paths and secondary effect cascades
- Compliance threats and modelling errors

2. SSM tool provides all the necessary web interfaces for the fulfilment of this user story.

  - EFPF Single-Sign-On is used as well, as the SSM relates to this core EFPF component
  - EFPF Portal is used in this case as the SSM tool offers its service through it
  - The technical solution applied in this user story is the "System Security Modeler (SSM) tool" that is connected to the EFPF portal via the data Spine.

3.4.4 Testing and Evaluation

The modelling of communication between ELDIA and KLEEMANN for remote monitoring of bins' fill level (in KLEEMANN premises) by ELDIA and the definition of the risk was enabled by using the System Security Modeler tool developed by UoS-ITI (in T4.4 of the EFPF Project). Using the tool started on October 2020 with KLEEMANN and CERTH (which has supported the existing system set up for both KLEEMANN and ELDIA), which have started to design the model that simulates the real-world communication scenario by using the interfaces and functionalities of the SSM tool.

The first part of the evaluation contains the tool's usability and the level of modelling that it enables. The tool interface was evaluated as user-friendly, enabling the creation of various systems' models quickly. Furthermore, the level of modelling that can provide was defined as well accepted by both KLEEMANN's IT staff and CERTH working on the real-world system setup. All the necessary means and components for setting up the system could be modelled by using the available assets provided by the SSM tool. A large variety of network assets (network types, routers, controllers, devices, sensors etc.), hosted assets (data, DBs, web clients etc.), spaces (public, private) and stakeholders (adults, organizations etc.) are available by the solution and enables detailed modelling of the existing system.

The second part of the evaluation is related to the risk definition and the threats detected by the tool. As soon as the modelling part was completed (December 2020), the tool's risk analysis was exported, and the results were available to stakeholders. This analysis was evaluated as very useful, detailed and concrete. The tool defines threats and risks, their root cause, their likelihood, their risk level (very high, high, medium, low, very low) and the effects of the threat. Furthermore, it was considered a unique feature of the control strategies available by the tool and support the users to mitigate risks and threats. Overall, the solution was considered to cover the needs of this user story and demonstrate a lot of potentials to be further used in other systems to provide system modelling and risk analysis.
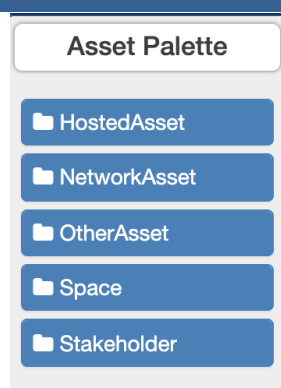
Figure 19: SSM Tool Main Asset Categories

The user requirements about the security modelling of the distance fill level monitoring between the two companies are:

1. The modelling of the communication between the participating companies within the fill level monitoring scenario

This requirement has been fulfilled as a detailed model has been created. The tool provided its web-based interface that enabled KLEEMANN and ELDIA with the support of CERTH to model the communication between the two participating companies within the fill level monitoring scenario. The detailed model is available in the following figure:
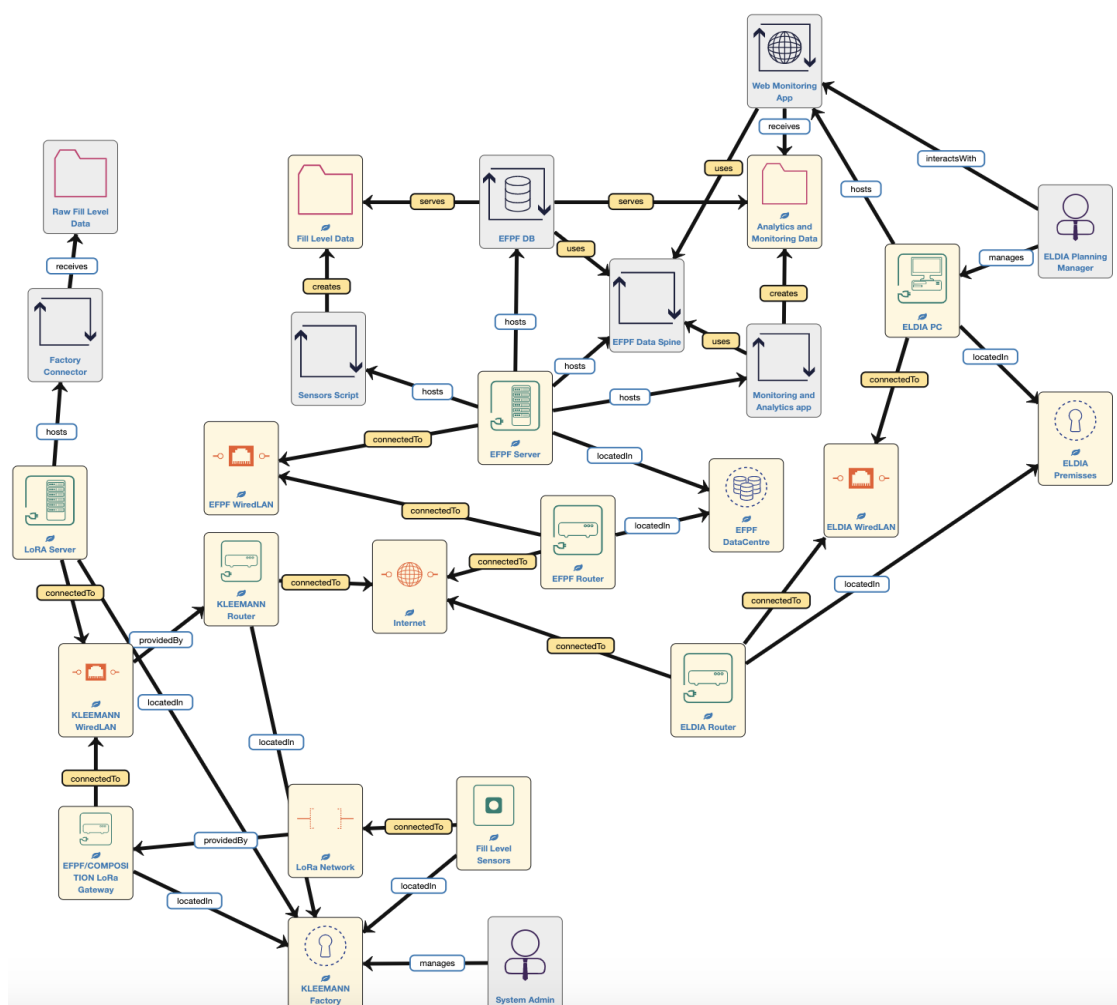

Figure 20: System Model of Fill Level Monitoring Scenario

2.   The definition of risks and threats to mitigate their impact

The tool was used to assess the existing use case, the connection between KLEEMANN and ELDIA for remote fill level monitoring, from an ICT risk level point of view, and assess the risk associated with the inclusion of new services in existing Factory Ecosystem chains. The tool autogenerates a catalogue of possible threats and potential risks. 711 treats were detected.
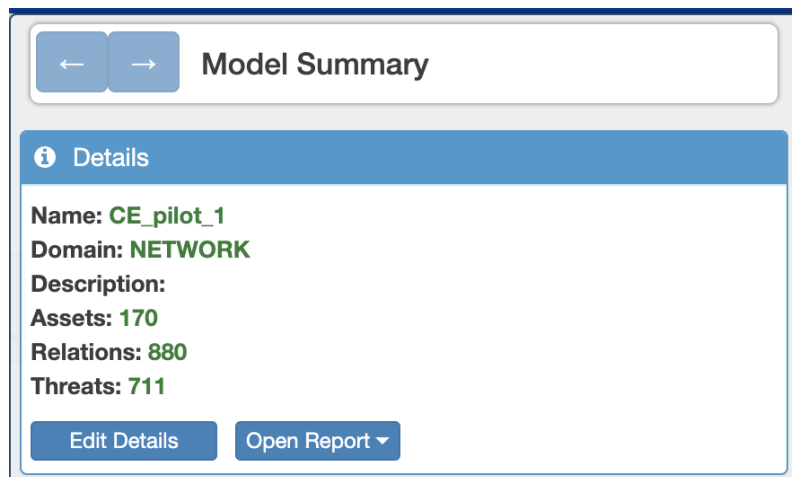
Figure 21: Model Summary

Then the threats checked one by one to define if they have been removed by security procedures followed from CERTH, KLEEMANN and ELDIA related to shop-floor installations and in general of EFPF project for the parts of the solutions that are using cloud services and components of the EFPF platform such as data spine, storage services, analytics services etc. Most of the threats were already solved by technical partners involved in the solutions. Some other threats were ignored as considered 'false positive', and some others have taken into consideration by IT departments. The above figure is a part of the final exported file/report that demonstrates the way some of the threats were handled:

Web Monitoring App

Consequence	Threats	Treatment Method	Status	Target Date	Controls
Loss of Control	• Insider attack to control "Web Monitoring App"	Mitigate	In Place	n/a	• Screening at ELDIA Planning Manager
Loss of Reliability	• Software bug (reliability) at process "Web Monitoring App"	Mitigate	In Place	n/a	• SoftwarePatching at ELDIA PC
Loss of Availability	• Malicious control of process "Web Monitoring App" • Security implementation issue for data "Analytics and Monitoring Data" • Software bug (crash) at process "Web Monitoring App" • Effect of overload at process "Web Monitoring App"	Mitigate	In Place	n/a	• HealthMonitoring at ELDIA PC • Encryption at Analytics and Monitoring Data • AccessKey at Web Monitoring App • KeyManagement at Web Monitoring App • SoftwarePatching at ELDIA PC
Loss of Availability	• Secondary threat to availablity of "Web Monitoring App" due to absent user	Ignore	n/a	n/a	
Overloaded	• Software bug overloads process "Web Monitoring App"	Mitigate	In Place	n/a	• SoftwarePatching at ELDIA PC

Figure 22: Example of Risk Analysis Export for System Part Related to Web Monitoring App

3.4.5 User value proposition

The proposed solution offers the following user value outcomes:

- Improves cybersecurity processes in closed-loop supply chains
- It allows conducting advanced risk assessments in a user-friendly way
- Enables the identification of risks throughout the circular supply chain data flows
- Protects the functioning of supply chains by demonstrating the existing complexities and assisting in developing a fast response.
- Secures various components vital for effective supply chain communication such as sensors, routers, gateways, servers, scripts and applications.

3.4.6 Compliance with Standards and Regulations

The SSM tool follows the workflow defined in the **ISO27005**[7] standard. It is a set of standards from the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) that provides guidelines and techniques for managing information security risks

3.4.7 Lessons Learned

The System Security Modeller solution was evaluated by target users KLE and ELDIA in their real-world industrial scenarios. Based on the actual user-based evaluations of the functional and non-functional aspects of the developed solution, the following lessons are learned. For detailed results or specific user evaluation comments/scores, please refer to Sections 5.2.3 and 5.3.3.

- Even though the solution is only tested for a short period, the end-users are confident that SSM will enable trusted and secure data and information flows across the entire supply chain
- A vital issue with SSM is to ensure that no supply chain partner will be exposed or threatened by any cybersecurity risks.
- The SSM tool, apart from identifying risks it also models their interrelationships and suggests a mitigation control strategy. This strengthens the tool's functionalities and helps end-users decide the risk mitigation technique they will follow.
- Last but not least, the pandemic has shown that rapid adoption of new solutions is not easy, especially for large manufacturers.

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[7] ISO/IEC 27005: 2018 – Information Security Risk Management https://www.iso.org/standard/75281.html

3.5 US5: Online Bidding for Processed Wastes

3.5.1 Short Description

The negotiation of offers and services regarding processed wastes is a very challenging procedure since it involves several organisations from different sectors (such as recycling companies) and needs fast decision making. All these procedures are conducted manually using phones and emails to select the offers and choose the best one based on specific criteria such as price, health and safety issues (regarding collection) etc. This procedure is inefficient and expensive. The three companies participating in the circular economy scenario need a solution that will provide automated bids and negotiations through an online system to obtain high-quality services and products at reasonable prices.

Partners involved in this user story were from the user side KLEEMANN, ELDIA and MILOIL and the technical side, CERTH and LINKS.

3.5.2 Requirements / Acceptance Criteria

- Initialize an online bidding process
- Choose the priority of the offer evaluation criteria
- Receive notification for a new bidding process.
- Submit an offer (predefined or new).
- Receive a ranked list of offers
- Explore details of the offers
- Select an offer
- Receive a selection /rejection notification
- Receive information for the pickup arrangement

3.5.3 Fulfilment of the US5 through EFPF

The Online Bidding Process is available to the user through the EFPF portal. An authenticated user can configure and set up a new agent and control the bidding processes using UI. A semantic framework provides matchmaking capabilities. It matches the requester agent with possible suppliers based on various criteria. It matches the request with the best submitting bid/offer to support and automate the selection process at the higher possible level.
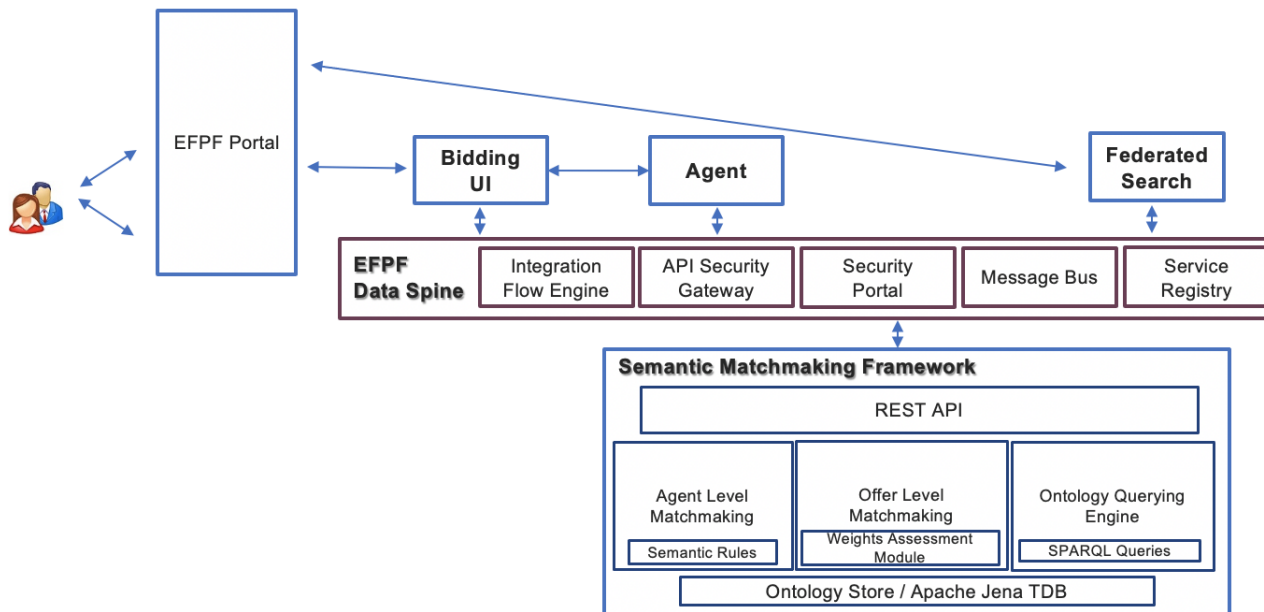
Figure 23: Online Bidding Process Solution Architecture

As depicted by the above picture, the EFPF components and tools used for the fulfilment of the user story are:

1. Matchmaker component for matches suppliers/requester and offers with request

2. Virtual Agents that represent companies in the automated negotiations (bidding process)

3. A web-based UI is the front-end part of the bidding process for the solution to be available to the users

4. EFPF Data Spine is used as well. NiFi integration flow is used for connecting services of matchmaker's semantic framework with EFPF. The matchmaker services used here are also registered to Service Registry. An API security gateway is used as well.

5. EFPF Portal is used too. The Online Bidding Process is available through the project's portal. SSO is used as well.

3.5.4   Testing and Evaluation

The three CE companies have tested and evaluated the Online Bidding Process solution for more than six months. This user story starts with the fill level monitoring (US1) using the fill level sensors' measurements at KLEEMANN's and ELDIA's facilities. When bins reach the predefined fill level set by the companies, the part of the bidding process starts. During the testing period, the online bidding process was successfully tested between KLEEMANN and ELDIA. MILOIL has also tested the online bidding process as a bio-energy company requesting processed wood-waste in scenario tests between MILOIL and ELDIA. ELDIA used the marketplace to sell the waste to bioenergy companies. MILOIL won the bidding process in the testing scenarios and arranged transportation with all the steps logged on the blockchain (US2/US3).

To sum up, the tests were performed (a) between KLEEMANN and ELDIA with KLEEMANN having the role of the requester for waste management services and ELDIA the role of the corresponding supplier and (b) between ELDIA that requests to sell the processed wastes and MILOIL that bids to buy them for producing bio-energy. For the testing scenario, each

company was represented by a virtual agent. Some dummy companies/agents were created and were part of the experiments to provide some more realistic test scenarios with more companies.

The experiments mentioned above in the online bidding process demonstrate the interconnections of the EFPF solutions and the capability of the EFPF platform to manage supply chain complexities and support decision-making. More specifically, the results demonstrate that the automated matchmaking between supply chain members and the real-time offers submission and evaluation strengthens the development of circular economy supply chains. The solution is well received from the three companies because technical partners have informed the pilot companies about the solution and provided training sessions on using it. Moreover, the user interface is well received, including most of the relevant information for the bidding process. During the experimentation/testing phase, there were many interactions between the CE pilot partners and technical partners to improve the user experience further and some capabilities missing in the initial delivered stage.

The user requirements were met through the multiple functionalities provided to the Online Bidding Process UI (accessible through the EFPF Portal). The most important functionalities are described below.

- Initialize an online bidding process

To initialize the bidding process, the user should set up/create his/her agent representative. A new agent can be registered in the system by completing a specific form with information about the company and the available services to use Online Bidding.

Figure 24: Create agent User Interface

Then the requester can initialize bidding and enter the requester's preferences for the requested service.
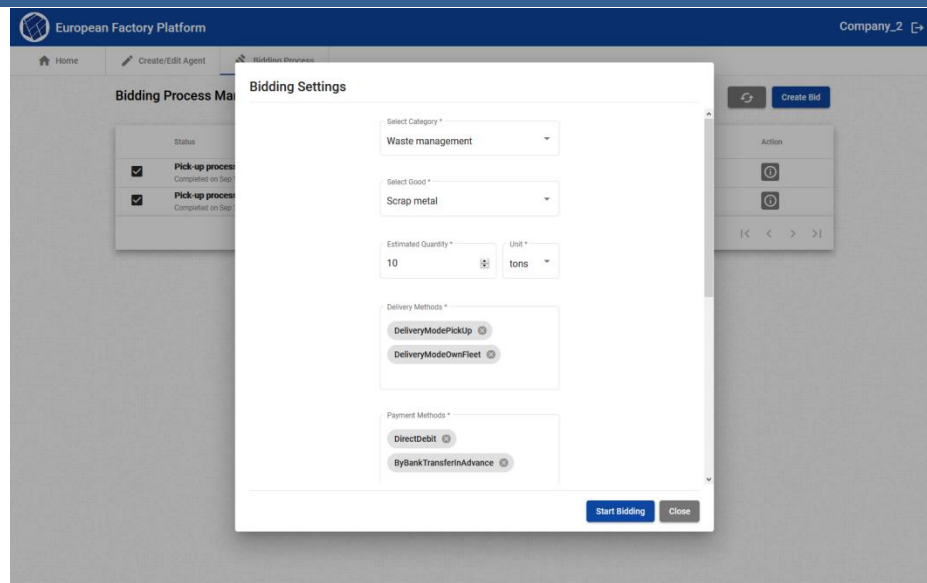
Figure 25: Initialise an online bidding process

- Choose the priority of offer evaluation criteria.

The above figure fulfils this requirement. Through this interface, a user can change the order list of the criteria that is going to be used by the matchmaking engine to evaluate the available offers. This is very important to be performed during the initialization phase of a bidding process because this is the point that the requester adds its preferences for the automated evaluation:
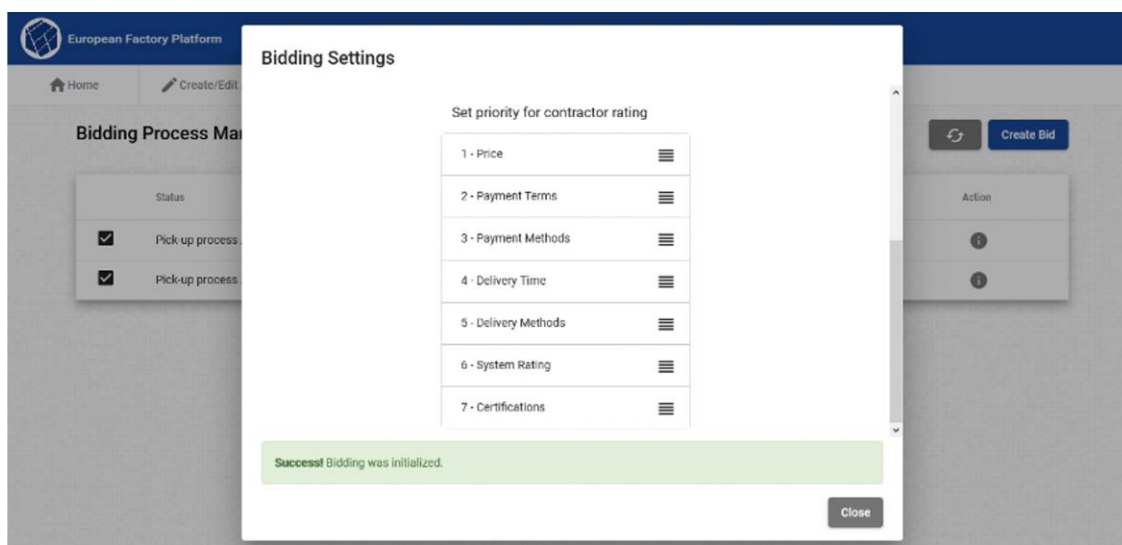
Figure 26: Choose the priority of offer evaluation criteria

- Receive notification of a new bidding process.

Both the requester and all the matching suppliers receive a notification through the solution's interface as a new entry is created in the main interface of the bidding process with the description: "Bidding Process Initialized".

- Submit an offer (predefined or new).

The supplier can receive notification for a new bidding process and submit an offer that may be pre-defined or new. The following interface enables this. As it is depicted in the figure, the user can select at the top of the pop-up interface a 'Default Offer' and send it or can create

on the fly a custom offering by adding all the necessary details (prices, delivery time and methods and payment methods) and send/submit it.

Figure 27: Suppliers offer setup User Interface

At the end of the bidding phase (all the suppliers have submitted an offer or the bidding duration has come to its end), the requester receives a ranked list of offers and suggestions for the best offer available.

Figure 28: The results of bidding User Interface

- Explore details of offers

All submitted offers' details are available to the requester if the user wants to ignore the system suggestion and be evaluated by himself.
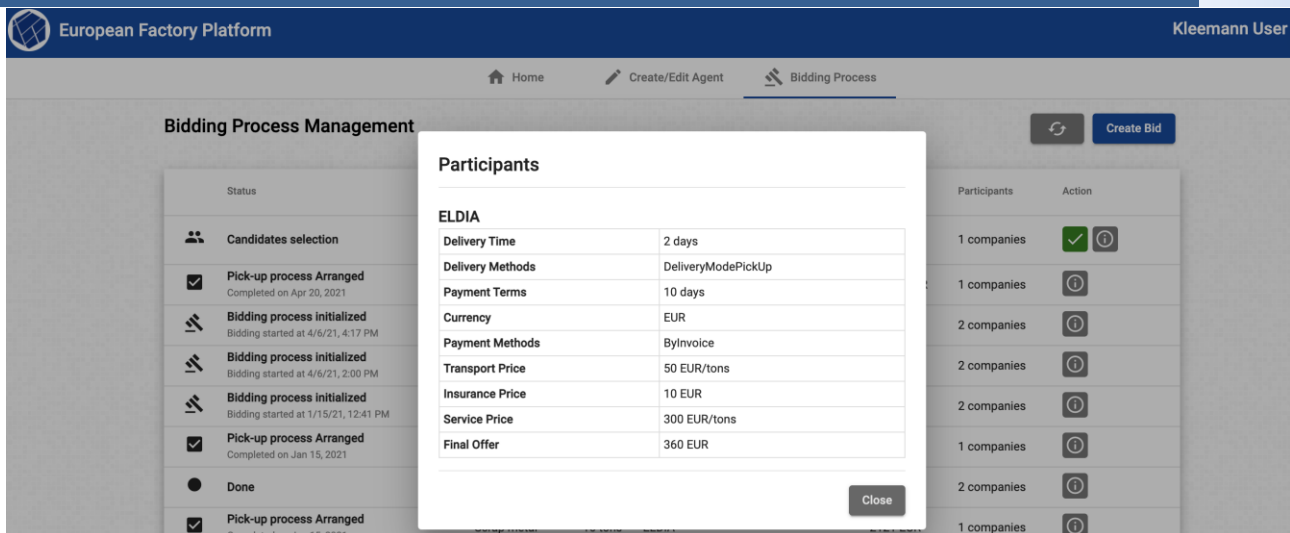
Figure 29: Details of an available offer

- Select an offer.

The user can select an offer from the drop-down list.
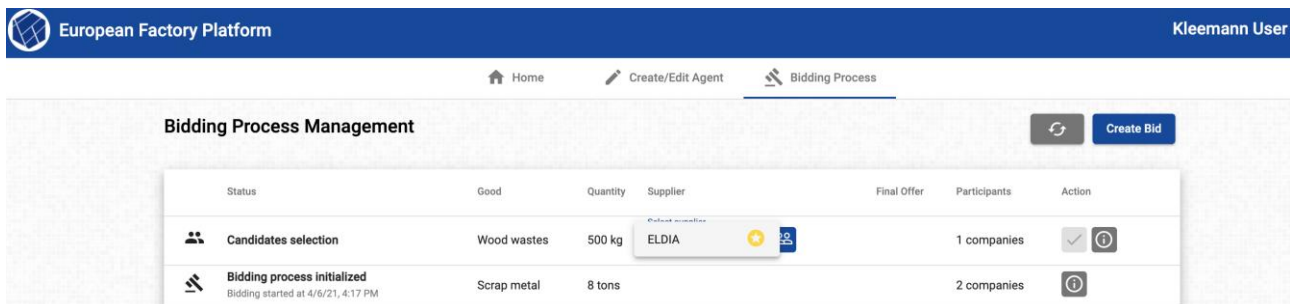
Figure 30: Offer Selection

- Receive a selection/rejection notification

Visual notification of win/lose offer in the bidding process is available to the supplier, and then she/he can move forward with the arrangements.
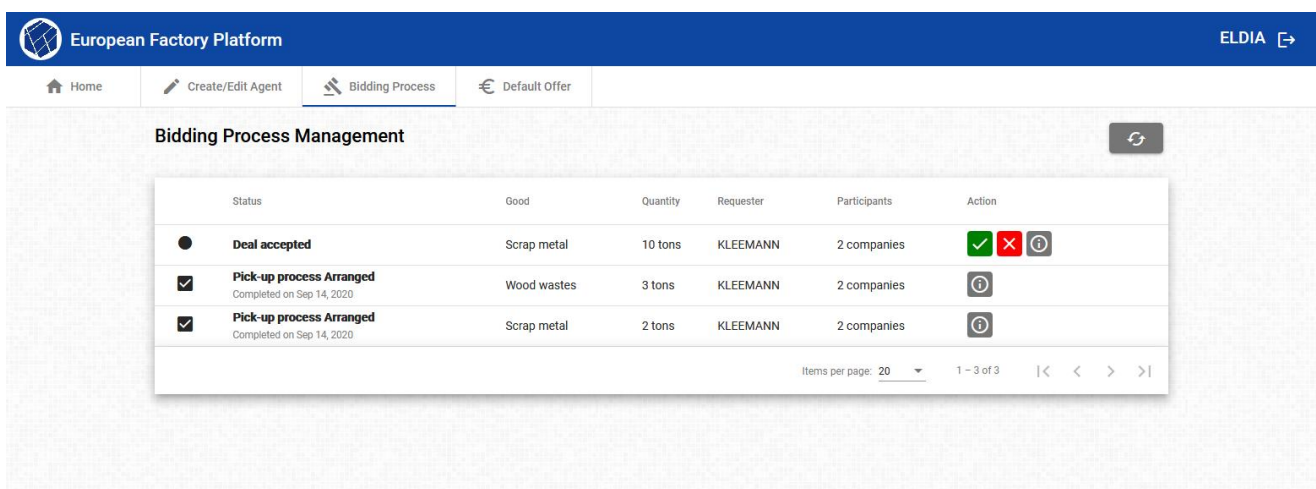
Figure 31: The supplier notification of a winning bid.

3.5.5   User value proposition

The proposed solution offers the following user value outcomes:

- Enables optimal matchmaking (right supplier and suitable material)
- Improves the design, execution, monitoring and optimisation of collaborative processes
- Enables automation and control of collection processes
- Provides automation in negotiations monitoring
- Minimises costs through efficient matchmaking

3.5.6   Compliance with Standards and Regulations

- **GoodRelations**[8] Language, **MSDL**[9] and **MASON**[10] ontologies are used to describe the companies and services of CE pilots coming from the COMPOSITION ecosystem and indexed for EFPF Federated Search and also used for the matchmaking services in the bidding process
- **FIPA/ACL** [11]was used for the communication between the Agents participating in a bidding process. FIPA Agent Communication specifications deal with Agent Communication Language (ACL) messages, message exchange interaction protocols, speech act theory-based communicative acts and content language representations.

3.5.7   Lessons Learned

The Online Bidding Process solution was evaluated by target users KLE, ELDIA and MILOIL in their real-world industrial scenarios and based on the actual user-based evaluations of the functional and non-functional aspects of the developed solution. The following lessons are learned. For detailed results or specific user evaluation comments/scores, please refer to Sections 5.2.4 and 5.3.4.

- The web-based online bidding process is an up-and-coming solution that addresses several fundamental supply chain complexities such as numerous phone calls and emails for negotiations.
- The companies that have tested the solution identified some initial improvements in time and resources, estimated at around 15%.
- However, the solution is still at the early stages before being fully commercial. The companies believe that it is only mature for the selection process and not for completing a transaction/payment process.
- Furthermore, a large-scale scenario comprised of more participants and services in the EFPF marketplace would give better insights and feedback to strengthen the developed solution. This scenario could not be tested in a large scale environment due to the limited number of end-users who participated in the EFPF project.

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[8] http://www.heppnetz.de/projects/goodrelations/

[9] https://infoneer.wp.txstate.edu/ontology-download/msdl-ontology/

[10] https://ieeexplore.ieee.org/document/1633441

[11] http://www.fipa.org/repository/aclspecs.html

3.6   US6: Search for New Customers / Market Research for Specialized Product Customers

3.6.1   Short Description

They are searching for specific suppliers that can manufacture highly customised products or provide tailor-made services that meet stringent deadlines is challenging for large manufacturers and SMEs. While SMEs have the flexibility and speed to respond to customer requests, larger companies may lack this ability. On the other hand, SMEs do not have the same business opportunities to expand their customers' network as larger companies do. The three circular economy pilot partners also identify these challenges.

Hence, a solution is needed to provide advanced search functionalities to help companies find customers and suppliers that could offer highly customised products and services without spending too much research.

Partners involved in this user story were from the user side KLEEMANN, ELDIA and MILOIL. As technical partners, SRFG, CERTH and C2K were responsible for the technical development.

3.6.2   Requirements / Acceptance Criteria

- Search for customers
- Customize search criteria
- View customer details and previous transactions ratings
- Select a possible customer
- Contact a possible customer
- Check an invitation
- Send acceptance/rejection
- Receive acceptance/rejection notification
- Negotiate online for collaboration

3.6.3   Fulfilment of the US6 through EFPF

The technical solution applied in this user story is fulfilled by various components and tools coming from the EFPF platform. The user story is strongly connected with services related to matchmaking and search capabilities of the EFPF platform and bidding mechanisms available for negotiations. In particular, the main parts for the realization of the user story are:

1. EFPF Federated Search is used to enable the discovery of possible partners and collaborators through the EFPF platform. Regarding Federated Search, a dataflow mechanism has been implemented to ingest base platform data from heterogeneous sources (EFPF base platform and other external platforms) to a standard index used as a federated search index across the EFPF platform.

2. EFPF Security Portal is used as well. Through EFPF Security Portal, the Federated Search reserves secure data exchange and communication. Furthermore, by using Security capabilities, the user can access the available search interface

3. The Data Spine, and specifically the Integration Flow Engine, which provides the federated index's main data flow, is used. The data ingestion process is implemented

as a set of Apache Nifi workflows. This data flow is triggered periodically to retrieve the latest data from the base and external platforms. In such a way, the Circular Economy scenario is engaged in the Federated Search solution. The companies' information, initially occupied in the Online Bidding matchmaking tool's back-end Ontology, is exposed to the Federated Search mechanism through the indexing mentioned above.

4. Online Bidding Process solution was described in the previous user story are used here as a tool that can enable negotiations over the EFPF platform

5. The Business Opportunity & Team Formation Tool tool is added to this user story as another tool used after searching for negotiations through EFPF. The tool supports the publication, application management and collaboration support of Business Opportunities within the EFPF framework. Business Opportunities can be included Procure Products or Services (Tender), Offer Products or Services, Find Staff resource and Call to make a Group Purchase

6. EFPF Portal is used too. The search mechanisms of the projects embedded in portal interfaces as part of its core services. Negotiations tools are also listed there.

3.6.4 Testing and Evaluation

The EFPF platform provides the functionality to search for new customers or specialized services and goods based on specific criteria. KLEEMANN, ELDIA and MILOIL have tested the solution for more than six months. The results have shown that companies can enter the marketplace and offer or request specific goods and services such as waste management services. During this period, ELDIA and MILOIL, which provide waste management and bio-energy solutions, have advertised their services to the EFPF platform, and KLEEMANN, as a potential customer, has searched for these specific solutions based on geographical and rating criteria to strengthen its circular economy strategy. Testing and evaluating this user story is performed in the first level of matching services, and more tests will continue.

Another solution focusing on stakeholder collaboration is available in the EFPF digital manufacturing platform. The solution is covered by multiple tools and core functions of the EFPF platform. The CE pilot partners have tested the solution separately, as collaboration in test scenarios, in this case, is not needed. The Federated Search functionalities and the Bidding Process tool (described in the previous user story and tested there) were available to users from September 2020 and tested for longer than six months. The TBMS tool was later available, and it is tested for a short period before this report. However, by the end of the project, the tool will be further tested and evaluated.

The tests were primarily focused on the search capabilities of the EFPF ecosystem to define how easy it is to find companies, products and future collaborators. Furthermore, it was also crucial for the CE pilots to test and evaluate if their companies are available in search results and the way they appear in them. So, the tests were about how they can find companies and how other companies can find them.

Figure 32: Auto-generated Landing Page for ELDIA

The above figure is an example of a landing page that is auto-generated for ELDIA by containing all the info for the company with data indexed from the COMPOSITION platform to the EFPF Federated Search index. The figure demonstrates how the output is if someone clicks on ELDIA in the search results.

The user story, as explained before, is fulfilled primarily by using the Federated Search tool User Interface, which is available in the EFPF Portal. The EFPF user can search for partners across the base platforms based on different criteria, e.g. capabilities, geographic locations, and acquired feedback and online rankings. The EFPF user is also able to search for products and services based on product/ service-related criteria. Figure 33 illustrates the intuitive UI for Federated Search. Furthermore, solutions such as the Online Bidding Process and Tendering and Bid Management participate in realising this user story and are connected to the negotiations' last phase.

- Search for customers

The Portal's Federated Search functionality realizes the requirement of Search for customers. The user is even provided with search term suggestions when he enters a search term to retrieve more effective search results.
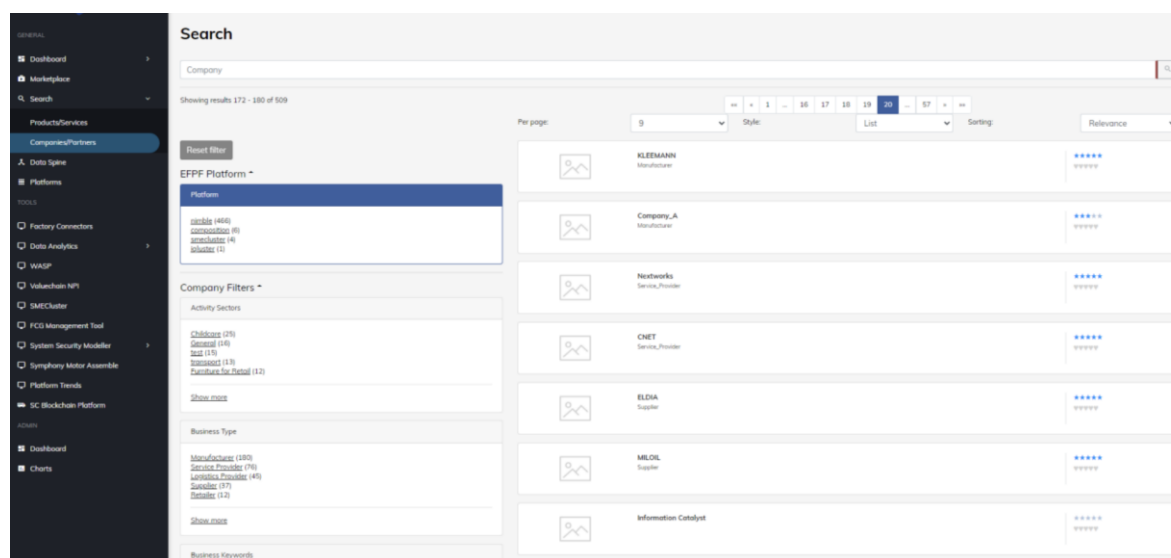
Figure 33: Federated Search user Interface

- Customize search criteria

The requirement of *Customize search criteria* is covered by the granular level filters given to drill down the results based on a range of facets based on the system's ontology. The user can narrow down his search to find the desired results.
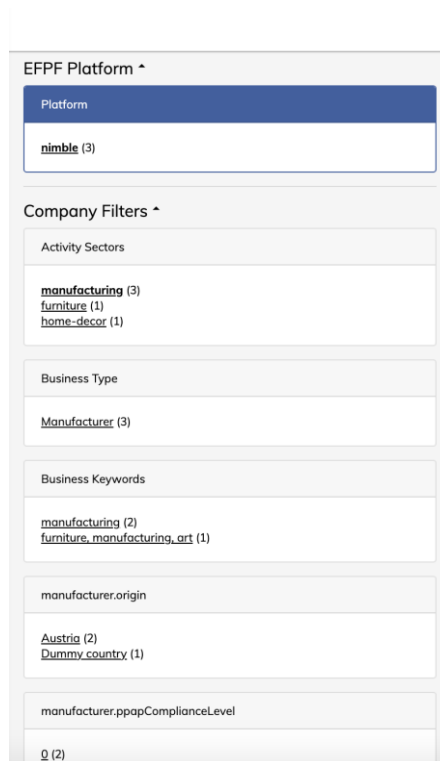
Figure 34: Filter Options User Interface

The user can click on the exciting product or service provider in the results list and view further details and options to execute a business transaction or business negotiation with the service provider. The user is redirected to the base platforms company and product pages to continue his transactions. This functionality fulfils the requirement of *View customer details and previous transactions ratings.* The figure below is an indicative example of the company landing pages User Interface.

Figure 35: Company Details page User Interface

- Select a possible customer

Select a possible customer requirement is covered by the search interface. A user can find a company and click on it to view further details and possible contact and negotiation options with this company/customer.

- Contact a possible partner

Contact a possible partner requirement is covered by multiple solutions/ways. For example, in the previous figure, a contact form is available to MILOIL company's landing page through the EFPF platform plus external links to its website. Furthermore, in the cases bidding mechanisms are available such as Online Bidding Process and TBMS, which can be used.

- Check an invitation

Check an invitation. As soon as a user searching for a customer has contacted this customer, the customer should be notified of this invitation for collaboration. If the invitation has been done through the contact form on landing pages, then the customers will receive an email as a kind of invitation. Using the Online Bidding process, a supplier will see a new open bidding process for good. In the case of TBMS, a new business opportunity would appear. However, the final solution is newly introduced to this pilot and is still in the first evaluation stages.

- Send acceptance/rejection

Send acceptance/rejection for the invitation (customer side) and receive invitation mechanism also cover this acceptance/rejection (requester side) requirements. In this case, just the contact forms are used then they are done through email conversations. If it is done through the online bidding process, then a future customer could select to not participate in the process, so the request will not receive an offer, or the customer will participate. There is an option to accept/reject a negotiation in the last phase, as depicted in the previous user story

and Figure 31. By choosing to use the TBMS solution, the customer can select or not contribute to a business opportunity.

- Negotiate online for collaboration.

Negotiate online for collaboration. This requirement is a bit covered by the previous one as there is no holistic mechanism for negotiation over the EFPF. The requirement is partially covered by the different solutions that can provide negotiations, such as automated negotiations, using the Online Bidding Process and the TBMS tool. In the figures below, the options to both tools to create are depicted:

Figure 36: Option to Create a Business Opportunity on TBMS Tool

Figure 37: Option to Initialize a Bidding Process

3.6.5   User value proposition

KLEEMANN and ELDIA came from the COMPOSITION project with no available search functionalities over a common platform. In the EFPF project, only an agent ecosystem has been set up. The first attempt of a bidding process has been implemented that was completely updated for the project's purposes. Therefore, there is the need for these companies to search for customers and services and be visible to other companies' searches. Of course, the same need applies to MILOIL, which was not participating in any of the previous projects/base platforms. The proposed solution offers the following user value outcomes:

- Improves time, costs, and service-related issues
- Offers new business opportunities, especially for SMEs
- Optimises circular supply chain management for larger companies
- Identifies suitable partners for products and services collaborations
- Improves search functionalities and interaction with other companies

3.6.6 Compliance with Standards and Regulations

- **eClass**: the eClass[12] taxonomy is a system for classification and product description. This is a mono-hierarchical classification system where the most fundamental structural element is the classification class. The latest versions include at least 38 different segments and many associated properties, which generally cover most market needs.
- **GoodRelations**[13] Language, **MSDL**[14] and **MASON**[15] ontologies are used to describe the companies and services of CE pilots coming from the COMPOSITION ecosystem and indexed for EFPF Federated Search

3.6.7 Lessons Learned

The Federated Search solution was evaluated by target users KLE, ELDIA and MILOIL in their real-world industrial scenarios and based on the actual user-based evaluations of the functional and non-functional aspects of the developed solution. The following lessons are learned.

- The Federated Search solution offers the opportunity to search for specialised circular economy partners and solutions based on different criteria, e.g. capabilities, geographic locations, and acquired feedback and online rankings and service-related criteria.
- The three companies are satisfied with the solution since most of the requirements are met. Still, more time is needed with more companies participating in the EFPF platform to test the federated search tool thoroughly.
- The negotiation tool is partially covered by online bidding and the TBMS tool

3.7 US7: Optimization of Planning Activities for Effective Waste Management through EFPF Platform

3.7.1 Short Description

The lack of automated notification of ELDIA's customers' bin's fill levels is the factor that triggered the development of a solution that will provide functionalities that will monitor the customers' bins' fill level so that the company can be notified when waste is ready for

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12 https://wiki.eclass.eu/wiki/Main_Page

13 http://www.heppnetz.de/projects/goodrelations/

14 https://infoneer.wp.txstate.edu/ontology-download/msdl-ontology/

15 https://ieeexplore.ieee.org/document/1633441

collection and optimise its planning activities for effective waste management. The developed solution will facilitate the logistics service and improve the reaction time of replacing full containers. Further analysis of the waste management data will enable possible estimations of various containers' fill-level and price and tonnage forecasting.

Partners involved in this user story were from the user side ELDIA and the technical side, LINKS and CERTH.

3.7.2 Requirements / Acceptance Criteria

- Monitor bins fill level of my customers
- Monitor the trend of fill level data
- Explore price forecast per material
- Explore tonnage predictions per material

3.7.3 Fulfilment of the US7 through EFPF

The solution is realised using various components of the EFPF project, especially Data Analytics and Factory Connectivity solutions.

1. The fill level sensors at the shop floor and the LoRa Gateway transmit fill level data described in user story 1.

2. The data are published to Data Spine/Message Bus using MQTT protocol to become available to other tools.

3. Data pre-processing and storage mechanisms of CERTH's Visual Analytics Tool

4. Data Analytics tools for time series analysis related to forecasting of future tonnages of raw materials/wastes

5. Deep Learning tool by LINKS for prices forecast for wastes/raw materials.

6. EFPF Portal enables access to the solution's interfaces. The main interface is CERTH's Visual Analytics tool that provides interfaces for monitoring and visualization of analytics tools (time series forecasting, deep learning)

7. The solution is available only to authorized users exploiting the capabilities of the Data Spine/Security Framework.

The solution architecture is available below:
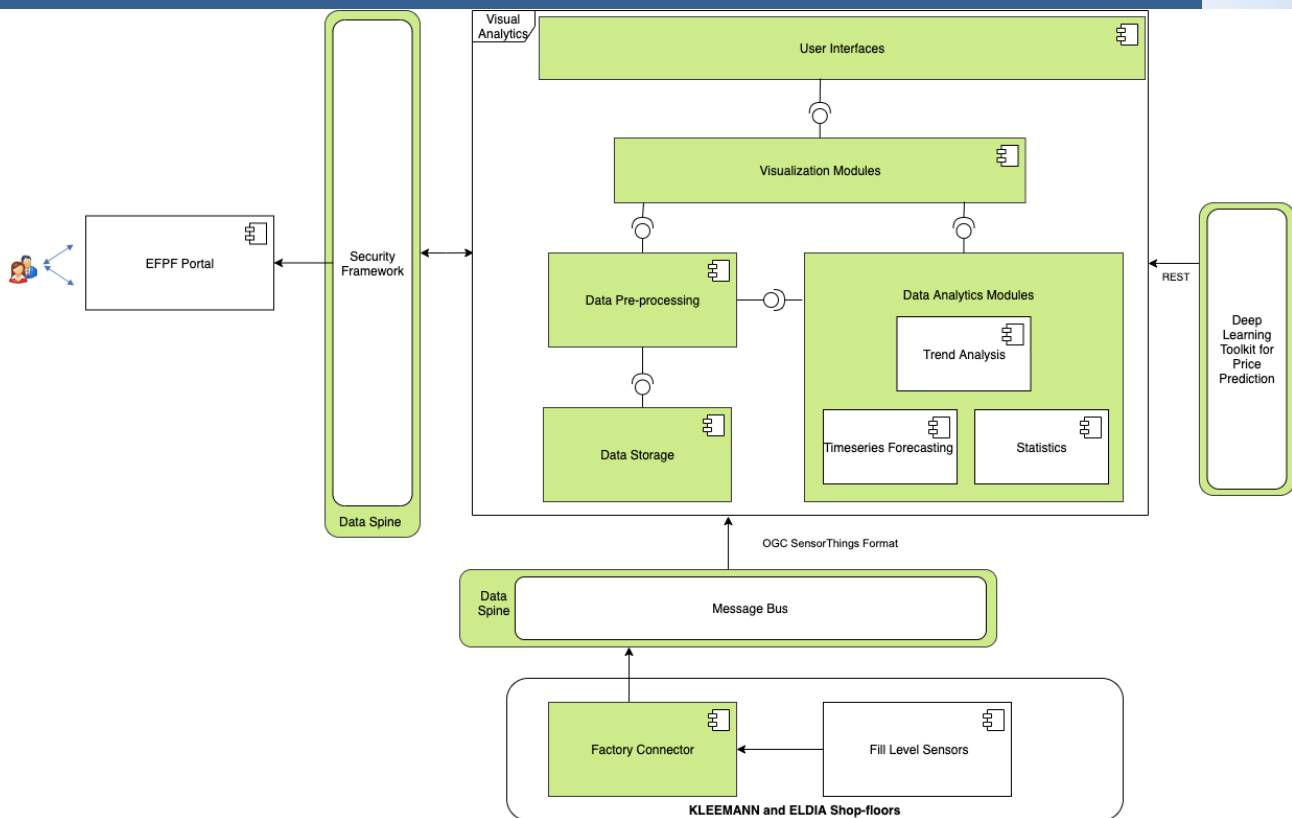
Figure 38: US7 Solution Architecture

3.7.4   Testing and Evaluation

In this user story, ELDIA has tested the solution for more than a year. ELDIA is continuously checking the fill-level monitoring of her customers' bins through the EFPF platform. The solution uses fill-level sensors that were installed during the COMPOSITION project. However, the solution is currently active and updated only through EFPF Portal, and it is entirely functional only by using EFPF infrastructure (Data Spine). The benefits of using EFPF platform infrastructure include added security, scalability, and extensibility of the solution, e.g. new data types can be easily integrated using the secure and interoperable Data Spine.

The measurements are reported to be very accurate. The data analytics tool is helping ELDIA's staff to monitor containers fill level, analyse the fill level trends, forecast the tonnage of wastes that will be transported, and perform price forecasting analysis for various types of wastes. The solution is in a mature stage, and ELDIA is using it in its day to day business. Some indicative screenshots of the EFPF solution that ELDIA uses for effective waste management and planning optimisation are listed below.
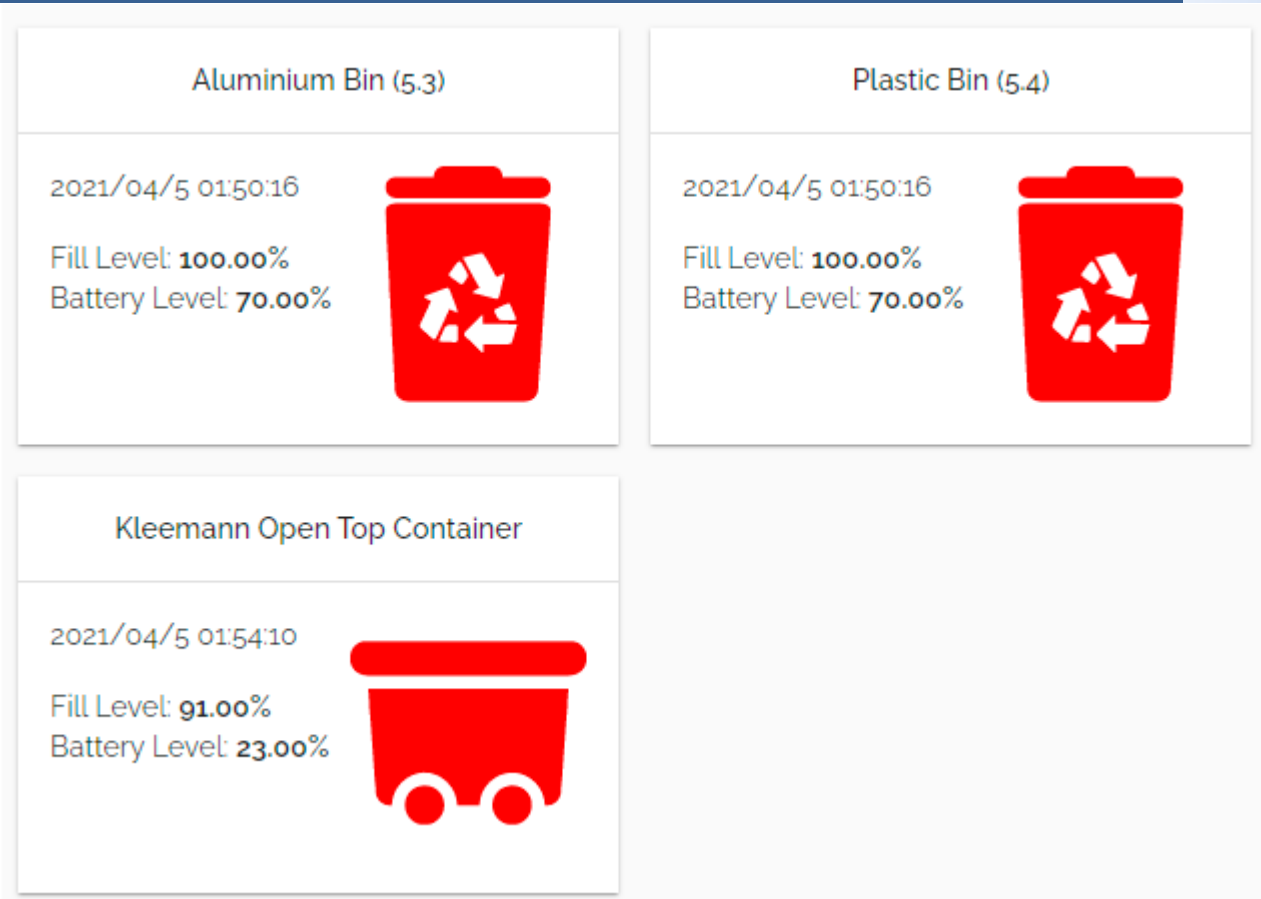
Figure 39: ELDIA's customer (KLEEMANN) fill level monitoring
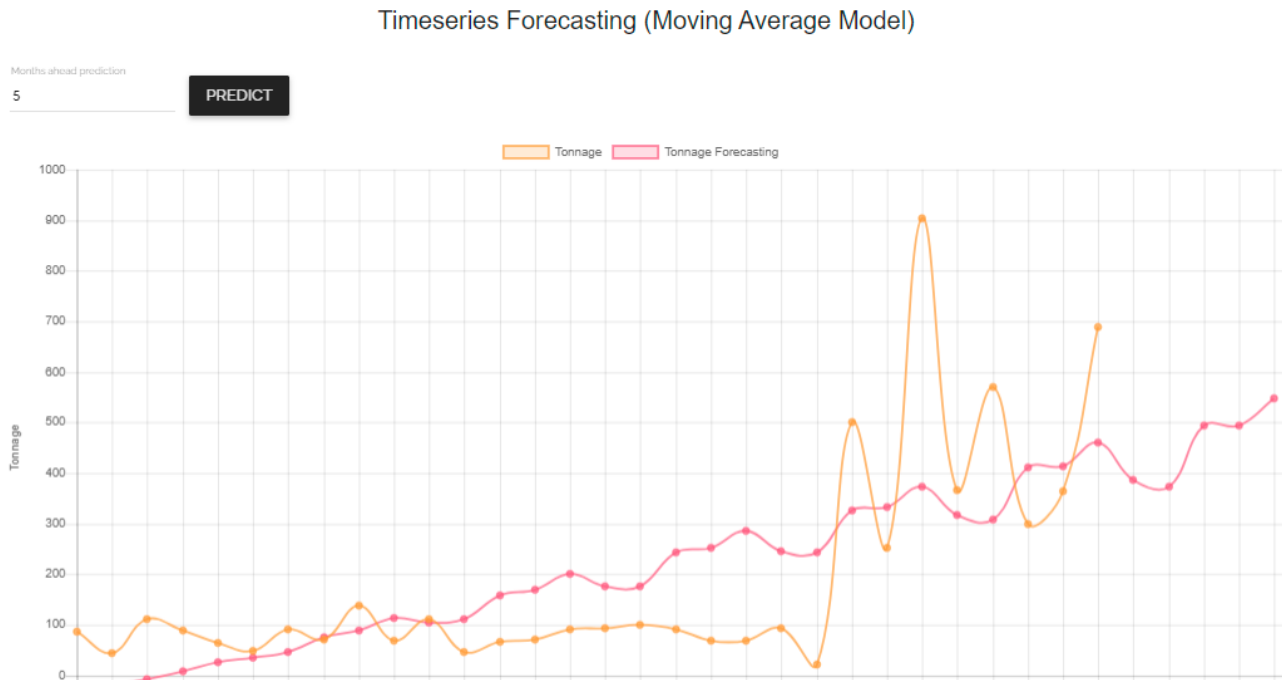
Figure 40: 5 months tonnage forecasting for brown paper

- *Monitor bins fill level of my customer's* requirement has been demonstrated how it is fulfilled and is available through the EFPF interfaces in Figure 39.
- *Explore tonnage predictions per material* requirement is fulfilled by the solutions that are described below:

Tonnage Forecasting

The Tonnage Forecasting component of the Visual and Data Analytics tool is related to estimating the future tonnage of raw material that a company will buy based on historical data. It aims to enhance suppliers' planning activities by estimating the future wastes/materials they have to pick up in the upcoming months. For EFPF purposes, the methodologies are available to ELDIA through the EFPF portal (as did the KLEEMAN case). An analytics dashboard with similar solutions has been set up during EFPF for MILOIL. The three available algorithms for tonnage forecasting are:

- Moving Average
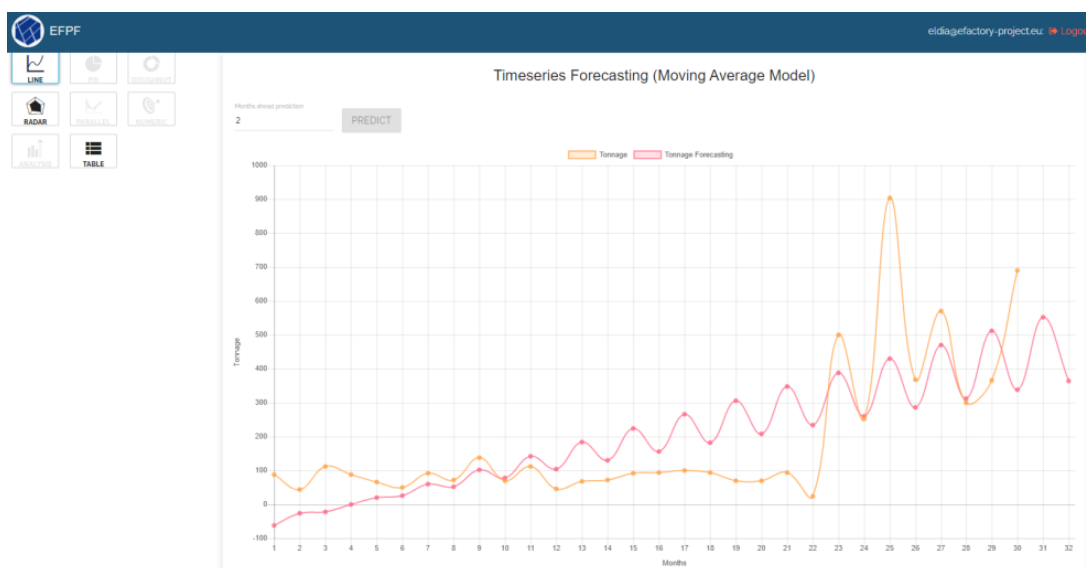
Figure 41: Tonnage forecasting with Moving Average method

- Auto-regression models
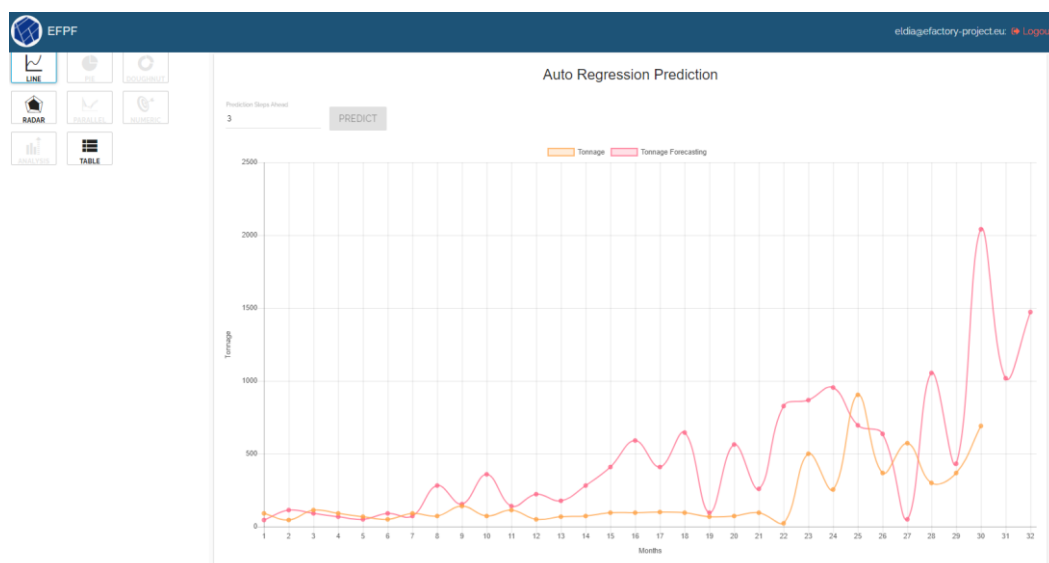
Figure 42: Tonnage forecasting with Auto-regression models

- Markov chain
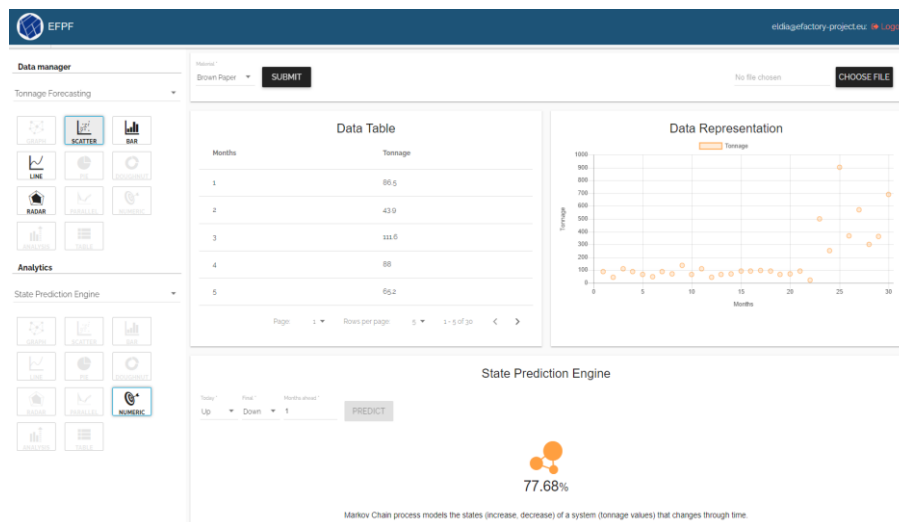
Figure 43: Tonnage forecasting with Markov Chain method

The user requirements about data analytics solution and the corresponding Acceptance criteria are:

- Deploy historical data related to previous purchases for raw material
- Explore tonnage predictions per raw material

The requirement of exploring tonnage predictions per raw material is covered within this component. The user can view tonnage predictions from the three methods implemented for this tool, as shown in the above figures. Furthermore, the requirement of deploying historical data is covered by the functionality of the Tonnage Forecasting module, which gives the user the capability of loading new data either from the Mongo DB connected to the tool or by uploading a CSV file with the historical data. The way the interface of the solution enables it is available in the following figure:
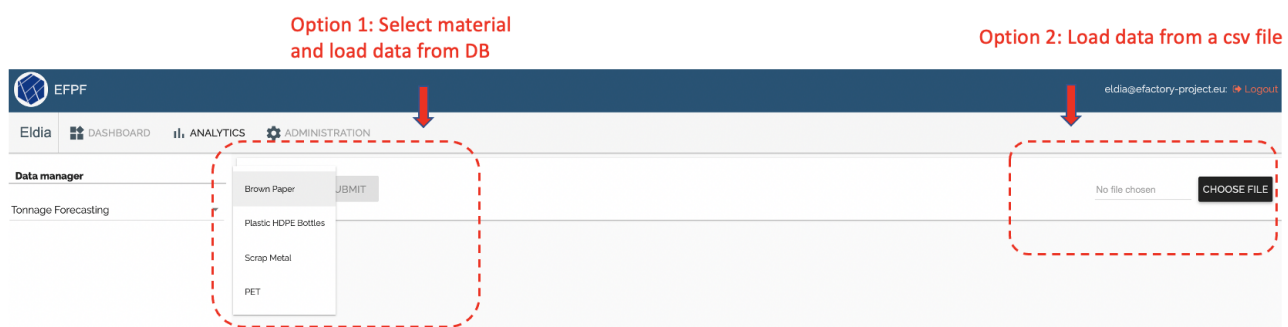
Figure 44: Load Data to Analytics tool

Explore the same user interface that covers price forecast per material requirement by selecting the corresponding method (price forecasting) in the drop-down menu instead of tonnage forecasting. Deep Learning Toolkit enables the price forecasting has been deployed by LINKS and provides its outcome to CERTH's Visual Analytics Tool.

Price Forecasting

The price Forecasting component provides the prediction for different types of materials to further support and optimize the planning activities for end-users (e.g. purchasing managers).

This module tries to predict the following values of a dataset containing information about purchases of a given good. A single instance of this module can predict the prices outlook of different goods by choosing different models when invoking the APIs. This feature can also have different models for the same good if the price behaviour changes in different scenarios.

The module can be trained using datasets already collected. Then, when deployed, it keeps learning using the single entries provided when updates to prices are issued. This process is called online learning. If the initial dataset is small, initial results can be highly inaccurate because the network predicts the results using random weights. Its accuracy improves as additional data becomes available.

The following figure shows the user interface of Price Forecasting inside Visual and Data Analytics Tool and proves the requirement to explore price forecast per raw material. The user can visualize the forecasting of price for the different types of materials.
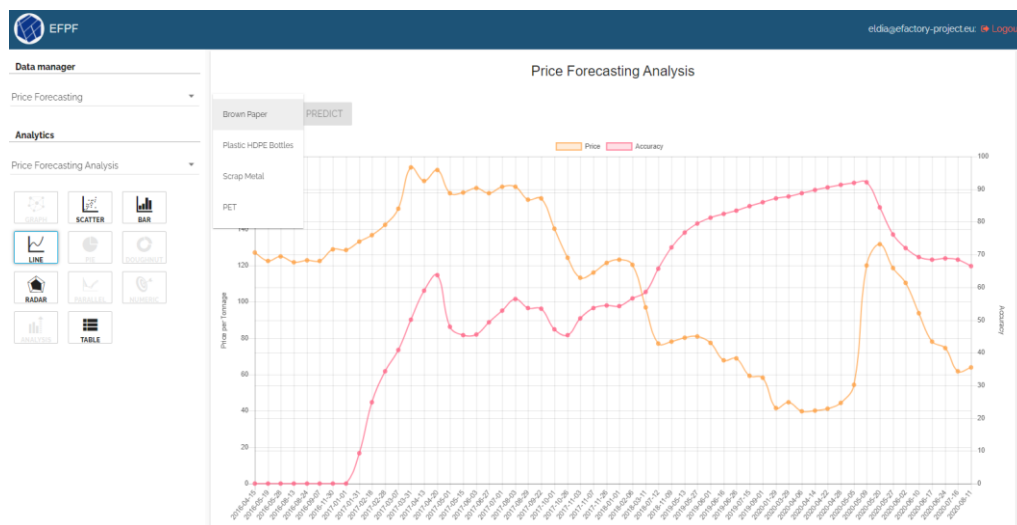
Figure 45: Price Forecasting Analysis for different raw materials

3.7.5 User value proposition

The proposed solution offers the following user value outcomes:

- Planning optimization over a waste management supply chain
- The improved reaction time of replacing full containers
- Price and tonnage forecasting

3.7.6 Compliance with Standards and Regulations

- MQTT is used for sensors' data transmission. MQTT is an OASIS standard messaging protocol for the Internet of Things (IoT)
- The fill level measurements data descriptions are based on the ISO/OGC Observation and Measurement (O&M) model
- For the ELDIA case and the open-top container in their premises, an IDS Trusted Connector was used for data transmission over MQTT. The connector's implementation following the DIN Spec 27070 and ISO 62443-3 standards

3.7.7 Lessons Learned

The Data Analytics solution was evaluated by target user ELDIA in its real-world industrial scenario. Based on the actual user-based evaluations of the functional and non-functional aspects of the developed solution, the following lessons are learned. For detailed results or specific user evaluation comments/scores, please refer to Sections 5.2.5 and 5.3.5.

- The Data Analytics and Forecasting solution are beneficial as it is of great assistance to the Management teams in their decision making based on past data.
- ELDIA has estimated that the analytics/forecasting implementation by the company's management team is offering savings of at least ½ of an employee's salary (€ 12000,00).

3.8   US8: Optimization of Planning Activities for Purchasing New Materials

3.8.1   Short Description

The rapid growth of MILOIL's contractual farming network has resulted in significant activities in the production and supply of animal feed which is the by-product of the processing of oilseeds of contractual farming. These activities require optimised procedures that will improve upstream and downstream supply chain planning. A key component to achieve optimised planning activities is accurate forecasting methods that will assist decision making especially when purchasing new materials.

Hence, a solution is needed to provide forecasting information for raw materials.

Partners involved in this user story were from the user side MILOIL and the technical side CERTH and LINKS.

3.8.2   Requirements / Acceptance Criteria

• Deploy historical data related to previous purchases for raw material
• Explore price forecast per raw material
• Explore tonnage predictions per raw material

3.8.3   Fulfilment of the US8 through EFPF

The solution is fulfilled by using CERTH's Visual and Data Analytics platform that provides UIs for data visualization, tonnage forecasting functionalities, load data from CSV files or stored data to databases, and import data database online form. Besides, CERTH's tool, the Deep Learning Toolkit by LINKS, is used as well. The solution is available through the EFPF portal. Data Spine/Security Framework functionalities are used for role management and authorized access to data and interfaces. It is based on the same technologies as the previous user story (US7). It demonstrates the application of the EFPF solution to another company/pilot partner (MILOIL), which has available similar data and relevant needs with another company (ELDIA).

3.8.4   Testing and Evaluation

MILOIL has tested the solution for over ten months with its actual data (from June 2020 to March 2021). An instance of Visual Analytics Tool with dummy data was available even before to support the end-user to get familiar with the tool. Opposite to KLEEMANN and ELDIA, which were COMPOSITION partners and familiar with the ICT tools from this base platform to EFPF, MILOIL is a new partner introduced on EFPF.

The end-user evaluated the tool for its usability and user-friendliness of the UIs. Besides that, the evaluation was focused on the quality of the predictions for both price and tonnage forecasting. For cargo, forecasting was defined as a lack of accuracy for actual data related to material, frying oils, so another method was added to moving average and Markov chain-based approaches initially available. For this reason, a method based on auto-regression was added as well. Furthermore, for tonnage forecasting, to get better prediction as the data from

MILOIL were not enough to train the artificial neural networks of the solution, the model was trained with global historical data about the specific materials.

- *Deploy historical data related to previous purchases for raw material* user requirement is fulfilled by the solution interface that enables data from DB and data from CSV. The interface to do this is the same introduced in Figure 44 for ELDIA. Besides this, to fully cover the requirement about deploy data, the end-user should update the database containing historical data related to materials and orders. This is enabled by the interface/form available in the following figure:

Figure 46: Insert Data for Order of a Material to Database

- *Explore price forecast per raw material* requirement is fulfilled by forecasts based on deep learning applied on historical data related to materials, and it is available to end-user through the Visual Analytics tool interface:
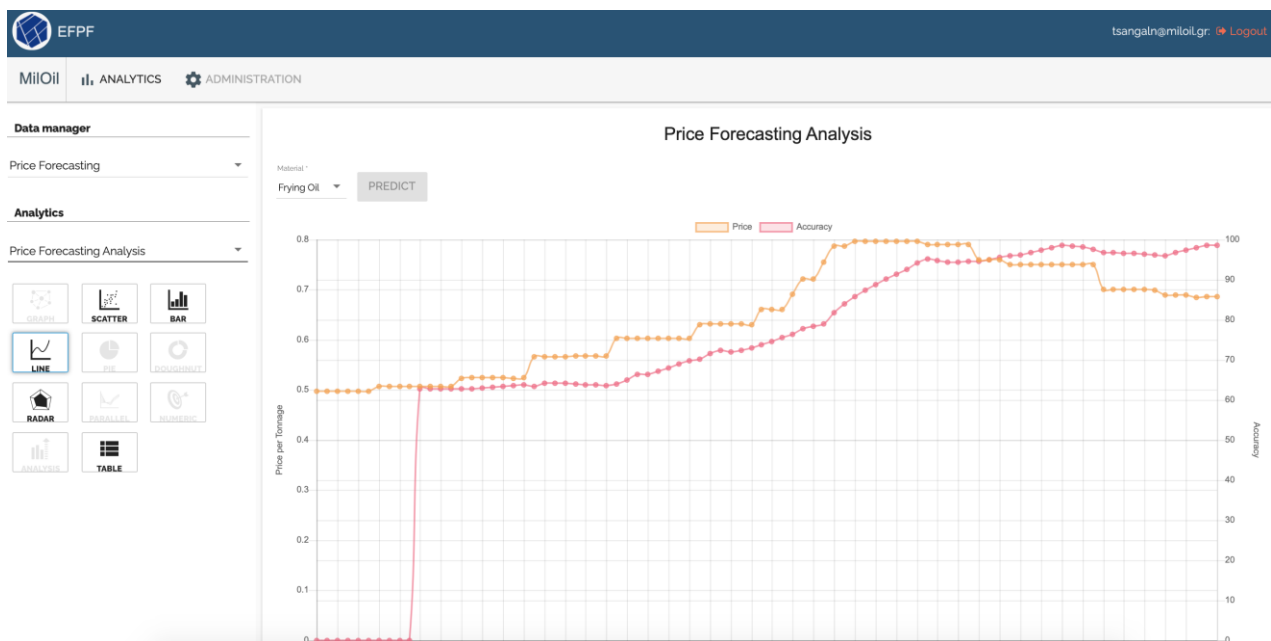
Figure 47: Price Forecasting Interface for MILOIL

- *Explore tonnage predictions per raw material* requirement is fulfilled by Visual Analytics tool providing three types of tonnage forecasting analysis and the corresponding interface. The following figure demonstrates the solution's outcome (in a test on March 2021, after MILOIL user loads nine months data and get predictions for the next four months:
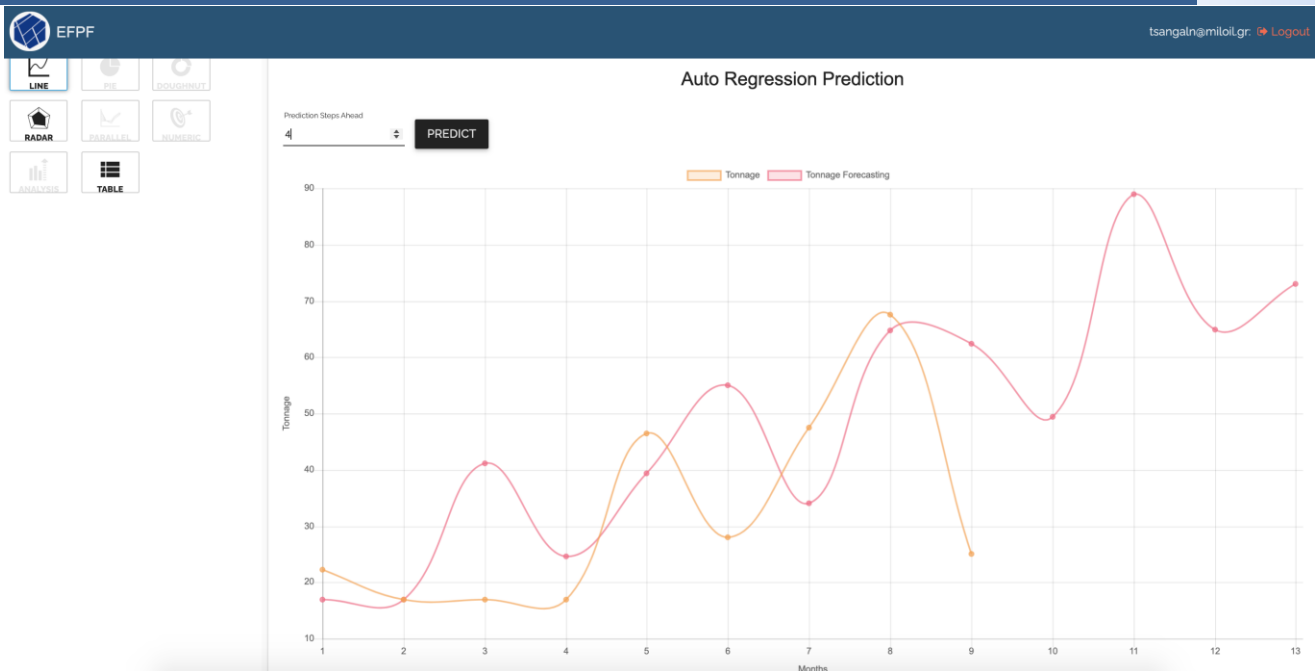
Figure 48:Tonnage Forecasting Interface for MILOIL

3.8.5   User value proposition

The proposed solution offers the following user value outcomes:

- Planning optimization over a bioenergy supply chain
- Price and tonnage forecasting

3.8.6   Compliance with Standards and Regulations

- MQTT is used for sensors' data transmission. MQTT is an OASIS standard messaging protocol for the Internet of Things (IoT)
- The fill level measurements data descriptions are based on the ISO/OGC Observation and Measurement (O&M) model

3.8.7   Lessons Learned

The Data Analytics solution was evaluated by target user MILOIL in its real-world industrial scenario. Based on the actual user-based evaluations of the functional and non-functional aspects of the developed solution, the following lessons are learned. For detailed results or specific user evaluation comments/scores, please refer to Sections 5.2.5 and 5.3.5.

The following lessons have been learnt from the data analytics solution:

- The optimisation of planning activities is expected to enable the extension of the contractual farming network
- The price and tonnage forecasting for specific raw materials will improve purchasing decision making
- The price and tonnage forecasting are expected to enhance the company's position in trading biodiesel.

3.9 US9: New Predictive Maintenance Solution for KLEEMANN Polishing Machine

3.9.1 Short Description

This user story focuses on the early detection of machine failures in the polishing machine at KLEEMANN's shop floor. The sensors installed are used to capture vibration data. To achieve this, a solution is needed to predict potential machine defects to improve maintenance operations and procedures.

Partners involved in this user story were from the user side KLEEMANN and the technical side CERTH.

3.9.2 Requirements / Acceptance Criteria

- Visualize vibration data coming from the polishing machine
- Monitor detected outliers in real-time

3.9.3 Fulfilment of the US9 through EFPF

The Predictive Maintenance solution of this user story was implemented using EFPF components such as vibration sensors connected over Wi-Fi in the KLEEMANN production line, the Data Spine(message bus and security framework), the portal that host the solution and the Visual Analytics tool that provides analytics and visualization capabilities. The solution's architecture is presenting in the following figure:
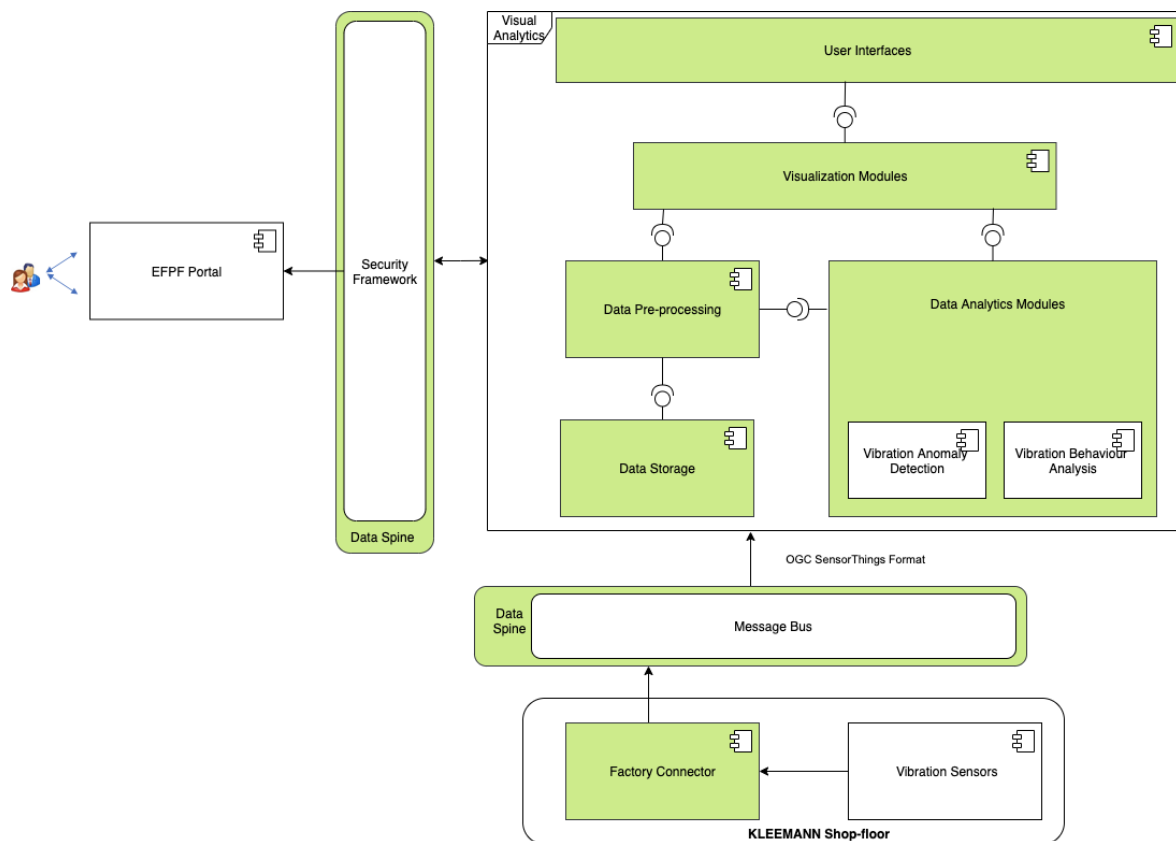
Figure 49: KLEEMANN Predictive Maintenance Solution Architecture

1.   Vibration Sensors available on KLEEMANN's polishing machine

Each deployed sensor consists of a feather ESP32 SoC board which provides the micro-controller unit and WiFi connectivity, and a Lis3DH3 axis mems accelerometer (see figure below). As soon as the motors are operating, the sensors are activated and continuously vibration samplings over WiFi. The samplings are received through MQTT by the analytic platform, and they have been processed as time series of accelerations in the 3-axis. The time-stamps between two successive sampling windows, which last 1 second each, are 1.5 –2.5 seconds apart, depending on wireless communication quality. The sensor's sensitivity is 0.038 m/s2 or 3.87 mg at a 1,344 kHz sampling rate and +2g measurement limit, which is the configuration applied in our case. The data was transmitted by using OGC Observation and Measurement JSON format.

Figure 50: SP32 board and Lis3DH on a breakout board

The solution initially tested in lab conditions by using the same setup as described above:

Figure 51: Lab-testing Setup

Besides the vibration sensor, the lab test system was powered by a VMARK IPS-2000C power supply, and the monitored rotating machine is RS-555SH-6513 with a nominal voltage of 12V.

2.   Data Spine's Message Bus is used as the secure broker for publishing vibration sensors data to be used by analytics components
3.   Data Spine's Security Framework is used to provide access to the solution and its data only to authorized users from KLEEMANN

4. EFPF Portal is used in this case as well to direct the user to the solution's interfaces
5. Visual and Data Analytics tool is used for the delivery of the predictive maintenance solution in terms of both data analysis and real-time monitoring

3.9.4   Testing and Evaluation

The solution implemented in this user story is tested and evaluated for three months at KLEEMANN's premises. The solution offers a new predictive maintenance method that needs more time to be evaluated since no deficiencies have occurred in the testing period. The measurements in regular machine operation demonstrated that the solution implemented has been working without any issues, and it is expected to deliver the expected performance. This solution comes as an addition to an already existing functionality based on Vibration Behaviour Analysis.

Figure 52: Installed sensor on the polishing machine

Based on this first evaluation period, the new solution, Vibration Anomaly Detection, seems more sensitive and captures more outliers than the previously available solution based on behaviour analysis through eigenvalues[16]. Furthermore, the newly deployed solution has a moving self-learned threshold. This feature is essential as in KLEEMANN, different pistons are used in this machine, so the machine operates differently based on the pistons' nature. KLEEMANN has given on-site feedback regarding the sensor's sensitivity calibration to avoid capturing vibration noise from other sources than the polishing machine. The sensors now capture only the polishing machine's activity.

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[16] https://en.wikipedia.org/wiki/Eigenvalues_and_eigenvectors

After the lab testing period, the solution was deployed to KLEEMANN and become available through the EFPF portal interfaces and CERTH's tool.

Figure 53: Vibration Sensors on KLEEMANN's Polishing Machine

Machine's vibration monitoring for Anomaly Detection

The machine's vibration monitoring for Anomaly Detection is a dynamic solution based on real-time data from deployed vibration sensors. The real-time vibrations monitoring and analysis result in an anomaly detection pipeline towards early fault detection predictive maintenance. The method uses the historical data to calculate the MAHALANOBIS distance of each point and modelling normal behaviour. A threshold is defined at this point, too, to detect outliers when new incoming sensor data overcome this threshold. The maintenance manager is visually informed via Visual Analytics when the machine's activity surpasses the abnormal vibration threshold and can check for potential faults in the machine operation.
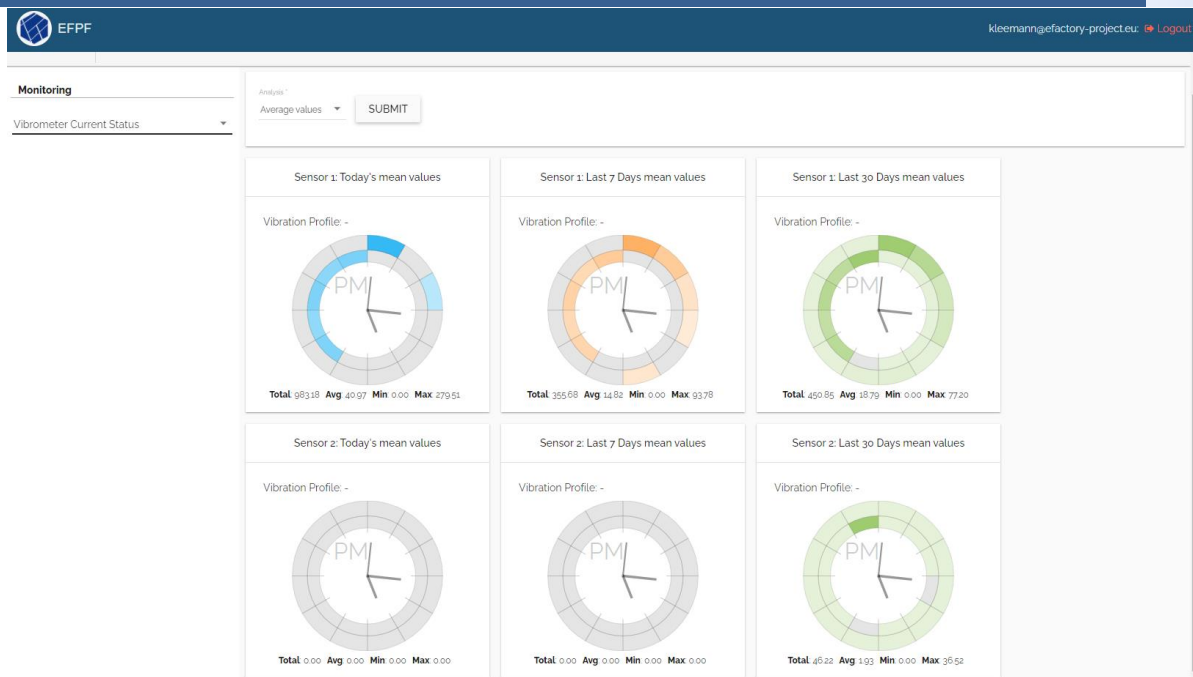
Figure 54: Vibrometer sensors current status

Figure 55: Machine Vibration Anomaly Detection

The user requirements about predictive maintenance solutions and the corresponding Acceptance criteria are:

- Visualise vibration data coming from the polishing machine
- Monitor detected outliers in real-time

The requirements are more than realized within the specific component of the Visual and Data Analytics tool. The user can view the sensor's current status (Figure 54) and the Anomaly Detection method applied on live data (Figure 55).

3.9.5 User value proposition

The proposed solution offers the following user value outcomes:

- Real-time condition monitoring
- Failure predictions are available
- KPIs tracking in real-time

3.9.6 Compliance with Standards and Regulations

- MQTT is used for sensors' data transmission. MQTT is an OASIS standard messaging protocol for the Internet of Things (IoT)
- The vibration sensors' data descriptions are based on the ISO/OGC Observation and Measurement (O&M) model

3.9.7 Lessons Learned

The Data Analytics solution (focusing on predictive maintenance) was evaluated by target user KLEEMANN in its real-world industrial scenario. Based on the actual user-based evaluations of the functional and non-functional aspects of the developed solution, the following lessons are learned. For detailed results or specific user evaluation comments/scores, please refer to Sections 5.2.5 and 5.3.5.

- A solution is a promising tool that is expected to improve maintenance management on the shop floor and allow predictive actions to be implemented.
- The data is visualised and analysed in real-time, and the maintenance manager can use this to provide predictive maintenance actions rather than corrective.
- A vital feature of the solution is that the threshold of abnormal vibrations can dynamically change, strengthening the accuracy of the vibration data concerning possible defects.
- Further testing is needed to analyse the vibration data and connect them to specific machine conditions

4   Concluding Remarks

The solutions that have been developed by the EFPF technical partners and deployed to the end-users are identified as critical factors for the successful development of the circular economy.

This deliverable has demonstrated how a circular economy scenario is applied in a real-world setting comprising three companies from different sectors. The waste producer (KLEEMANN) applies predictive maintenance (US9) to reduce the production of wastes. KLEEMANN monitors the waste bins fill level (US1), and when the bins reach a specific level, an online bidding process (US5) initiates to sell the waste. A waste management company (ELDIA) participates in the bidding process (US5) and provides an accepted offer from KLEEMANN. All these arrangements are performed through a trusted and secured information flow solution (US4) while all the assets, including transportation and supply chain data, are tracked and traced through blockchain (US2, US3). ELDIA uses the data analytics tool (US7) to get insights on price and tonnage predictions that will help search for customers (US6) that fulfil its needs. ELDIA is ready to sell, an online bidding process initiates again, and other companies interested in ELDIA's product participate. In this pilot testing, MILOIL is the company that wins the bidding process. MILOIL uses a similar tool to optimise its planning activities (US8) and sell its product to a potential customer. As already noted, most of the developed EFPF solutions are used by all the circular economy participants in all the phases of the loop where negotiations and purchases for the exchanged good to exist. This is also illustrated in Figure 56, which summarises the developed EFPF solutions and their application by the three pilot partners.

The developed solutions have addressed the problems that have been identified in section 1.3. The use of traditional communication means has been addressed by all the developed solutions since the communication is now fully automated through the EFPF platform. The blockchain solution addresses the lack of automated waste tracking and tracing and visibility throughout the entire supply chain. The data analytics solution addresses the lack of shop-floor automation and real-time data for optimisation of planning procedures. The lack of a marketplace and the complex collaboration procedures and rules, and the diversity of IT systems are addressed by the federated search tool and the online bidding process. The entry barriers due to limited awareness of business opportunities are addressed by the federated search tool. Finally, the lack of interoperability and integration of enterprise systems is addressed by all the developed solution since they are running on a common platform, the EFPF platform.

The overall findings of this deliverable show that, even though more testing and evaluation is needed, the solutions facilitate circular economy activities within the waste management sector. The most important benefit for the three companies of this pilot is the development of a standard digital supply chain management ecosystem that improves collaborative procedures towards the circular economy.
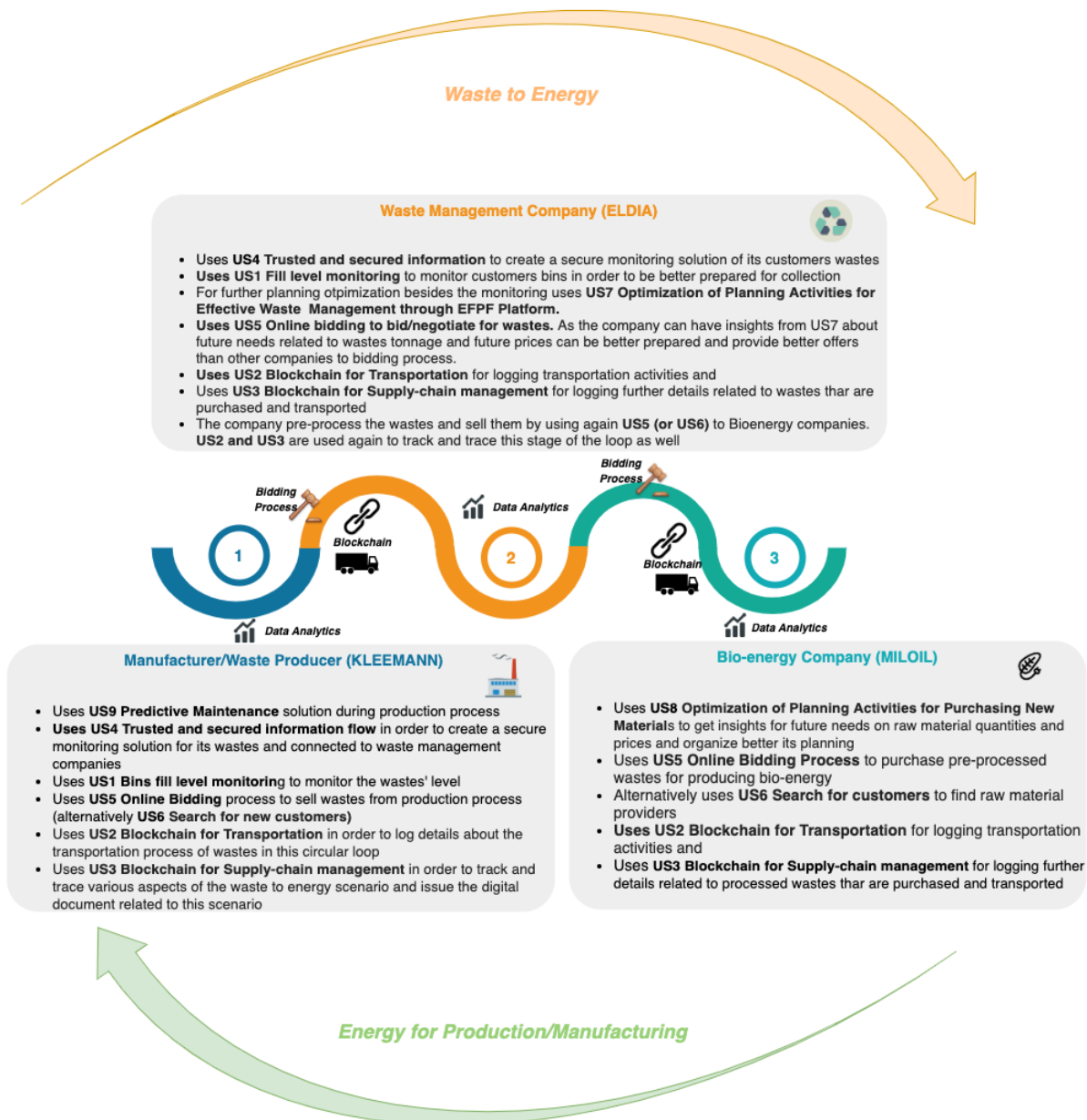
Figure 56: Overview of Circular Economy Pilot EFPF solutions

5 Annexe A: Questionnaires for Solution Evaluation

5.1   Methodology and Generic Questionnaire

Target users evaluated the functional and usability aspects of the (CE pilot specific) EFPF solutions. The evaluation process involved the users testing and working with the solution and then recording their experiences in a specific questionnaire. The questionnaire was composed of 2 parts for each solution, the first part focused on usability aspects, and the second focused on the functional aspects. The use of questionnaire allowed the users to record their experience and overall satisfaction with the developed solutions in their own time. The first part of the questionnaire (shown below) remained for all solutions, whereas the second part was customised to suit the functional aspects of different solutions.

Q#	Questions	Disagree 1	2	3	4	Agree 5
Q1	Overall, I am satisfied with how easy it was to use the tool	☐	☐	☐	☐	☐
Notes	*Any suggestions for enhancements?					
Q2	The functions and capabilities of the tool are properly visible and usable	☐	☐	☐	☐	☐
Notes	*Any suggestions for enhancements?					
Q3	I am able to complete tasks & scenarios without needing developers help	☐	☐	☐	☐	☐
Notes	*Any suggestions for enhancements?					
Q4	The documentation and instruction were easy to understand and follow	☐	☐	☐	☐	☐
Notes	*Any suggestions for enhancements?					
Q5	I felt confident and comfortable using this tool	☐	☐	☐	☐	☐
Notes	*Any suggestions for enhancements?					
Q6	The interfaces of the tool provided adequate information about the purpose and functions of the tool	☐	☐	☐	☐	☐
Notes	*Any suggestions for enhancements?					
Q7	I found the tool was easy to install/configure/execute	☐	☐	☐	☐	☐
Notes	*Any suggestions for enhancements?					
Q8	I will recommend this tool to the contacts in my business network	☐	☐	☐	☐	☐
Notes	*Any suggestions for enhancements?					

Generic Questionnaire for all Solutions

5.2   EFPF Tools Specific Questionnaires

This section presents the questionnaires used to evaluate the functional aspects of the solutions developed in the EFPF project for the CE pilot.

5.2.1   Fill Level Monitoring

Q#	Questions	Disagree 1	2	3	4	Agree 5
Q1	I can easily monitor the fill level in various open-top containers					
Notes	*Any suggestions for enhancements?					
Q2	I can get a valuable analysis of fill level sensors data					
Notes	*Any suggestions for enhancements?					
Q3	Fill level sensors provide accurate measurements of open-top containers filling level					
Notes	*Any suggestions for enhancements?					
Q4	Fill level sensors provide frequently updated measurements					
Notes	*Any suggestions for enhancements?					
Q5	I can explore with different ways the analysis results					
Notes	*Any suggestions for enhancements?					
Q6	The tool provides to the users a complete solution for wastes monitoring					
Notes	*Any suggestions for enhancements?					
Q7	Accessibility of the tool is easy through single sign-on functionality					
Notes	*Any suggestions for enhancements?					

5.2.2 Blockchain Dapp for Wastes Tracking

Q#	Questions	Disagree 1	2	3	4	Agree 5
Q1	I can easily add a new asset for tracking					
Notes	*Any suggestions for enhancements?					
Q2	I can modify the asset status, and I can move it to the next phase in the case I am an authorised user to do this					
Notes	*Any suggestions for enhancements?					
Q3	I can monitor the different stages of asset's transportation					
Notes	*Any suggestions for enhancements?					
Q4	I can explore details for every asset					
Notes	*Any suggestions for enhancements?					
Q5	I can easily manage the digitally signed waste management document					
Notes	*Any suggestions for enhancements?					
Q6	I can download the waste management document					
Notes	*Any suggestions for enhancements?					
Q7	Waste Management Blockchain app provides a complete service for specific assets tracking					
Notes	*Any suggestions for enhancements?					
Q8	The Waste Management Blockchain app provides functionalities to ensure complete visibility of waste transportation in a CE scenario					
Notes	*Any suggestions for enhancements?					
Q9	I can add drivers and trucks information with an easy way					
Notes	*Any suggestions for enhancements?					
Q10	A mobile app provides a satisfactory level of support to delivery process monitoring					
Notes	*Any suggestions for enhancements?					
Q11	Accessibility of the tool is easy through single sign-on functionality					
Notes	*Any suggestions for enhancements?					

5.2.3   System Security Modeler

Q#	Questions	Disagree 1	2	3	4	Agree 5
Q1	The user interface is intuitive					
Notes	*Any suggestions for enhancements?					
Q2	I can quickly identify the assets and relate them to my specific case					
Notes	*Any suggestions for enhancements?					
Q3	I can quickly draw the diagram with all the needed assets and relationships among them					
Notes	*Any suggestions for enhancements?					
Q4	I can validate the model, and I get meaningful suggestions to correct errors					
Notes	*Any suggestions for enhancements?					
Q5	I can run the risk analysis, and the computation time is reasonable					
Notes	*Any suggestions for enhancements?					
Q6	I can browse the result of the risk analysis and understand the meaning and the involved assets and relationships					
Notes	*Any suggestions for enhancements?					
Q7	I can find suggestions on what controls to apply to mitigate specific risks					
Notes	*Any suggestions for enhancements?					
Q8	I understand the system output, and it is helpful for my business case					
Notes	*Any suggestions for enhancements?					

5.2.4 Online Bidding Process

Q#	Questions	Disagree 1	2	3	4	Agree 5
Q1	I can easily set up an online bidding process for a service/good					
Notes	*Any suggestions for enhancements?					
Q2	I can modify(or register) an agent to represent the company in the bidding process					
Notes	*Any suggestions for enhancements?					
Q3	I can monitor the different stages during the bidding process					
Notes	*Any suggestions for enhancements?					
Q4	I can explore previous bidding processes					
Notes	*Any suggestions for enhancements?					
Q5	The online bidding process provides a service that is not available in any tool that I know					
Notes	*Any suggestions for enhancements?					
Q6	The online Bidding Process provides a high level of automation for online negotiations					
Notes	*Any suggestions for enhancements?					
Q7	Submitting default or new offers through UI is an easy process					
Notes	*Any suggestions for enhancements?					
Q8	Online Bidding Process provides a satisfactory number of user criteria to evaluate offers					
Notes	*Any suggestions for enhancements?					
Q9	Online Bidding Process matches the request with the best available offer					
Notes	*Any suggestions for enhancements?					
Q10	An adequate list of services/goods is available					
Notes	*Any suggestions for enhancements?					
Q11	Accessibility of the tool is easy through single sign-on functionality					
Notes	*Any suggestions for enhancements?					

5.2.5   Visual and Data Analytics

Q#	Questions	Disagree 1	2	3	4	Agree 5
Q1	I can easily select different analytics and monitoring services					
Notes	*Any suggestions for enhancements?					
Q2	I can deploy historical data or use available live data or data from databases					
Notes	*Any suggestions for enhancements?					
Q3	Sensors live data coming from COMPOSITION are available for analysis through the EFPF portal					
Notes	*Any suggestions for enhancements?					
Q4	The visualization services provide an adequate number of different graphs that cover users' needs					
Notes	*Any suggestions for enhancements?					
Q5	The tool provides valuable insights and forecasts related to different domains					
Notes	*Any suggestions for enhancements?					
Q6	The tool's forecasts can improve planning activities					
Notes	*Any suggestions for enhancements?					
Q7	Visual and Data analytics tool provides some specific functionalities that are not available to other tools					
Notes	*Any suggestions for enhancements?					
Q8	The analytics results are available to the user without significant delays					
Notes	*Any suggestions for enhancements?					
Q9	A broad set of analytic and monitoring solutions are available through the tool					
Notes	*Any suggestions for enhancements?					
Q10	Accessibility of the tool is easy through single sign-on functionality					
Notes	*Any suggestions for enhancements?					

5.3 Answers to EFPF Specific Questionnaires

This section presents the answers to the questionnaires used to evaluate the functional aspects of the solutions developed in the EFPF project for the CE pilot.

5.3.1 Fill level monitoring tool

Based on the way data is stored in the RateMe system, please read this document bottom up				
Date	**Responses**	**Questions**	**Question Type**	**User Score**
2/4/2021 7:31		Please add your details	new-question-free	Empty
2/4/2021 7:31		I can configure the fill level limit for getting notifications	new-question-five	5
2/4/2021 7:31		I can receive notifications about fill level	new-question-five	5
2/4/2021 7:31		Accessibility of the tool is easy through single sign on functionality	new-question-five	5
2/4/2021 7:31	Absolutely true	The tool provides to the users a complete solution for wastes monitoring	new-question-five	5
2/4/2021 7:31	Very useful application for our Logistics Department	Fill level sensors provide frequently updated measurements	new-question-five	5
2/4/2021 7:31	On a large container, sometimes we get less accurate measurement due to the fact that it is not evenly loaded....	Fill level sensors provide accurate measurements of open top containers filling level	new-question-five	4
2/4/2021 7:31		I can get a useful analysis of fill level sensors data	new-question-five	5
2/4/2021 7:31	Extremely important for our company to be able to monitor a large number of containers	I can easily monitor the fill level in various open top containers	new-question-five	5
2/4/2021 7:31		EFPF Tools - Fill Level Monitoring	new-question-splash	Empty
2/4/2021 7:31		I will recommend this tool to the contacts in my business network	new-question-five	5
2/4/2021 7:31		I found the tool was easy to install/configure/execute	new-question-five	5
2/4/2021 7:31		The interfaces of the tool provided adequate information about the purpose and functions of the tool	new-question-five	5
2/4/2021 7:31		I felt confident and comfortable using this tool	new-question-five	5
2/4/2021 7:31		The documentation and instruction were easy to understand and follow	new-question-five	5
2/4/2021 7:31	Very complete tool	I am able to complete tasks & scenarios without needing developers help	new-question-five	5
2/4/2021 7:31	User friendly interface	The functions and capabilities of the tool are properly visible and usable	new-question-five	5
2/4/2021 7:31	Very straight forward procedure	Overall, I am satisfied with how easy it was to use the tool	new-question-five	5
2/4/2021 7:31		EFPF Tools - Fill Level Monitoring	new-question-splash	Empty
2/4/2021 7:31		EFPF - Tools Evaluation Questionnaire	new-question-splash	Empty
2/4/2021 7:31			introduction	Empty

Figure 57: Answer 1 (Fill level monitoring tool)

Based on the way data is stored in the RateMe system, please read this document bottom up				
Date	**Responses**	**Questions**	**Question Type**	**User Score**
5/4/2021 4:28		Please add your details	new-question-free	Empty
5/4/2021 4:28		I can configure the fill level limit for getting notifications	new-question-five	5
5/4/2021 4:28		I can receive notifications about fill level	new-question-five	5
5/4/2021 4:28		Accessibility of the tool is easy through single sign on functionality	new-question-five	5
5/4/2021 4:28		The tool provides to the users a complete solution for wastes monitoring	new-question-five	5
5/4/2021 4:28		Fill level sensors provide frequently updated measurements	new-question-five	5
5/4/2021 4:28		Fill level sensors provide accurate measurements of open top containers filling level	new-question-five	5
5/4/2021 4:28		I can get a useful analysis of fill level sensors data	new-question-five	5
5/4/2021 4:28		I can easily monitor the fill level in various open top containers	new-question-five	5
5/4/2021 4:28		EFPF Tools - Fill Level Monitoring	new-question-splash	Empty
5/4/2021 4:28		I will recommend this tool to the contacts in my business network	new-question-five	5
5/4/2021 4:28		I found the tool was easy to install/configure/execute	new-question-five	5
5/4/2021 4:28		The interfaces of the tool provided adequate information about the purpose and functions of the tool	new-question-five	5
5/4/2021 4:28		I felt confident and comfortable using this tool	new-question-five	5
5/4/2021 4:28		The documentation and instruction were easy to understand and follow	new-question-five	5
5/4/2021 4:28		I am able to complete tasks & scenarios without needing developers help	new-question-five	5
5/4/2021 4:28		The functions and capabilities of the tool are properly visible and usable	new-question-five	5
5/4/2021 4:28		Overall, I am satisfied with how easy it was to use the tool	new-question-five	5
5/4/2021 4:28		EFPF Tools - Fill Level Monitoring	new-question-splash	Empty
5/4/2021 4:28		EFPF - Tools Evaluation Questionnaire	new-question-splash	Empty
5/4/2021 4:28			introduction	Empty

Figure 58: Answer 2 (Fill level monitoring tool)

5.3.2   Waste tracking blockchain App

	Based on the way data is stored in the RateMe system, please read this document bottom up			
Date	**Responses**	**Questions**	**Question Type**	**User Score**
2/4/2021 8:13		Please add your details	new-question-form	Empty
2/4/2021 8:13		Accessibility of the tool is easy through single sign on functionality	new-question-five	5
2/4/2021 8:13		A mobile app provides satisfactory level of support to delivery pro	new-question-five	5
2/4/2021 8:13		I am able to add drivers and trucks information with an easy way	new-question-five	5
2/4/2021 8:13		The Waste Management Blockchain app provides functionalities to	new-question-five	5
2/4/2021 8:13	The automation and transparency throughout the process	Waste Management Blockchain app provides a complete service fo	new-question-five	5
2/4/2021 8:13		I can download the waste management document	new-question-five	5
2/4/2021 8:13	It is simple and transparent	I can easily manage the digital signed waste management documen	new-question-five	5
2/4/2021 8:13		I am able to explore details for every asset	new-question-five	5
2/4/2021 8:13	Extremely important for our Logistics Department	I can monitor the different stages of asset's transportation	new-question-five	5
2/4/2021 8:13		I can modify the asset status and I can move it to the next phase in	new-question-five	5
2/4/2021 8:13		I can easily add a new asset for tracking	new-question-five	5
2/4/2021 8:13		EFPF Tools - Waste Tracking Blockchain App	new-question-spla	Empty
2/4/2021 8:13		I will recommend this tool to the contacts in my business network	new-question-five	5
2/4/2021 8:13	No complications found	I found the tool was easy to install/configure/execute	new-question-five	5
2/4/2021 8:13		The interfaces of the tool provided adequate information about the	new-question-five	5
2/4/2021 8:13	User friendly application	I felt confident and comfortable using this tool	new-question-five	5
2/4/2021 8:13		The documentation and instruction were easy to understand and fo	new-question-five	4
2/4/2021 8:13		I am able to complete tasks & scenarios without needing deve	new-question-five	4
2/4/2021 8:13		The functions and capabilities of the tool are properly visible and	new-question-five	5
2/4/2021 8:13		Overall, I am satisfied with how easy it was to use the tool	new-question-five	5
2/4/2021 8:13		EFPF - Waste Tracking Blockchain App	new-question-spla	Empty
2/4/2021 8:13		EFPF - Tools Evaluation Questionnaire	new-question-spla	Empty
2/4/2021 8:13			introduction	Empty

Figure 59: Answer 1 (Waste tracking blockchain App)

	Based on the way data is stored in the RateMe system, please read this document bottom up			
Date	**Responses**	**Questions**	**Question Type**	**User Score**
11/4/2021 8:13		Please add your details	new-question-fo	Empty
11/4/2021 8:13		Accessibility of the tool is easy through single sign on funct	new-question-fiv	5
11/4/2021 8:13		A mobile app provides satisfactory level of support to delive	new-question-fiv	5
11/4/2021 8:13		I am able to add drivers and trucks information with an eas	new-question-fiv	5
11/4/2021 8:13	Full visibility, trust and security at all transportation l	The Waste Management Blockchain app provides functiona	new-question-fiv	5
11/4/2021 8:13		Waste Management Blockchain app provides a complete se	new-question-fiv	5
11/4/2021 8:13	Very important and saves time from searching at hard	I can download the waste management document	new-question-fiv	5
11/4/2021 8:13		I can easily manage the digital signed waste management	new-question-fiv	5
11/4/2021 8:13		I am able to explore details for every asset	new-question-fiv	5
11/4/2021 8:13		I can monitor the different stages of asset's transportation	new-question-fiv	5
11/4/2021 8:13		I can modify the asset status and I can move it to the next p	new-question-fiv	5
11/4/2021 8:13		I can easily add a new asset for tracking	new-question-fiv	5
11/4/2021 8:13		EFPF Tools - Waste Tracking Blockchain App	new-question-sp	Empty
11/4/2021 8:13	We need to become more confident regarding transac	I will recommend this tool to the contacts in my business ne	new-question-fiv	4
11/4/2021 8:13	Very user friendly app	I found the tool was easy to install/configure/execute	new-question-fiv	5
11/4/2021 8:13		The interfaces of the tool provided adequate information a	new-question-fiv	5
11/4/2021 8:13	Very user friendly app	I felt confident and comfortable using this tool	new-question-fiv	5
11/4/2021 8:13		The documentation and instruction were easy to understan	new-question-fiv	5
11/4/2021 8:13		I am able to complete tasks & scenarios without needi	new-question-fiv	5
11/4/2021 8:13		The functions and capabilities of the tool are properly visib	new-question-fiv	5
11/4/2021 8:13		Overall, I am satisfied with how easy it was to use the tool	new-question-fiv	5
11/4/2021 8:13		EFPF - Waste Tracking Blockchain App	new-question-sp	Empty
11/4/2021 8:13		EFPF - Tools Evaluation Questionnaire	new-question-sp	Empty
11/4/2021 8:13			introduction	Empty

Figure 60: Answer 2 (Waste tracking blockchain App)

5.3.3   System Security Modeler

Based on the way data is stored in the RateMe system, please read this document bottom up				
Date	**Responses**	**Questions**	**Question Type**	**User Score**
27/4/2021 8:01		**Please add your details**	new-question-form	Empty
27/4/2021 8:01		I understand the system output and it is useful for my business cas	new-question-five	5
27/4/2021 8:01		I can find suggestions on what controls to apply to mitigate specifi	new-question-five	5
27/4/2021 8:01	Yes. I need to be sure that no partner will be threatened	I can browse the result of the risk analysis and understand the mea	new-question-five	5
27/4/2021 8:01	Yes it is simple and in reasonable time	I can run the risk analysis and the computation time is reasonable	new-question-five	5
27/4/2021 8:01		I can validate the model and I get meaningful suggestions to correc	new-question-five	5
27/4/2021 8:01	Yes but more time is needed to test the solution	I can easily draw the diagram with all the needed assets and relati	new-question-five	4
27/4/2021 8:01		I can easily identify the assets and relate them to my specific case	new-question-five	5
27/4/2021 8:01		The user interface is intuitive	new-question-five	5
27/4/2021 8:01		**EFPF Tools - System Security Modeller**	new-question-spla	Empty
27/4/2021 8:01		I will recommend this tool to the contacts in my business network	new-question-five	5
27/4/2021 8:01		I found the tool was easy to install/configure/execute	new-question-five	5
27/4/2021 8:01		The interfaces of the tool provided adequate information about the	new-question-five	5
27/4/2021 8:01	Not 100% confident since the app is tested for a short peri	I felt confident and comfortable using this tool	new-question-five	4
27/4/2021 8:01		The documentation and instruction were easy to understand and fo	new-question-five	5
27/4/2021 8:01		I am able to complete tasks & scenarios without needing deve	new-question-five	5
27/4/2021 8:01		The functions and capabilities of the tool are properly visible and	new-question-five	5
27/4/2021 8:01	Yes it seems to be a user friendly application	Overall, I am satisfied with how easy it was to use the tool	new-question-five	5
27/4/2021 8:01		**EFPF - System Security Modeller**	new-question-spla	Empty
27/4/2021 8:01		**EFPF - Tools Evaluation Questionnaire**	new-question-spla	Empty
27/4/2021 8:01			introduction	Empty

Figure 61: Answer 1 (System Security Modeler)

Based on the way data is stored in the RateMe system, please read this document bottom up				
Date	**Responses**	**Questions**	**Question Type**	**User Score**
27/4/2021 9:13		**Please add your details**	new-question-form	Empty
27/4/2021 9:13	It is really useful as it is possible to identify possible secu	I understand the system output and it is useful for my business cas	new-question-five	4
27/4/2021 9:13	Yes there are many suggestion how to mitigate risks and fa	I can find suggestions on what controls to apply to mitigate specifi	new-question-five	4
27/4/2021 9:13	There are details for every threat and risk with root causes	I can browse the result of the risk analysis and understand the mea	new-question-five	5
27/4/2021 9:13	Risk analysis was available in some seconds even if the sy	I can run the risk analysis and the computation time is reasonable	new-question-five	5
27/4/2021 9:13	Yes automate validation is available by just clicking a but	I can validate the model and I get meaningful suggestions to correc	new-question-five	5
27/4/2021 9:13	Yes, a great drag and drop menu is available	I can easily draw the diagram with all the needed assets and relati	new-question-five	5
27/4/2021 9:13	Yes. Most of the expected assets are there. Only some very	I can easily identify the assets and relate them to my specific case	new-question-five	4
27/4/2021 9:13	The UI is very good and easy to use. You can understand w	The user interface is intuitive	new-question-five	4
27/4/2021 9:13		**EFPF Tools - System Security Modeller**	new-question-spla	Empty
27/4/2021 9:13	Yes as it can help companies to create and execute securit	I will recommend this tool to the contacts in my business network	new-question-five	4
27/4/2021 9:13	It is available through EFPF portal using SSO so it is easy t	I found the tool was easy to install/configure/execute	new-question-five	5
27/4/2021 9:13	Yes	The interfaces of the tool provided adequate information about the	new-question-five	5
27/4/2021 9:13	Yes. Only some issues with zoom in/zoom out causes a few	I felt confident and comfortable using this tool	new-question-five	4
27/4/2021 9:13	The documentation is really concrete and useful. A comple	The documentation and instruction were easy to understand and fo	new-question-five	5
27/4/2021 9:13	Someone with an ICT background is needed as the tool mo	I am able to complete tasks & scenarios without needing deve	new-question-five	4
27/4/2021 9:13	Yes they are visible and easy to use	The functions and capabilities of the tool are properly visible and	new-question-five	5
27/4/2021 9:13	The tool was really easy to use with a nice drag and drop	Overall, I am satisfied with how easy it was to use the tool	new-question-five	5
27/4/2021 9:13		**EFPF - System Security Modeller**	new-question-spla	Empty
27/4/2021 9:13		**EFPF - Tools Evaluation Questionnaire**	new-question-spla	Empty
27/4/2021 9:13			introduction	Empty

Figure 62: Answer 2 (System Security Modeler)

5.3.4 Online Bidding Process

Based on the way data is stored in the RateMe system, please read this document bottom up				
Date	Responses	Questions	Question Type	User Scor
2/4/2021 7:55			thanks	Empty
2/4/2021 7:55		Please add your details	new-question-form	Empty
2/4/2021 7:55		Accessibility of the tool is easy through single sign on functionality	new-question-five	5
2/4/2021 7:55		An adequate list of services/goods is available	new-question-five	5
2/4/2021 7:55	Based on the criteria set forward	Online Bidding Process match the request with the best available offer	new-question-five	5
2/4/2021 7:55		Online Bidding Process provides a satisfactory number of user criteria in ord	new-question-five	5
2/4/2021 7:55	It is very straight forward and and adds t	Online Bidding Process provides a high level of automation for online negot	new-question-five	5
2/4/2021 7:55		Online bidding process provides a service that is not available in any tool th	new-question-five	5
2/4/2021 7:55	It is good to have previous data availabl	I am able to explore previous bidding processes	new-question-five	5
2/4/2021 7:55	Very important for the bidding process	I can monitor the different stages during the bidding process	new-question-five	5
2/4/2021 7:55		I can modify (or register) an agent to represent the company in bidding proce	new-question-five	Empty
2/4/2021 7:55	It is very important for our firm that has a	I can easily setup an online bidding process for a service/good	new-question-five	5
2/4/2021 7:55		EFPF Tools - Online Bidding Process	new-question-spla	Empty
2/4/2021 7:55		I will recommend this tool to the contacts in my business network	new-question-five	5
2/4/2021 7:55	User friendly	I found the tool was easy to install/configure/execute	new-question-five	5
2/4/2021 7:55	It covers all the angles of the procedure	The interfaces of the tool provided adequate information about the purpose	new-question-five	5
2/4/2021 7:55		I felt confident and comfortable using this tool	new-question-five	5
2/4/2021 7:55	User friendly	The documentation and instruction were easy to understand and follow	new-question-five	5
2/4/2021 7:55	It is very straight forward	I am able to complete tasks & scenarios without needing developers he	new-question-five	5
2/4/2021 7:55		The functions and capabilities of the tool are properly visible and usable	new-question-five	5
2/4/2021 7:55	It is a user friendly application	Overall, I am satisfied with how easy it was to use the tool	new-question-five	5
2/4/2021 7:55		EFPF Tools - Online Bidding Process	new-question-spla	Empty
2/4/2021 7:55		EFPF - Tools Evaluation Questionnaire	new-question-spla	Empty
2/4/2021 7:55			introduction	Empty

Figure 63: Answer 1 (Online Bidding Process)

Based on the way data is stored in the RateMe system, please read this document bottom up				
Date	Responses	Questions	Question Type	User Scor
9/4/2021 8:45			thanks	Empty
9/4/2021 8:45		Please add your details	new-question-form	Empty
9/4/2021 8:45	Easy to use tool	Accessibility of the tool is easy through single sign on functionality	new-question-five	5
9/4/2021 8:45		An adequate list of services/goods is available	new-question-five	5
9/4/2021 8:45	Yes, but more tests need to be done	Online Bidding Process match the request with the best available offer	new-question-five	4
9/4/2021 8:45		Online Bidding Process provides a satisfactory number of user criteria in ord	new-question-five	5
9/4/2021 8:45		Online Bidding Process provides a high level of automation for online negot	new-question-five	5
9/4/2021 8:45		Online bidding process provides a service that is not available in any tool th	new-question-five	5
9/4/2021 8:45		I am able to explore previous bidding processes	new-question-five	5
9/4/2021 8:45		I can monitor the different stages during the bidding process	new-question-five	5
9/4/2021 8:45		I can modify (or register) an agent to represent the company in bidding proce	new-question-five	Empty
9/4/2021 8:45	Very easily and less time needed	I can easily setup an online bidding process for a service/good	new-question-five	5
9/4/2021 8:45		EFPF Tools - Online Bidding Process	new-question-spla	Empty
9/4/2021 8:45	Yes, already did that with 1 of our key custon	I will recommend this tool to the contacts in my business network	new-question-five	5
9/4/2021 8:45		I found the tool was easy to install/configure/execute	new-question-five	5
9/4/2021 8:45		The interfaces of the tool provided adequate information about the purpose	new-question-five	5
9/4/2021 8:45	Yes, but not for completing a transaction/pa	I felt confident and comfortable using this tool	new-question-five	4
9/4/2021 8:45		The documentation and instruction were easy to understand and follow	new-question-five	5
9/4/2021 8:45		I am able to complete tasks & scenarios without needing developers he	new-question-five	5
9/4/2021 8:45		The functions and capabilities of the tool are properly visible and usable	new-question-five	5
9/4/2021 8:45		Overall, I am satisfied with how easy it was to use the tool	new-question-five	5
9/4/2021 8:45		EFPF Tools - Online Bidding Process	new-question-spla	Empty
9/4/2021 8:45		EFPF - Tools Evaluation Questionnaire	new-question-spla	Empty
9/4/2021 8:45			introduction	Empty

Figure 64: Answer 2 (Online Bidding Process)

5.3.5 Visual and Data Analytics tool

Based on the way data is stored in the RateMe system, please read this document bottom up				
Date	**Responses**	**Questions**	**Question Type**	**User Score**
2/4/2021 8:17		**Please add your details**	new-question-form	Empty
2/4/2021 8:17		Accessibility of the tool is easy through single sign on functionality	new-question-five	5
2/4/2021 8:17	We get many options for the same item	A wide set of analytic and monitoring solutions are available through the tool	new-question-five	5
2/4/2021 8:17		The analytics results are available to the user without significant delays	new-question-five	5
2/4/2021 8:17		Visual and Data analytics tool provides some specific functionalities that are n	new-question-five	5
2/4/2021 8:17		The tools forecasts can improve planning activities for supply chain domain or	new-question-five	4
2/4/2021 8:17	Very useful tool for upper management decision making	The tool provides useful insights and forecasts related to different domains	new-question-five	5
2/4/2021 8:17		The visualization services provide an adequate number of different graphs th	new-question-five	4
2/4/2021 8:17		Are Sensors live data coming from factory available for analysis through EFPF	new-question-five	5
2/4/2021 8:17	Very important fact	I can deploy historical data or use available live data or data from data bases	new-question-five	5
2/4/2021 8:17	It is a very useful tool for decision making	I can easily select different analytics and monitoring services	new-question-five	5
2/4/2021 8:17		**EFPF - Visual and Data Analytics for CE**	new-question-splash	Empty
2/4/2021 8:17		I will recommend this tool to the contacts in my business network	new-question-five	4
2/4/2021 8:17		I found the tool was easy to install/configure/execute	new-question-five	4
2/4/2021 8:17		The interfaces of the tool provided adequate information about the purpose a	new-question-five	5
2/4/2021 8:17		I felt confident and comfortable using this tool	new-question-five	5
2/4/2021 8:17		The documentation and instruction were easy to understand and follow	new-question-five	4
2/4/2021 8:17		I am able to complete tasks & scenarios without needing developers help	new-question-five	5
2/4/2021 8:17		The functions and capabilities of the tool are properly visible and usable	new-question-five	4
2/4/2021 8:17		Overall, I am satisfied with how easy it was to use the tool	new-question-five	5
2/4/2021 8:17		**EFPF Tools - Visual and Data Analytics for CE**	new-question-splash	Empty
2/4/2021 8:17		**EFPF - Tools Evaluation Questionnaire**	new-question-splash	Empty
2/4/2021 8:17			introduction	Empty
1/4/2021 8:46			thanks	Empty

Figure 65: Answer 1 (Visual and Data Analytics tool)

Based on the way data is stored in the RateMe system, please read this document bottom up				
Date	**Responses**	**Questions**	**Question Type**	**User Score**
31/3/2021 13:39			thanks	Empty
31/3/2021 13:39		**Please add your details**	new-question-form	Empty
31/3/2021 13:39		Accessibility of the tool is easy through single sign on functionality	new-question-five	5
31/3/2021 13:39		A wide set of analytic and monitoring solutions are available through the tool	new-question-five	5
31/3/2021 13:39	They are available in real time.	The analytics results are available to the user without significant delays	new-question-five	5
31/3/2021 13:39	Vibration visual and data analytics is only offered by this tool. Specifi	Visual and Data analytics tool provides some specific functionalities that are n	new-question-five	5
31/3/2021 13:39		The tools forecasts can improve planning activities for supply chain domain or	new-question-five	5
31/3/2021 13:39	Predictive Maintenance and smart waste management	The tool provides useful insights and forecasts related to different domains	new-question-five	5
31/3/2021 13:39		The visualization services provide an adequate number of different graphs th	new-question-five	5
31/3/2021 13:39	Yes they are available through EFPF portal	Are Sensors live data coming from factory available for analysis through EFPF	new-question-five	5
31/3/2021 13:39		I can deploy historical data or use available live data or data from data bases	new-question-five	5
31/3/2021 13:39	I can easily select vibration or fill level analytics	I can easily select different analytics and monitoring services	new-question-five	5
31/3/2021 13:39		**EFPF - Visual and Data Analytics for CE**	new-question-splash	Empty
31/3/2021 13:39	Easy to install, understand and implement. It also saves time and m	I will recommend this tool to the contacts in my business network	new-question-five	5
31/3/2021 13:39		I found the tool was easy to install/configure/execute	new-question-five	5
31/3/2021 13:39	Adequate information about the vibration behavior and fill level mon	The interfaces of the tool provided adequate information about the purpose a	new-question-five	5
31/3/2021 13:39		I felt confident and comfortable using this tool	new-question-five	5
31/3/2021 13:39		The documentation and instruction were easy to understand and follow	new-question-five	5
31/3/2021 13:39	The administration tab allows me to set fill level limits for my bins an	I am able to complete tasks & scenarios without needing developers he	new-question-five	5
31/3/2021 13:39	Vibrometer current status and fill level monitoring are presented in a	The functions and capabilities of the tool are properly visible and usable	new-question-five	5
31/3/2021 13:39	User friendly tool. Easy to access and understand its functional prope	Overall, I am satisfied with how easy it was to use the tool	new-question-five	5
31/3/2021 13:39		**EFPF Tools - Visual and Data Analytics for CE**	new-question-splash	Empty
31/3/2021 13:39		**EFPF - Tools Evaluation Questionnaire**	new-question-splash	Empty
31/3/2021 13:39			introduction	Empty

Figure 66: Answer 2 (Visual and Data Analytics tool)

6 Annexe B: History

Document History	
Versions	V0.1: • Document set-up and draft Table of Contents V0.2: • First draft version V0.3: • Final draft • First review • Second review • V1.0 • final version of D9.3
Contributions	Theofilos Mastos (KLE) Alexandros Nizamis (CERTH)