PlastiCircle: *Improvement of the plastic packaging waste chain from a circular economy approach*

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PlastiCircle Deliverable

D6.4: Pilot in Alba Iulia

Cristina Eseanu, Alexandra Crisan, Valentin Voinica (Alba Iulia Municipality) Lucia Pera (Polaris M Holding)

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Author: Cristina Eseanu, Alexandra Crisan, Valentin Voinica (Alba Iulia Municipality), Lucia Pera (Polaris M Holding)

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Abstract

This deliverable describes the structure of the PlastiCircle pilot in Alba Iulia and the specific results from the pilot in Arnsberg - Goldis neighbourhood.

Partners

1. ITENE: INSTITUTO TECNOLÓGICO DEL EMBALAJE, TRANSPORTE Y LOGÍSTICA
2. SINTEF: STIFTELSEN SINTEF
3.
4. AXION: AXION RECYCLING
5. CRF: CENTRO RICERCHE FIAT
6. UTRECH: GEMEENTE UTRECHT
7. Las Naves: FUNDACION DE LA COMUNITAT VALENCIANA PARA LA PROMOCION ESTRATEGICA EL DESARROLLO Y LA INNOVACION URBANA
8. ALBA: PRIMARIA MUNICIPIULUI ALBA IULIA
9. MOV: MESTNA OBCINA VELENJE
10. SAV: SOCIEDAD ANONIMA AGRICULTORES DE LA VEGA DE VALENCIA
11. POLARIS: POLARIS M HOLDING SRL
12. INTERVAL: INDUSTRIAS TERMOPLÁSTICAS VALENCIANAS
13. ARMACELL: Armacell Benelux S.C.S.
14. DERBIGUM: Imperbel N.V.
15. PROPLAST: CONSORZIO PER LA PROMOZIONE DELLA CULTURA PLASTICA PROPLAST
16. Hahn: HAHN PLASTICS Ltd.
17. ECOEMBES: ECOEMBALAJES ESPAÑA S.A.
18. KIMbcn: Fundació Knowledge Innovation Market Barcelona
19. PLASTICSEUROPE: PLASTICSEUROPE
20. ICLEI: ICLEI EUROPASEKRETARIAT GMBH
21. PIVISA: PICVISA MACHINE VISION SYSTEMS SL

21.1 CALAF: CALAF INDUSTRIAL

22. SINTEF: SINTEF AS

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Publishable summary

With less than 30% of the plastic waste produced yearly in the EU recycled at present, the European plastic market has plenty of room to improve and bridge the gaps to the circular economy model.

The PlastiCircle project aims to address these challenges by developing a holistic process founded on four axes, including: collection, sorting, transport and valorisation in value-added products. The ultimate goal is to improve the collection and valorisation of domestic packaging waste across EU28 and contribute to the creation of new companies and jobs in the sector in the long run.

Pilot project activities undertaken so far have focused on two of the four axes, namely collection and sorting, solutions developed being tested through pilots in Valencia, Utrecht and Alba Iulia, with an additional location (Velenje) actively monitoring progress and considering the feasibility of implementing its own pilot.

Alba Iulia has a much smaller surface and population than Valencia and Utrecht and is at an earlier stage in the process of improving the waste management system and applying circular economy principles on recycling. The Alba Iulia pilot had similar objectives and KPIs to Valencia and Utrecht and in many ways was an adaptation of the technical and communication strategies of the Valencia pilot to local specificities. The pilot was more focused on informing citizens on correct recycling activities and the importance of recycling and testing social and behavioural changes in the pilot area.

This document describes the planning and implementation activities of the Alba Iulia pilot and presents the key outcomes achieved, ending with conclusions on the lessons learned and future applications in the local municipality and beyond.

1. Introduction

The strategic objective of the PlastiCircle project is to increase the recycling rates and valorisation of polymers derived from domestic packaging waste. Four axes divided in several work packages have been devised to achieve this objective.

From a technology standpoint, PlastiCircle is developing solutions in several work packages: WP2 – collection, WP3 – transport, WP4 – sorting, WP5 – recycling. WP6 is focused on integrating and validating the results from these four work packages with a view to achieve the following objectives:

[O6.1] Assure seamlessly integration of PlastiCircle Modules from WP2 to WP5

[O6.2] Assure the achievement of results on collection, transport, sorting and recycling

[O6.3] Test project developments of WP2 and WP3 in Valencia, Utrecht and Alba Iulia

[O6.4] Demonstrate replicability of the test results in other cities after the project

In a first step, results coming from WP2 and WP3 must be compiled and examined (SINTEF) and related to requirements from the municipalities and the local situation. Each city – Valencia (Las Naves), Utrecht, Alba Iulia – have defined together with their waste managers (SAV, POLARIS) the following information:

1) Localization of the pilot (district),
2) Involved actors (municipality staff, citizens, transport companies, and sorting facilities), with roles and responsibilities
3) Time plan for the pilot: communication, technical installations and testing, duration
4) Starting conditions. Characterization protocol for the waste – KPI's
5) Technical requirements to be considered for each pilot
6) Communication to citizens. Communication channels, events and timeline for actions.
7) Planning of logistics with transport and implementation of technical material and transport software
8) Pilot blue-prints,
9) Phase in and phase out of equipment – send them back to Valencia

The Alba Iulia pilot focused on the first two axes of the PlastiCircle project, related to collection and transport, while also providing input to the third one, sorting. The main local challenges related to plastic recycling include: a) the transition from two existing waste fractions ("wet" – general waste and "dry" – recyclables) to a new system involving a dedicated plastic smart container, requiring an informing campaign on correct sorting of plastic and b) the migration to an integrated waste management system operated at district level. The citizens'

level of consciousness regarding the environment and waste collection and reuse is an important issue. It is also critical to provide more assistance to the local companies specialized in recycling in order to improve the economic contribution of this sector to the local economy; general waste characterization, optimized transport routes and eco-driving constitute important levers for success in this area.

Whereas Valencia and Utrecht focused on improving plastic packaging recycling rates and transport efficiency, in Alba Iulia the emphasis was placed on raising awareness and engaging citizens in the plastic recycling process. Aligned with PlastiCircle objectives, local pilot objectives included:

- Informing and raising involvement and awareness of citizens on how to properly recycle plastics and the importance of recycling for the environment, health and the economy.

  Our logo - "You select because you care!" - was designed to convey the message that we want the citizens living in the pilot area to play an active part in all the interesting pilot activities and make a direct contribution to our city's look, health and economy.

- Testing innovative collection methods (citizens' platform, smart containers, optimization of collection routes), able to increase the efficiency of plastic packaging collection and recycling.

  PlastiCircle offered the citizens from the pilot area the possibility for an extensive local test regarding better information and importance of correct recycling, together with a first test of usage a container with card reader and labelling system. We also wanted to test several solutions for waste transport efficiency.

- Collecting suggestions from citizens and data on quantities, types of plastics and the possibility of recycling them, applying locally the concepts of the circular economy.

- Collecting sociological data, obtaining feedback from citizens and detailed information on the quantities and types of waste which can be recycled in order to shape the development of the local waste management system in the near future.

The Alba Iulia municipality worked with waste managers and partners to define a feasible plan and approach for implementing the pilot. The COVID-19 pandemic had (and still has) important effects on the project and the broader economy. Numerous adjustments to timelines, strategies and tactics were required to meet COVID-19-related challenges – please see section 2 for details.

2. Pilot planning

Prior to commencing the delivery of the pilot in line with strategic objectives outlined in the publishable summary, several planning activities were conducted.

The location was established through stakeholder consultations, taking into account the existing types of residential buildings, their waste management systems and the fit with broader objectives. The apartment blocks, associations and administrators in the designated area were identified – for a schema of the location please see section 2.1.

The governance framework was defined, including actors, roles and responsibilities. It was also agreed that progress would be discussed in weekly on-line project partners meetings taking place from pilot start to finish, and several financial and technical reports would be submitted to the project management authority.

The starting conditions (KPIs) were fleshed out and the project plan with month-by-month critical activities was mapped out. The initial planning for the Alba Iulia pilot was described in D6.1 for M25. However, several adjustments had to be made in the wake of the Covid-19 pandemic, resulting in the extension of initial timelines – the pilot was finally executed in the Arnsberg-Goldis neighbourhood from M38 through to M41 (July – Octo 2020), with project closure activities scheduled to end in January 2021. Section 2.3 provides an overview of planned vs. realised activities against the initial and revised timelines.

The technical requirements for the sensors, communication platform and transport-related equipment were defined, together with the communication and engagement strategy and the planning for waste logistics.

The pilot blueprints and maps showing the pilot neighbourhood and the location of sensors, transceivers, transport routes were created - please refer to section 2.8 for details.

Lastly, the activities for equipment phase in and phase out were defined and they are currently in the process of being finalised.

2.1 Local aspects and pilot location

Located in a different geography from the other European countries hosting PlastiCircle pilots and currently in transition, Romania reports a recycling rate of domestic waste of only 14%. The national situation is better in terms of plastic recycling, especially PET – the figure below demonstrates that recycling rates of plastic packaging waste across the EU report high fluctuations (source: European Parliament news).

Figure 1 Recycling rate of plastic packaging waste within the EU

The pilot city Alba Iulia is undergoing its own transition towards new local waste operators and the start of an integrated waste management system for the entire Alba county.

Figure 2 PlastiCircle pilot cities

Figure 3 Alba Iulia aerial view

Located in Central-Western Romania, Alba Iulia covers 103.6 sq. km. According to the 2011 census, the city had a population of 64,000 inhabitants, with a density of 566 inhabitants/sq. km. Alba Iulia in turn is undergoing its own transition towards new local waste operators and the start of an integrated waste management system for the entire Alba county. The population followed an upward trend in recent years, with the latest data collected in 2017 showing a total count of 74,000 inhabitants when including surrounding areas. Population distribution by age indicates a relatively young population, with the majority of inhabitants (65%) falling into the 16-59 age bracket. Inhabitants aged 60 and above account for a 20% share of the total population. Children aged 0-15 account for the remaining 15%.

The majority of the population (31,921 inhabitants equivalent to 68.7% of the population) live in apartment blocks managed by associations, the remainder (14,548 inhabitants equivalent to 31.3%) in individual homes. There are 172 registered associations at present.

As already presented in the pilot planning D6.1, Alba Iulia has some particularities in sorting and collection of waste:

- It is preferred to implement pilot in blocks areas, where waste quantities are bigger than in residential homes areas (where a small container and a dedicated yellow bag for recyclables are used)
- Usage of metal or plastic Eurocontainers (1,1m3) in dedicated locations for blocks of flats
- Containers are usually for “wet” (general waste) and “dry” (recyclables)

fractions; lack of specific containers for plastic and information regarding correct sorting for recycling, require extensive information to be disseminated to the public in order to improve behaviour

- Contrary to residential homes, apartment blocks often report additional challenges regarding waste – waste is often mixed, contaminated and not put in correct container. New information on correct recycling and citizens' training are needed
- The container's lid is often left open, imposing adaption of filling sensors
- The container is washed weekly, so extra waterproof measures were needed for filling sensors
- The density of the population and narrow streets in the pilot neighbourhood impose limits on signal transmission from labelling and container ID tests

Apartment blocks were selected as the main focus of the pilot after consideration of the different types of residential buildings represented in Alba Iulia and the effectiveness of their existent waste systems. Whereas individual homes already have a successful waste management system in place, apartment blocks pose distinct challenges that could be further investigated through the pilot. The Arnsberg-Goldis (delimited by Bd. Revoluției – str. Cloşca – Bd. Încoronării – str. Vasile Goldis) was ultimately selected as location due to its fit with project requirements – centrally located and well integrated socially, it mainly comprises apartment blocks (137 blocks with 40 associations), hosts over 4000 families and 18 existing containers locations.

Figure 4 Location of pilot district Arnsberg-Goldis in Alba Iulia

2.2 Pilot actors

Role	Responsible
➢ **Local pilot coordination (technical and communication) – Alba Iulia Municipality**	Valentin Voinica (PM), Cristina Eseanu (APM), Alexandra Crisan (Local expert); Support: Doina Mira, Viorica Sicoe, George Edves, Cristina Coman
➢ **Local communication contact – Alba Iulia Municipality**	Team, dedicated project e-mail & Facebook page
➢ **Operations - Containers, transport, pre-sorting, waste characterization – Polaris M Holding**	Lucia Pera (Director), Traian Bobaila (Operations manager), drivers, operators
➢ **Pilot coordination and planning partners**	ITENE, SINTEF
Smart devices (identification modules/ transceivers)	ITENE
➢ **Project platform, IoT, Administrative platform, Citizens' platform, mobile applications**	SAV
➢ **Surveys/ surveys**	SINTEF, ITENE
➢ **Transport – route optimization, eco-driving partners**	ITENE, SAV
➢ **Communication partner**	ICLEI
➢ **Eco-points and rewards; plastic bench**	ITENE, Las Naves; Hahn Plastics; Polaris
➢ **Shipment to Picvisa (automatic sorting partner) – Alba Iulia Municipality**	Cancelled due to EU legal restrictions and COVID19
➢ **Citizens' representation and contact – Alba Iulia**	Apartment block administrators

Table 1: Roles and responsible actors in the Alba Iulia pilot

2.3 Pilot time plan

The initial planning envisaged the Pilot running in Alba Iulia from M31 through to M38 (December 2019 -July 2020), with citizens' involvement from April to June 2020. The plan had to be revised in response to the onset of the COVID-19 pandemic in March, which disrupted engagement and communication strategies and adversely impacted the level of technical support for smart containers and availability of the waste collection partner, Polaris. The project team made the decision to postpone the implementation period to July-

September/ October 2020.

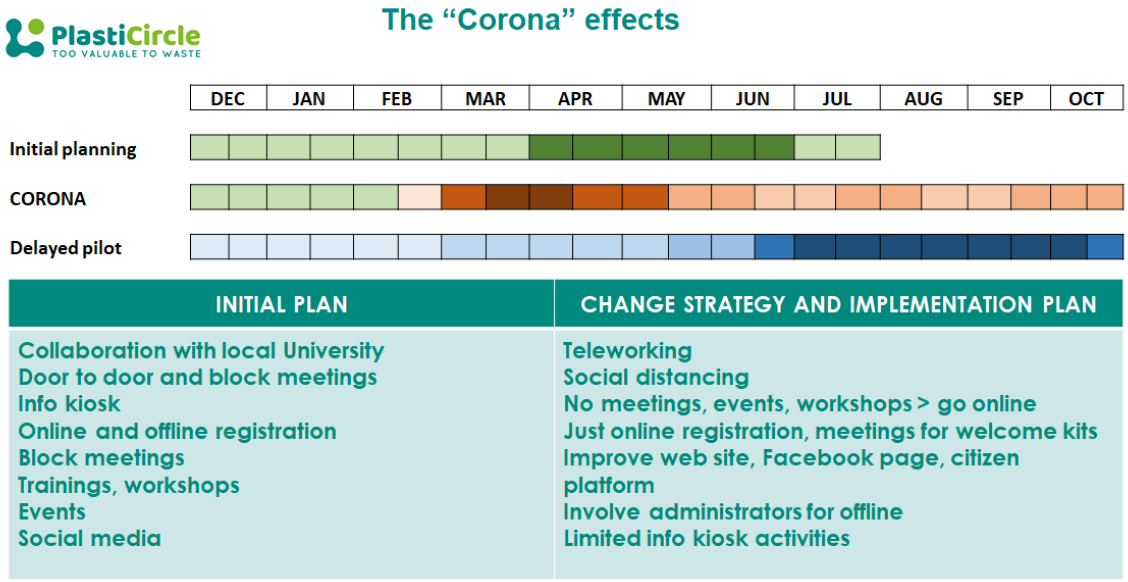


Figure 5 Overview of the "corona" effects

Corona effects

The COVID-19 pandemic caused numerous changes in the strategies devised for the Alba Iulia pilot, as most personnel entered in telework from home and limitations were imposed on contacting and working with citizens and running various activities face-to-face.

The initial implementation plan envisaged the Sociology Faculty of the local university actively supporting us with door-to-door activities, manual registration of citizens, the info kiosk, surveys and events. COVID forced us to revise our plan and think of other ways to contact citizens as meetings were banned and universities were forced to shift activities online. Our updated approach consisted of engagement and education activities conducted mainly online, combined with offline information disseminated with the help of apartment associations. Many planned events, training and workshops had to be cancelled or adjusted, with focus shifting towards online meetings, presentations and QA sessions, plus improved online interactions via the website, Facebook page and citizens' platform.

We also encountered several technical challenges in adapting labelling systems to our containers, testing sensors, finding locations for transceivers, establishing transport routes, translating and customising the citizens and administrative platform, adapting surveys, activities and waste profiling procedures.

The effects of the pandemic were also felt by the municipality and Polaris M Holding our local operations partner. Special public health measures and changes were introduced in the way the city hall operates to maintain the quality of services provided to citizens. Polaris had to operate numerous other

activities (like daily disinfections of container locations, blocks entry, new waste transfer location, etc.).

We successfully navigated these challenges through the hard work and dedication of our team and the full support of our project partners in all these activities.

A summary of the high-level activities completed, including deviations from the initial plan, is presented below:

- **Technical activities:**

  Smart containers

  Equipment installation activities scheduled for February and March tracked well against the initial plan. In the first instance, the filling sensor had to be adapted using brackets to fit local waste patterns – i.e., citizens often leave the container lid open in Alba Iulia, rendering measurements ineffective. The communication of the information collected from the sensor to the IoT cloud platform in Valencia was tested with good results, but revealed the need for further adjustments – specifically, the sensor reading frequency and platform had to be tailored (three-hour interval instead of 8 hours) since the container was smaller and filling up much faster than in Valencia. With on-site support from ITENE and SAV, all filling sensors and labelling devices were successfully installed on 21 new plastic containers located at Polaris HQ during the first week of March. The coverage area was also tested with good results using 7 transceivers and 2 test labelling devices moved near existing container locations from the pilot area. In response to the national state of emergency and alert due to COVID-19, the plastic containers remained at Polaris HQ until June, with some requiring their battery to be recharged prior to dispatch to target area starting July 1st. In parallel, KPIs, activities and training materials were adapted for containers maintenance procedure. Final tests for containers and labelling systems were completed in June. From July through to October, maintenance activities were performed – repositioning label rolls within label dispensers, recharging batteries, changing defective filling sensors and label dispensers. The containers remained on location until December 2020 to allow for the collection of additional route optimisation data. The reclaiming of the equipment from containers and shipping back to Valencia is planned to follow in January 2021 as part of project phase out.

  Transportation

  It was agreed that a dedicated truck would be used to pick up the smart containers from the pilot location. The initial plan envisaged the receipt

and installation of a CAN-BUS interface from Valencia at the start of July 2020 to provide information on dedicated truck location and performance (consumption, distance covered, speed, etc.). While the equipment was received on time, an additional 3 weeks were necessary to adapt the CAN-BUS interface to the Polaris truck (Iveco). A further delay was incurred due to challenges in obtaining specialised support to install the sensor onto the truck - several firms authorised to complete this operation refused to help due to the risk of damaging the truck on-board computer; our partners were also unable to provide on-site support due to COVID-19 travel restrictions. The installation was ultimately performed in-house with support from a specialist, SAV and the supplier, the equipment becoming functional in August and starting to send data to the platform from September onwards. In parallel, SAV also adapted the mobile app based on the GPS information provided and updated the map for route optimisation with information from the filling sensors, as well as data regarding preventive and eco-driving parameters etc. The drivers of the dedicated truck received instructions prior to commencing operations.

While some initial route optimisation data were collected, some additional technical challenges were encountered – i.e. communication protocol between the mobile app and CAN-BUS, unsuccessful CAN-BUS reset requiring a new CAN-BUS device. Final data regarding optimised routes will be collected and analysed in December- January, with phase out of truck equipment lined up for January 2021.

Communication platform

The cloud platform for receiving and displaying filling sensors and labelling devices information was made available as planned in March. Working with SAV, ITENE, Las Naves and the Alba municipality, the project team translated and adapted the citizens' registration, the participants' portal, the management portal and the cloud platform. Further key improvements were introduced in April and May to support the revised engagement strategy focused on online interaction: 1) automation of citizens' registration process to display only those details relevant to pilot participants based on GIS information – 3 drop-down tables implemented including street, number and apartment block; 2) adaptation and upload of surveys with SINTEF and ITENE onto the platform to streamline the data collection from users and automatically compute results. Citizens also received more online content and additional improvements were made with regards to the display of eco-points and prizes.

Final updates to the platform were made from May to June, including the integration between PlastiCircle and the dedicated pilot website. A dedicated training about a limited access to platform was performed in

August, for promoters available at info kiosk, in order to ease participants registration with their support.

- **Characterization :**

  First, KPIs, step by step activities and training materials were adapted for general characterisation, material sorting for Picvisa and individual characterisation (together with translated dedicated platform as for registration of participant eco-points).

  The initial planning factored in 3 general waste characterisation activities during March (pre-pilot), May (during pilot) and June (post-pilot). The timelines had to be adjusted due to COVID-19. The pre-pilot characterisation took place on June 26th and involved the characterization of 2 fractions, dry and wet, using a process similar to that of Valencia. The characterisation scheduled during the pilot took place on September 3rd and covered 3 factions, dry, wet and PlastiCircle containers. The post-pilot characterisation was rescheduled for October but ultimately could not be completed due to increasing COVID-19 incidence making manual manipulation of waste not recommended.

  In terms of individual characterisation, activities took place from July through to October. The dedicated pilot truck was set up to pick up the PlastiCircle materials and transport them diligently, protecting the contents. Bags were manually sorted to check for the quality of the plastic prepared for recycling and data was entered in the platform either directly or manually based on paper records. The personnel handling the sorting received training on the characterisation protocol beforehand.

  Initial planning also envisaged waste being transferred to partner Picvisa Barcelona to test the sorting mechanism. This was scheduled to run in 2 tranches – a) initial tranche of 1 tonne of pre-sorted dry waste collected prior to the pilot and b) second tranche of 1 tonne of pre-sorted waste collected during the Pilot from the PlastiCircle containers. The sorting mechanism was agreed with Picvisa - e.g., no metal waste, size restrictions, no organic waste, bottles emptied and pressed etc. However, transport to Picvisa was ultimately cancelled due to several factors including: legal restrictions on transporting waste in excess of 50 kilograms across European national states (special permits required); and restrictions to handling waste due to COVID-19, given the high contamination risk difficult to avoid. As alternative, Picvisa is replicating the composition of Alba Iulia waste based on general characterisation in order to test the sorting mechanism.

- **Communication and dissemination**

  The planning of communication took place as described in D6.1,

however, with some adjustments due to unavoidable functional delays in the context of COVID-19 related restrictions (including lockdown in March – May 2020 on the Romanian territory). The engagement and communications strategy had to be adapted in response to social distancing, face to face, meeting and events restrictions and in person training were replaced by communication and promotion using more comprehensive online and printed materials.

Initially the planning envisaged the citizens being directly involved from March through July. This had to be shifted later in the year, with the March – June period focusing on:

- Decision on communication actions
- Preparation of communication materials (online/offline)
- Analysing possibilities for organizing public events
- Staff training

The campaign for attracting citizens to participate in the pilot was rescheduled for June 15th, alongside other engagement activities including: the preparation and distribution of "welcome kits" with dedicated plastic bags and RFID cards; the organisation of online workshops and technical activities etc. The collection process officially started on July 1st, together with plastic containers becoming available.

From July – October 2020 we entered the monitoring period, with some online activities taking place – e.g., Zoom and Facebook activities, dissemination activities and just one offline activity (info kiosk).

From November-December 2020 we have entered the final phase involving analysis, validation of results and closing activities.

- **Surveys to involved parties:**

Two sets of surveys were translated and adapted with SINTEF to allow for more consideration to citizens' education and the assessment of improvements in their behaviour during the PlastiCircle pilot: a) an initial survey, following registration meant to assess the initial level of education and awareness and b) a final survey towards the end of the pilot to assess improvements in long-term behaviour and gather feedback and suggestions.

The initial survey was delivered on June 15th, while the second was made available in October. The project team also requested feedback from block administrations, Polaris and municipality personnel for the social assessment lifecycle.

2.4 Starting conditions/ Pilot KPIs

For Alba Iulia pilot objectives mirrored overall project objectives, but with particular focus on:

- Informing and involving citizens in aspects regarding correct plastic recycling and its importance for health, environment and economy
- Performing a first test of innovative solutions like smart containers, citizens platform, route optimization in order to improve plastic collection efficiency and recycling
- Receiving feedback from citizens together with data regarding quantities and types of plastic (addressing first steps to a circular economy)

For the environmental evaluation of our project, the selected environmental key point indicators (KPI) are described below:

- **K1: Distance travelled**: the existing distance from a starting point (A) to a point of arrival (B) of the planned route and the units will be kilometres (km).
- **K2: Time travelled:** it is the time since the vehicle leaves the waste manager depot, until it returns to the facilities once the route is completed. The units are minutes (min) or hours (h).
- **K3: Collections performed:** number of containers collected during the route. The unit will be the total number of containers served.
- **K4: Relative CO_2e emission:**
  - K4.1 = CO_2e/Tonne collected
  - K4.2 = CO_2e/driven distance (km)
- **K5: Performance:**
  - K5.1 = energy cost/tonne collected
  - K5.2 = (personal & energy) cost/tonne collected
  - K5.3 = % inappropriate materials RSU containers
- **K6: Fuel consumption**: amount of fuel consumed by the vehicle to carry out the programmed route. The units are litres of diesel (l).

KPIs FOR CITIZENS' CHARACTERISATION: The results will be based on characterisation performed to the citizens' waste bags, the main objective is to improve the citizens characterisation taking place at home.

- **K7: % Not packaging waste:** Global percentage of unwanted material found in the characterised bags, before and after the pilot.
  - K7.1: % in number
  - K7.2: % in weight
- **K8: % No empty packaging:** Global percentage of number of packaging that still contain product inside

- **K9: % stacked packaging:** Global percentage of heaped packaging (one packaging inside of another)
- **K10: % compacted bottles:** Percentage of the number of bottles compacted.
- **K11: % selective collection rate:** Fraction of plastic packaging waste collected.
    - PRE-pilot:
        - wet fraction (WF) 200 kg
        - dry fraction (DF) 200 kg
    - MID/ FINAL -pilot:
        - wet fraction 200 kg
        - dry fraction 200 kg
        - PlastiCircle fraction (PF) all the bags in the containers (110 kg)
- **K12: Compaction level in container –** kg/m3
- **K13: Filling level.** % fill level when trucks unloads

Related to communication campaign:

- **K14** Number of people registered and number participating in the project.
- **K15** Number of visits in web supports
- **K16** Number of followers and engagement in social media
- **K17** Number of people attending meetings organized such as events or conferences.

2.5 Technical equipment and requirements for the pilot

a) Filling level sensor

The filling sensor used in Alba Iulia is similar to those used in Valencia pilot (TSwasTe product). It has an ultrasonic sensor for level, and supplementary temperature and shock sensors, information being sent to the IoT platform from Valencia via GSM-GPRS (module with Spanish SIM card for data transmission). Mounting is simplified to a single screw.

Figure 6 Filing sensor with L bracket for lateral mount and sensor mounted inside container

Relative to the Valencia pilot (where the sensor is mounted on the lid and big capacity containers are emptied every 3-5 days), several particularities apply:

- The container lid is frequently left open
- Exposure to rain, humidity, shock is much higher
- Containers are small, fill fast and are emptied daily
- Existing procedure for washing containers is not recommendable

Several adjustments were made to accommodate these particularities:

- A lateral mount was installed using an adaptive L bracket
- A high-capacity battery was needed
- In order to ease communication, metal containers were abandoned
- Existing containers in locations made installation difficult; we opted for installation in Polaris courtyard on new, plastic containers

A test sensor was mounted in order to check if the measurements were correct for the lateral mount and data available in project platform.

b) RFID card/ keychain

Participants' interaction with smart containers was based on the usage of a RFID card or keychain, easy to use, prepared and delivered by ITENE and registered in the project platform for each participant.

Figure 7 Usage of a RFID key-chain on identity module

c) Identity module (label dispenser)

This module is a complex prototype, able to read the user's card, generate a bar code label, read it with laser and combine data in order to send to local transceivers via LoRA. Initial concerns were related to:

- Mounting on smaller containers, in a place where truck can still operate them
- Necessity for high-capacity batteries
- Resistance to shocks and humidity
- Steering away from the washing containers procedure

Figure 8 Identity module: a) appearance; b) indoor – label roll and reader; c) batteries and electronics

d) Local Transceivers

Based on the experience with the Valencia pilot, ITENE prepared the prototype of a transceiver able to receive data over LoRA and send them to the project platform in Valencia via GSM-GPRS, using a Spanish SIM data card. As the pilot neighbourhood in Alba Iulia is characterized by narrow streets and a multitude of blocks, coverage was the main concern, followed by finding proper locations in order to ensure a good coverage for all containers, together with data transmission to platform.

Figure 9 Local transceivers prepared for Alba Iulia, included high gain antennas in order to improve coverage; a) outside; b) inside electronics

A communication diagram (presented below) includes level sensors, identity modules, LoRA/ GSM transceivers and platform server, together with GPRS/ internet connections.

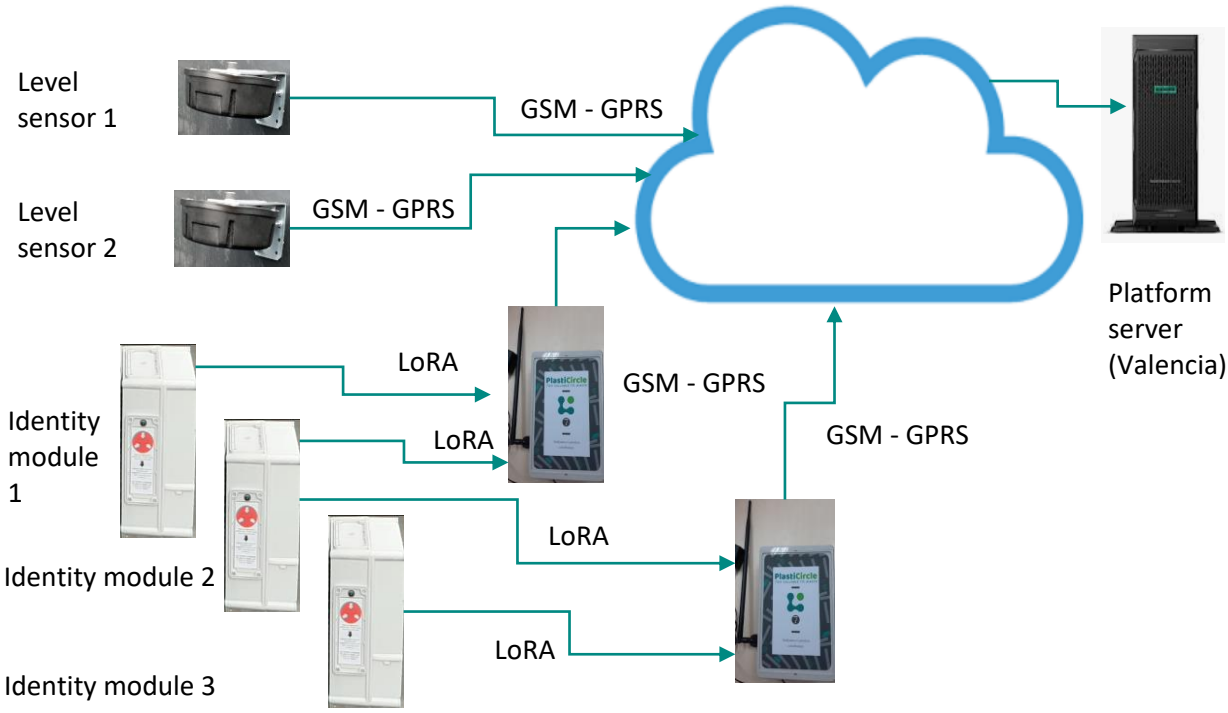


Figure 10 Communication schematic diagram and main components

Containers in Alba Iulia are completely different from those in Valencia; therefore, the mounting of filling sensors and identification module had just a basic installation CAD design. Instead, tests were conducted for best options to ensure correct functioning. After measurements, first installation was tested on truck for real operation and was replicated for all containers.

Figure 11 Containers with installed modules in Polaris courtyard (left: initial design)

Alba Iulia used the platform developed and installed in Valencia; consequently, special drawings for installing telecom/ network equipment or computers were not needed.

Also, the local network configuration was similar to that tested in Valencia, including:

- Filling level sensors data (including temperature, shock) are transmitted by GSM - GPRS to the cloud server;
- Identification modules (labelling smart devices) send information (RFID card, label number) by LoRA to the receiver nodes in range of the Goldis – Arnsberg pilot area;
- Receiver nodes send data to the clod server via GSM – GPRS;
- Data received in the cloud server is stored in a PostgreSQL database to be visualized in the IoT platform installed in Valencia and accessible online.

Points of interest (like truck starting point, containers location and allocated smart device and filling sensor, finish truck point at transfer ramp) are already integrated in pilot maps. Sorting and processing of waste is not available locally, but will become available in a location placed at 15 km from Alba Iulia.

e) CAN-BUS

Controller Area Network (CAN bus) is defined as a robust vehicle bus standard designed specially to allow microcontrollers and devices to communicate with each other's applications without a host computer. As a message – based protocol, CAN-BUS can be used in multiple applications, including those for reading all sensors available on a vehicle for its computer.

Figure 12 CAN-BUS kit prepared for installation on dedicated truck in Alba Iulia

Main concerns regarding usage of a CAN-BUS device in Alba Iulia were related to the adapting to a specific truck (Iveco), availability/ functionality of sensors and signals on a 7-year-old truck and installing/ trouble shooting device, as international help on local site was not possible.

2.6 Planning of communication to citizens

As explained in D6.1, the involvement of citizens in the Alba Iulia pilot followed a similar workflow as in the Valencia pilot (see figure below) and consisted of:

- receiving info about pilot and activities at registration and receiving an NFC card,
- correctly sort and prepare waste for recycling
- using the NFC card at the label dispenser,
- attaching the label to the bag,
- its content being characterized and,
- the compensation according to the results of the characterization.

Figure 13 Citizen involvement in PlastiCircle is similar to Valencia pilot

Registration Process

The pilot area chosen in Alba Iulia was one of the most densely populated neighbourhoods in the city, therefore the socio-demographic profile is a mixt one, in terms of age or digital skills. While the registration process was designed for online interaction only in the context of Covid19-related restrictions, an offline component was eventually added in the second half of the pilot in order to help citizens with an expected digital gap register.

Therefore, two registration modalities were used during the pilot:

- **Online Registration:** participants register through the dedicated website and come to the headquarters of the Municipality to pick up their welcome kit and the smart device card. This modality was used since the start of the pilot in June and July 2020.

Figure 14 Online registration and short meeting for welcome kits

- **On-line with support (Manual Registration):** Citizens are informed and helped to register in the digital participants' data base by street informers. This modality was in use since September 2020 and was possible in a context where social interaction in person was still possible, actually before the second wave of Covid-19 infections hit Romania in the fall of 2020.

Figure 15 Online registration with support at info kiosk

Communication Strategy

According to the communication strategy of the project, set up for all the three pilot cities, a set of communication tools were launched in Alba Iulia, with the transversal goal of achieving a citizen-centred approach that, in addition to benefiting from the project incentive, will help for a better environment and increased personal satisfaction when improving the neighbourhood.

As already identified in D6.1, for Alba Iulia, the citizen's level of consciousness regarding the environment and waste collection and reuse, as well as citizen behaviour, are important aspects. This was considered in the planning of communication actions. The educative and awareness-raising dimensions were very important, with the main goal being informing about the benefits for the environment of recycling plastic.

Apart from these, similar to the pilot in Valencia, the communication tools had

the multiple purpose of:

- informing about how to participate in the pilot action
- training about the right waste sorting at home
- raising awareness about the importance of circular economy
- usage of smart container

The objectives were not treated separately, but as a whole in every dissemination action of the campaign.

Visual identity elements

The definition of a visual identity and corresponding elements were one of the most important aspects of the early planning period, before the actual project start. The elements were discussed and approved by ICLEI, being a combination between PlastiCircle visual identity and Alba Iulia branding manual, consisting of:

- A pilot logo combining the PlastiCircle logo and the Alba Iulia city logo, in line with the general visual identity and colour range approved for the project;

Figure 16 Alba Iulia pilot logo

- A slogan adapted to the need of educating and raising awareness among the citizens. The slogan contains a call-to-action and implies as well an appeal to the individual responsibility of citizens: SELECTEZI PENTRU CA ITI PASA! (YOU SELECT BECAUSE YOU CARE!). The slogan was used along with the logo described above.

Figure 17 Alba Iulia pilot slogan

- A character whose image appeared on all communication materials, in order to make the message more tangible and for facilitating the visual identification of the pilot among targeted citizens.

Figure 18 Alba Iulia - final pilot character

Communication Tools

Given the fact that the pilot in Alba Iulia was heavily influenced by the context of restrictions and social distancing imposed due to the Covid19 pandemic, most of the communication had to be adapted and deployed online. The tools set up were:

- The pilot website: https://plasticircle-albaiulia.ro/ was set up before the actual pilot start, in April-May 2020 and offered to citizens:
    - General information about the PlastiCircle project and about the pilots deployed in the three participating cities
    - Specific information about the pilot in Alba Iulia and explanations about how to participate
    - Extended versions of 'Terms and conditions" and "Confidentiality policy" approved by municipal DPO (Data Protection Officer)
    - A news section, containing the latest activities deployed within the pilot in Alba Iulia
    - Informing articles regarding plastic recycling
    - The integration with the platform https://registro.supermarcelina.com/alba_iulia/
    - A login section for the registered users, allowing them to enter the platform

Figure 19 Pilot webpage Tabs, including Platform login

- The platform where the citizens were able to register and actually take part in the pilot was adapted after the model of the platform used in Valencia pilot, and translated into Romanian language: https://registro.supermarcelina.com/alba_iulia/

- The Facebook page dedicated to the pilot in Alba Iulia:

  https://www.facebook.com/PlastiCircle-Alba-Iulia-111169163954409/

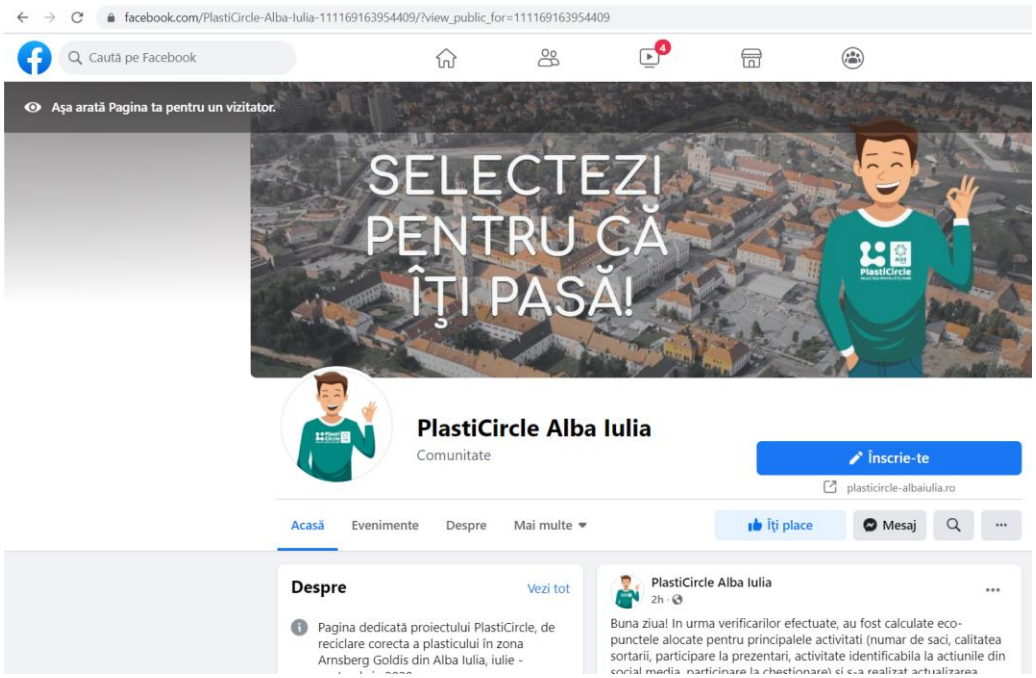


Figure 20 Facebook page PlastiCircle Alba Iulia

The page was set up in June 2020 and was an important communication tool during the pilot, allowing the project team to inform citizens about the registration process (both online and offline/ online with support), to launch challenges, to keep participants informed about the latest developments of the project and to answer various questions of interested persons.

- Email address of the pilot contact@plasticircle-albaiulia.ro was setup along with the website construction and was made public on all info materials, on the website and on the Facebook page as well. It was used

for gathering citizens' feedback and for sending messages of interest to all registered participants.

- The official project video presenting the pilot in Alba Iulia: https://www.facebook.com/111169163954409/videos/1744979065669159/
- Dedicated phone line to the municipal dispatch

Communication materials

Several items consisting of communication materials were created for the pilot and were included in the welcome kit, distributed in the neighbourhood and also used on the containers dedicated to the pilot. All items included and respected the visual identity elements described above.

- Labels for containers:

Figure 21. Big (A2) label on dedicated containers

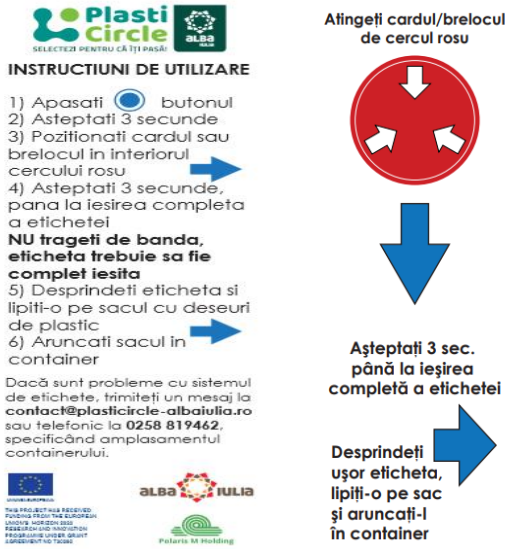


Figure 22 Informational stickers regarding correct usage of labelling system on container

- Flyer inviting citizens to take part in the project:

Figure 23 Informational flyer and registering invitation

- General informational flyer on how to recycle plastic:

Figure 24 General informational flyer - correct sorting of plastic

- Brochure dedicated to pilot participants:

Figure 25 General informational brochure for registered users

- Rollups for events and posters with registering details for bloc entrances and local shops:

Figure 26 Rollups and posters for block entrances and local shops

- Personalised stationary:

Figure 27 Personalized stationery: a) bags used for packing welcome kits; b) agenda; c) pen

Communication actions targeted at citizens and pilot participants

- Press release about the pilot start on the official website of Alba Iulia Municipality:

  https://www.apulum.ro/index.php/primaria/detail/comunicat-de-presa-proiect-pilot-pentru-colectare-selectiva-si-reciclare-pl

- A pre-pilot informative event targeting some administrators from block flat owners' associations took place at the Municipality on June 12th, 2020. The event was an opportunity to inform them about the project, about the pilot and about the general importance of educating citizens on plastic recycling. Few owners who live in the pilot neighbourhood were also enrolled in the platform as pilot participants, were given welcome kits and NFC cards. All participants also given communication materials (posters and leaflets) to be distributed to the general public in the pilot area, since block administrators are usually in touch with all owners and therefore, they constitute a significant dissemination factor and opportunity.

  Given the very restrictive context where the Alba Iulia pilot took place, with Covid19-related restrictions imposed by authorities (gatherings forbidden, social distancing imposed) but also facing general fear of physical social interaction among the population, this was the only physical event which could be organized as such. Therefore, the communication actions had to be focused on alternative online solutions.

Figure 28 Pre-pilot event

- Pilot participants were invited via email to Zoom meetings in order to get more information about the project and about their involvement

Sesiunea 1 de prezentare PlastiCircle Mesaje primite ×

Plasticircle Alba <contact@plasticircle-albaiulia.ro> joi, 30 iul., 14:48
către

Buna ziua,

Deoarece interesul pentru proiectul PlastiCircle este in crestere si au aparut diverse intrebari privind desfasurarea proiectului, va invitam la o scurta intalnire on-line astazi, de la ora 17,30 (calculator, telefon, tableta), prin accesarea adresei web de mai jos

Topic: PlastiCircle Alba Iulia
Time: Jul 30, 2020 05:30 PM Bucharest

Join Zoom Meeting

https://us04web.zoom.us/j/71299950287?pwd=cWhqR2JkaGM4RWN1ZjFPVXBibHpiUT09
<https://us04web.zoom.us/j/71299950287?pwd=cWhqR2JkaGM4RWN1ZjFPVXBibHpiUT09>

Meeting ID: 712 9995 0287
Passcode: 6FiXnU

Va asteptam!

Echipa PlastiCircle Alba Iulia

Sesiunea 2 de prezentare PlastiCircle Mesaje primite ×

Plasticircle Alba <contact@plasticircle-albaiulia.ro>
către

lun., 17 aug., 14:10

Stimati parteneri,

In cazul in care programul va permite, va invitam maine 18 august, de la ora 17,30 la o scurta intalnire (30 min) on-line de prezentare a proiectului PlastiCircle, prin accesarea adresei web de mai jos.

Reamintim ca participarea la un astfel de eveniment este recompensata cu eco puncte.

Topic: PlastiCircle 2
Time: Aug 18, 2020 05:30 PM Bucharest

Join Zoom Meeting
https://us04web.zoom.us/j/73507685069?pwd=U2lNMGZyQ0pSekc0VWNxaGFHaWNoQT09

Meeting ID: 735 0768 5069
Passcode: Ruj4Rm

Va asteptam!
Echipa PlastiCircle Alba Iulia

Figure 29 Invites to presentations via Zoom

- A live session of questions and answers was organized on Facebook:

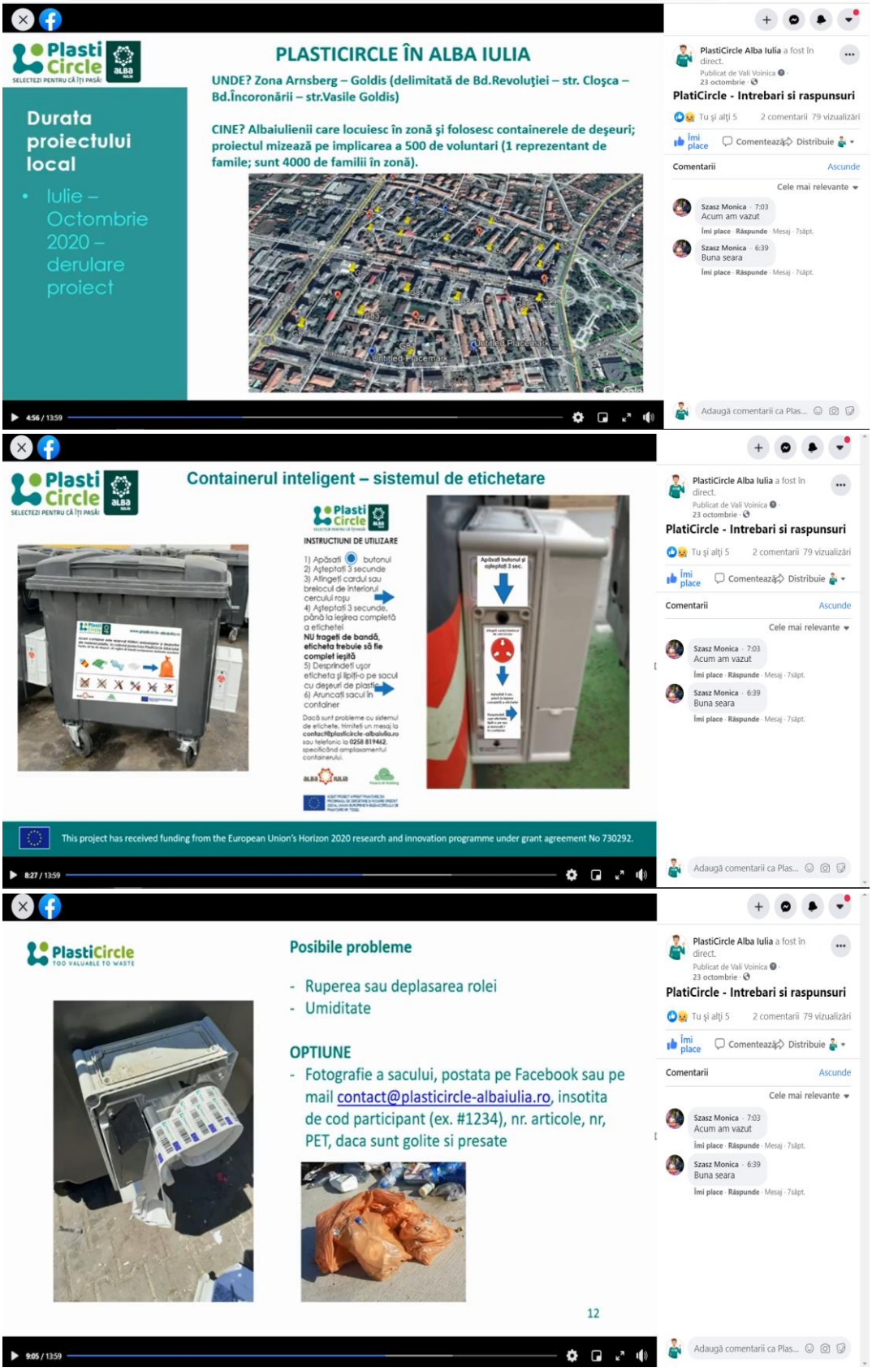


Figure 30 Live Q&A session

- 5 challenges were posted on Facebook in order to engage pilot participants and create opportunities for them to earn eco-points:

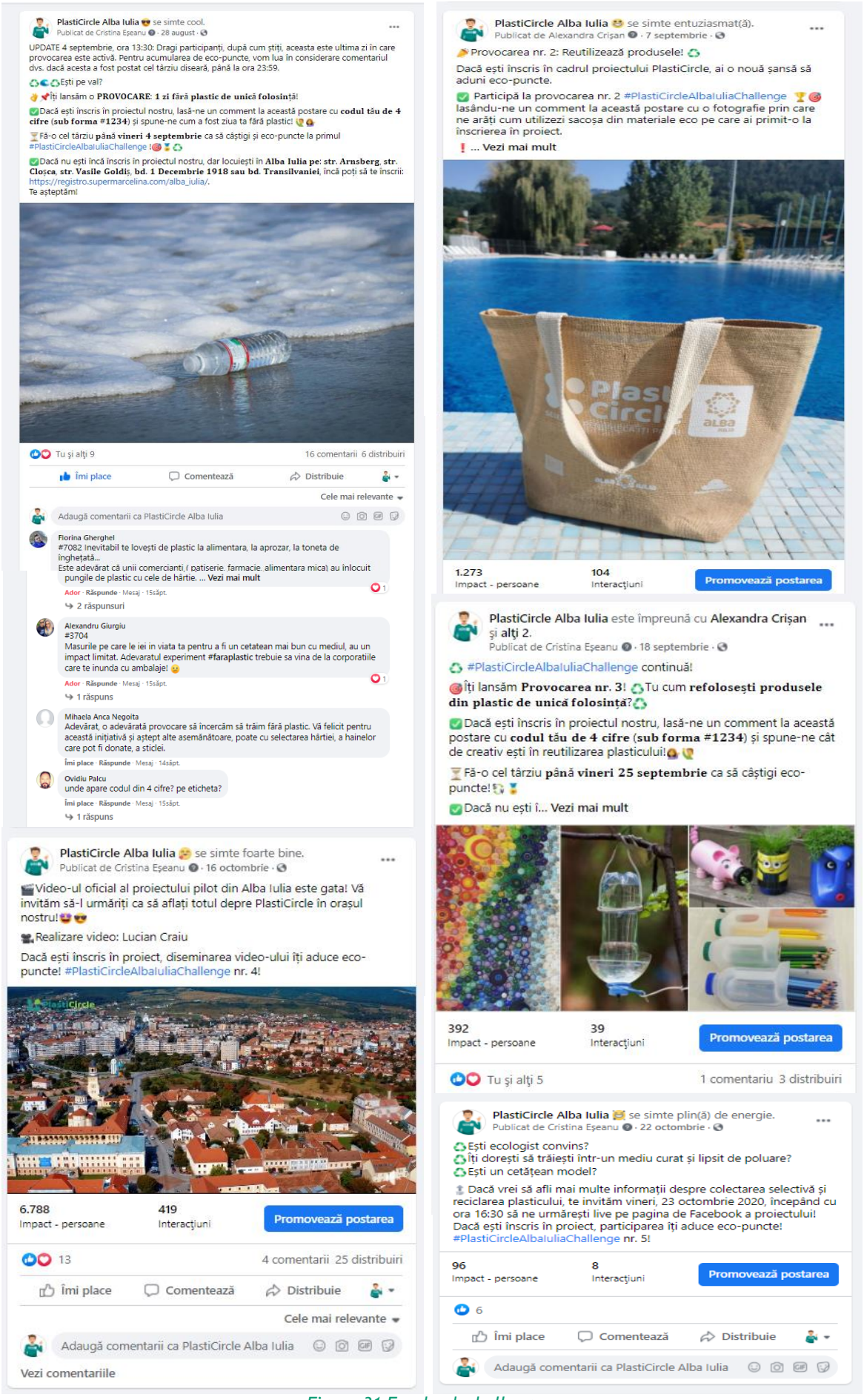


Figure 31 Facebook challenges

After the pilot, participants were informed about the allocation of eco-points in the platform and were given a timeframe when they could inquire about the number of points assigned. Another timeframe was dedicated to the actual redemption of prizes.

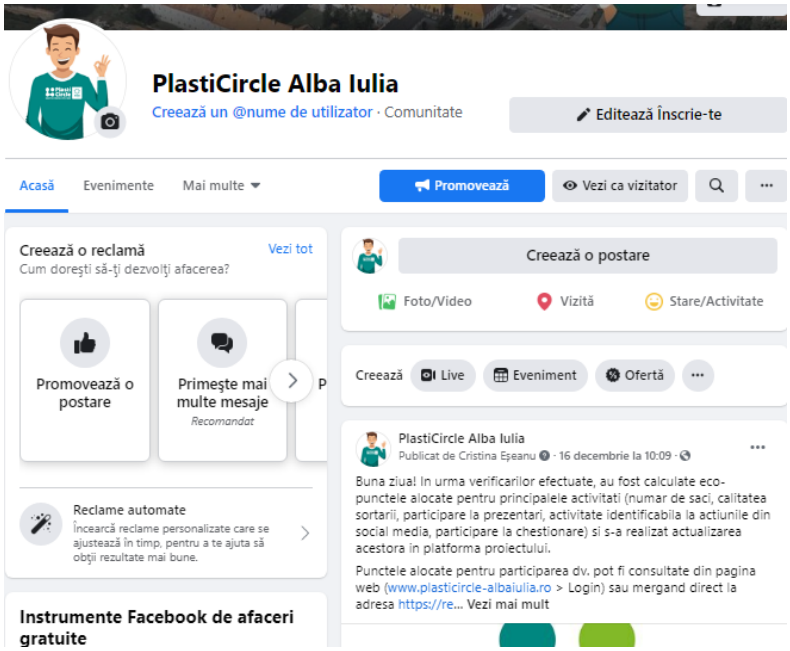


Figure 32 Facebook announcement regarding points' allocation

2.7 Planning of waste logistics

The local waste logistics is in a transitional stage, as new requirements were set for the future waste city operator (private company) and a new integrated waste system will operate at Alba district level, including an environment compliant sorting, recycling and waste dump – currently in process of allocating administrator rights as part of a bidding process. Waste from Alba Iulia is currently transported to a distant sorting and waste dump.

Regarding waste collection from individual homes, the operator for Alba Iulia currently collects only 2 different kinds of domestic waste streams separately (as shown below); as part of downstream processing operations, these 2 streams are further broken down through manual selection into 4 streams:

- "Dry" fraction (recycled materials; paper, glass, aluminium, plastic; considered usually at 80kg/m3), collected in a yellow bag
- "Wet" fraction (garbage, mixed waste, usual considered at 280kg/m3), collected in standard plastic containers (120l)

Figure 33 Waste collection from homes - standard plastic 120l container and yellow bag for recyclables

In contrast to Valencia (where 3m3 containers are used) and Utrecht (using many 5m3 underground containers), in Alba Iulia in high density areas typical for blocks of apartments, mobile (on wheels) euro containers of 1.1m3 are used (plastic or metal) for "wet" and "dry" fractions. Usually, for bigger capacity, several containers for each fraction are placed in a location dedicated to specific blocks.

Figure 34 Plastic and metal Euro containers (1.1 m3) and container location

The recycling process for individual homes using the "yellow bag" has been reporting relatively good results for several years. However, the dry fraction from apartment blocks, where quantities are much bigger, has plenty of room for improvements - some citizens do not pay attention to the container type, do not sort or press packages, or mix recyclable materials with other, unwanted materials. This is why we decided to use apartment blocks for our pilot location, PlastiCircle offering a good opportunity to improve communication and information related to plastic recycling.

The frequency of collection varies depending on the type of residence. The collection is scheduled to run weekly for individual houses (4,33 collections/ house/ month) and daily for associations of flat apartments (30-31 collections/ container/ month). An average of 18,800tonnes/year are collected from the population (of which 6700t/year from households) and 10,600tonnes/year from companies/ institutions.

In the upcoming period, according to updated legislation, in Alba Iulia we shall

have four recyclable waste types that are going to be collected separately from the start, in different containers.

Figure 35 Project for underground containers with 4 different fractions

Waste management for the administration and entities operating in Romania is regulated under national law 101/2016 and many other legal provisions and regulations, adapting the main EU policies. A single provider (Polaris) has exclusivity over the provision of the public service to households and apartment associations in Alba Iulia, with several small companies offering separate recycling service contracts to companies. According to public bid processes, waste management operator for the city, together with operator for local sorting location and district waste dump are expected to become operational.

The waste collection system is door to door for houses and bring banks for apartments associations. After collection, Polaris sorts manually only a part of waste and sells the recyclable materials to specialized companies, for final collection and recycling. Majority of materials, waste and garbage are transported to a distant sorting and waste dump.

In practice, Polaris uses 9 trucks for waste collection with diesel motorization - Iveco Euro-Cargo (EEV type, 2013), Iveco Trakker (EEV type) and Iveco Daily (EEV type) EEV (fabrication year: 2012). These trucks have the following characteristics:

- Brand and model; Iveco, 2013, Euro4
- Engine: diesel
- Fuel used (petrol, gasoil, gas, electric vehicles, etc.): diesel
- Average consumption of vehicles: 53l/100km
- Distance travelled yearly per truck: 18.000km; average distance for one route: 33km
- Capacity: 7 trucks x 16m3 + 2 trucks x 8m3
- Age of fleet: 7 years

Each truck travels 33km on average per route, with each route planned around a central platform/ transfer ramp (established in May 2020), where the trucks

begin and finish their journey. The trucks follow a daily routine, established according to the frequency of collection contracted with the administration. Drivers know their daily routine and routes; each truck has GPS, but just for reporting position to the dispatch (no tablets or smart phones available for drivers). Polaris replaced this year several Iveco trucks with frequent problems with new Euro 6 Ford trucks, but they are in warranty and devices like CAN-Bus are not allowed.

Regarding the pilot experience in Alba Iulia, it was decided to be implemented in the Arnsberg-Goldis area, as a 'pilot neighbourhood'. This area is managed by Polaris and they are in charge of the collection of the wet and dry fractions.

The usual operative done by Polaris to collect the plastic packaging waste was performed daily during the pilot, on a dedicated route. One single truck made the collection of dedicated PlastiCircle containers from the neighbourhood, starting from technical point (str. Livezii, emptied waste at sort ramp located on the city belt) and continued the collection route to other areas of the city. The final point of the route was at the transfer platform.

Figure 36 Polaris truck and rear operation of PlastiCircle container

Figure 37 Polaris transfer ramp with PET sorted in big bags

For the purpose of the pilot, the usual route was updated according to: distance between containers; route length; communication systems covering that area.

Truck information collected by a special CAN BUS device was used for route optimization and eco-driving tests.

2.8 Pilot blue-prints – maps

The pilot neighbourhood covered a total surface of 268,326 sqm. (dimensions 589 x 554 x 340 x 576 m; perimeter 2,111 m). The neighbourhood is centrally located, near the touristic zone of the Alba Carolina fortress. The two red points show the positions of the Polaris technical headquarter and the waste transfer ramp.

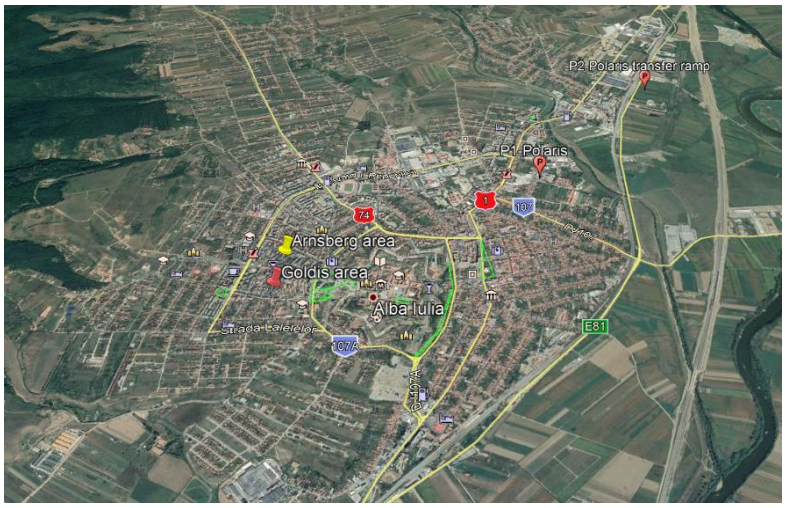


Figure 38 Alba Iulia general map, with pilot areas and Polaris locations

Figure 39 Main dimensions of the pilot area

The following table and map indicate the positions of the transceivers (in red, the initial 8 locations; in green, supplementary locations in institutions).

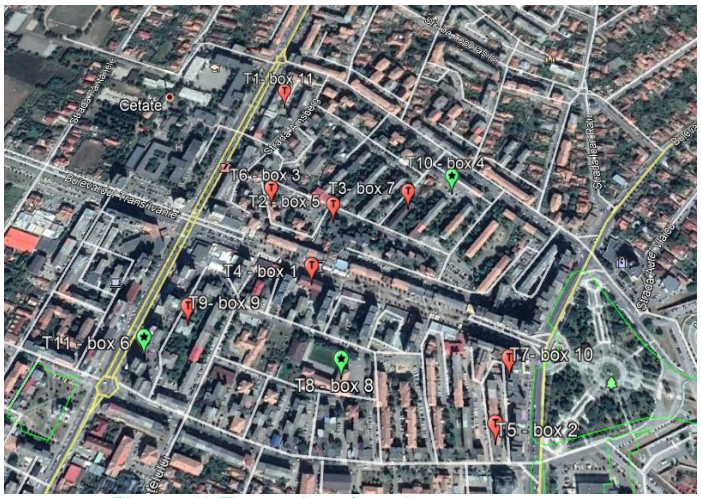


Figure 40 Transceiver locations

Latitude	Longitude	No.
46° 4'11.32"N	23°33'36.28"E	1
46° 4'4.96"N	23°33'48.85"E	2
46° 4'15.21"N	23°33'32.62"E	3
46° 4'16.91"N	23°33'45.19"E	4
46° 4'14.65"N	23°33'37.12"E	5
46° 4'7.00"N	23°33'26.33"E	6
46° 4'15.80"N	23°33'42.21"E	7
46° 4'7.02"N	23°33'39.04"E	8
46° 4'8.68"N	23°33'28.68"E	9
46° 4'7.92"N	23°33'49.57"E	10
46° 4'21.08"N	23°33'32.23"E	11

Table 2 Transceiver details

Dedicated PlastiCircle containers were placed near existing locations, in order to be operated normally, but during a dedicated trip. The prefix indicates the area (A – Arnsberg, G- Goldis), allocated general location number and number of smart identification (labelling) device installed on PlastiCircle containers.

Figure 41 Locations of smart containers

Each container location was identified in field and saved with GPS localisation.

ARNSBERG

No.	Container code	Labelling box	Latitude	Longitude
1	A45	L30	46° 4'20.16"N	23°33'36.26"E
2	A46	L24	46° 4'17.13"N	23°33'35.33"E

3	A47	L29	46° 4'16.20"N	23°33'31.11"E
4	A48	L2	46° 4'15.46"N	23°33'34.80"E
5	A49	L18	46° 4'14.90"N	23°33'40.11"E
6	A50	L25	46° 4'13.71"N	23°33'44.90"E
7	A51	L19	46° 4'17.01"N	23°33'45.33"E
8	A52	L23	46° 4'13.67"N	23°33'50.54"E
9	A53	L13	46° 4'13.76"N	23°33'52.40"E
10	A54	L22	46° 4'11.79"N	23°33'50.03"E
11	A55	L1	46° 4'11.20"N	23°33'49.89"E
GOLDIS				
12	G78	L12	46° 4'8.57"N	23°33'48.59"E
13	G79	L14	46° 4'8.50"N	23°33'49.25"E
14	G80	L6	46° 4'7.27"N	23°33'47.66"E
15	G81	L8	46° 4'3.92"N	23°33'37.21"E
16	G83	L16	46° 4'7.30"N	23°33'32.25"E
17	G84	L5	46° 4'8.55"N	23°33'41.29"E
18	G85	L4	46° 4'9.36"N	23°33'36.31"E
19	G86	L26	46° 4'11.31"N	23°33'30.34"E
20	G87	L17	46° 4'6.24"N	23°33'27.05"E

Table 3 PlastiCircle containers location details

Looking to filter the participants living in the pilot area during the registration process, we prepared two maps, including container allocation/ association/ block and postal details (street, number, block, entrance, code).

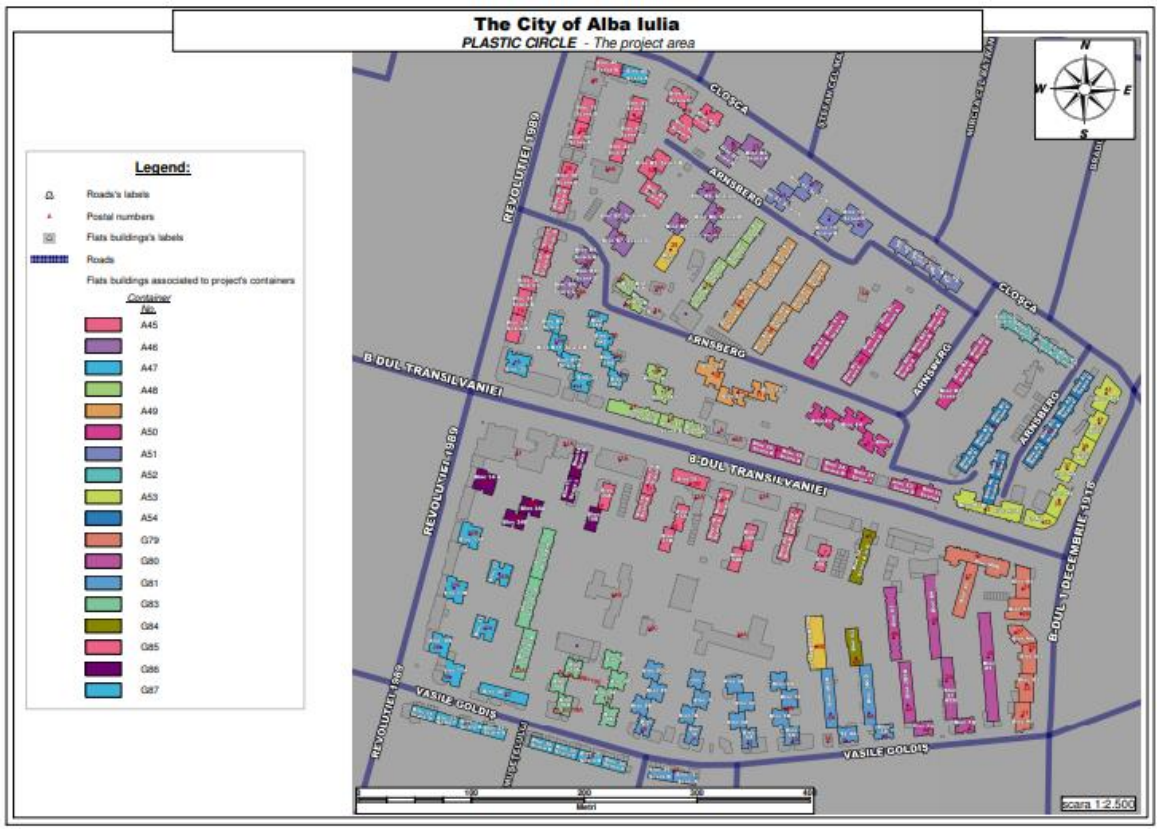


Figure 42 Allocated blocks to containers in the pilot area prepared by colleagues from GIS department

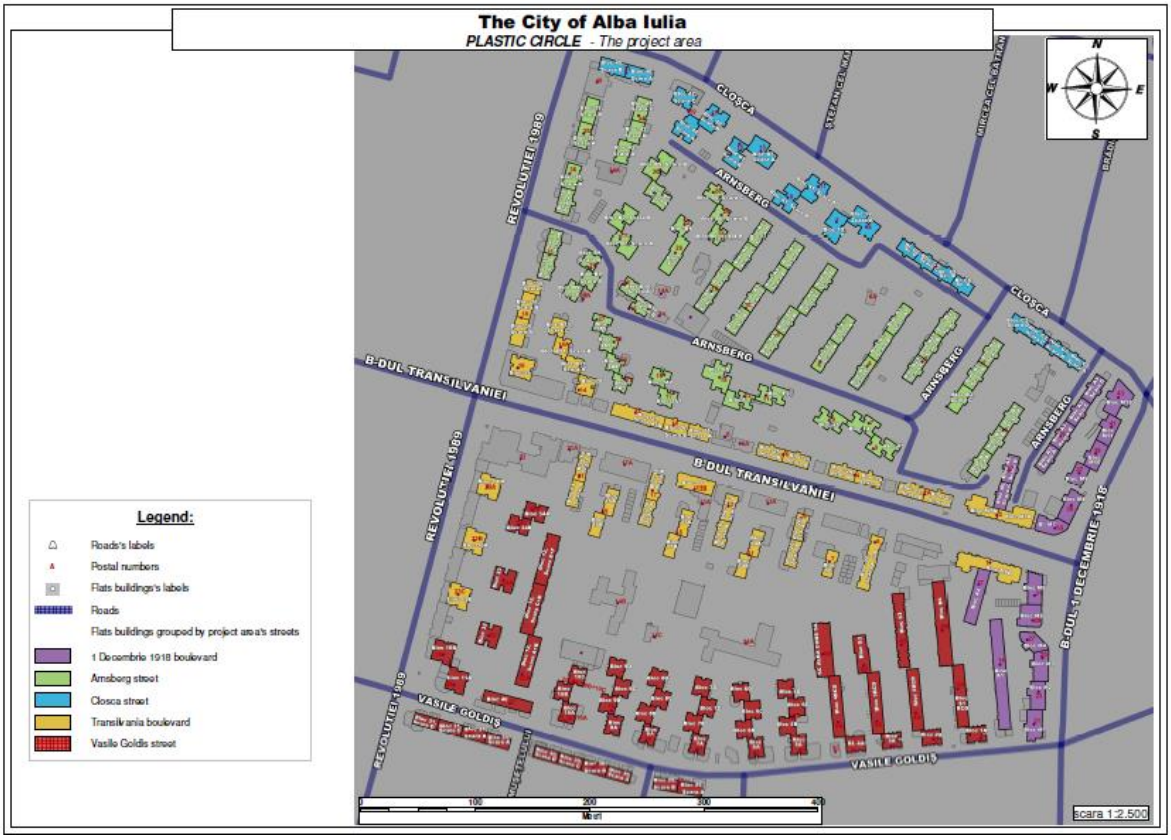


Figure 43 Map of streets, numbers, blocks and postal codes prepared by colleagues from GIS department, used for preparing drop-down lists for validating users living in the pilot area (example in table below)

(ENG)	(Street/ Boulevard > drop down list?)		(Number)	Block	(Entrance / stair)
Nr/ No crt	(Value)	(street name)		(Value)	(Value)
1	B-dul	1 Decembrie 1918	15	A1	A
2	B-dul	1 Decembrie 1918	15	A1	B
3	B-dul	1 Decembrie 1918	15	A1	C
4	B-dul	1 Decembrie 1918	15	A1	D
5	B-dul	1 Decembrie 1918	17	A2	A
6	B-dul	1 Decembrie 1918	17	A2	B
7	B-dul	1 Decembrie 1918	17	A2	C
8	B-dul	1 Decembrie 1918	17	A2	D
148	Strada	Vasile Goldis	20	10A	
149	Strada	Vasile Goldis	20	10B	
150	Strada	Vasile Goldis	20	10C	
151	Strada	Vasile Goldis	26	11A	
152	Strada	Vasile Goldis	26	11B	

Table 4 Example of location details for filtering participants at registration

2.9 Phase in and phase out of equipment

In order to adapt and test the level sensor, a first sensor was sent by SAV and

installed by Alba Iulia Municipality/ Polaris on an existing container in January 2020.
An important transport was shipped from ITENE/ SAV Valencia and received in February, including:

- Identification (labelling modules)
- Filling sensors
- RFID cards/ key chains
- Transceivers
- Consumable orange plastic bags
- Accessories (batteries, chargers, rivets, special screw drivers)

In the same period, Polaris prepared 21 new plastic containers, ready for installation of smart devices, tools for installation and Alba municipality prepared accessories (brackets, screws, etc.).

Installation activities were conducted from March 3rd to March 6th by a mixed team from Itene, SAV, Polaris and the Alba Iulia municipality. The main activities were performed in two locations:

- At Polaris technical courtyard for containers (mounting brackets and filling sensors, deciding on identity module position with tests on truck, mount identity modules with rivets, local test for generating labels and data from filling sensors); in total, 21 containers were prepared
- In a dedicated room in the city hall, for programming and testing transceivers, followed by a fast deployment of transceivers in 8 locations within the pilot area

Containers must be deployed in the pilot area right at the start of the pilot; therefore, final tests for coverage were performed using 2 back-up identity modules positioned in the future container locations, generating labels, sending data to transceivers and checking data availability in the platform. Installation was finalised with a general training and Q&A session regarding devices, maintenance and platform.

The pilot start was postponed, which allowed us to improve our solution; 3 other transceivers were installed in the pilot area to improve expected transceivers coverage.

In June, Polaris and AIM tested containers, changed one identity module and recharged batteries for non-functional identity modules.

The smart containers were deployed in pilot area locations at the start of the pilot on July 1st.

In mid-November we initiated the recovery of transceivers from their locations.

Given technical delays in transport activities and need for additional data from filling sensors to calculate the optimized routes, containers will be recovered from

locations in January 2021, followed by sensors and identity modules.

The final phase out activity is programmed for February 2021, including transport of equipment to Valencia.

3. Results

3.1 Communication campaign and participation

3.1.1 List of KPIs

The list of KPI's identified in Communication Plan are

- **K14** Number of people registered and number participating in the project.
- **K15** Number of visits in web supports
- **K16** Number of followers and engagement in social media
- **K17** Number of people attending meetings organized such as events or conferences.

.

3.1.2 KPI's Performance

K14: Number of people registered and the number of participations in the project

As shown below, a total of 254 registrations were made, cumulating 476 participants. This is a significant number if we consider the absence or face to face activities, like information sessions, workshops or events, able to promote the project effectively.

Parameter	Value
Registrations	254
Citizens	476
Average no. citizens/ registration	1.9

Table 5 KPI14 Number of registrations

The statistics indicate a rather homogenous socio-demographic profile of the users

across indicators such as gender, age range and education level. The majority of users were more mature individuals with a higher education level, characteristics which tend to be correlated with a higher degree of environmental awareness and recognition of the importance of recycling.

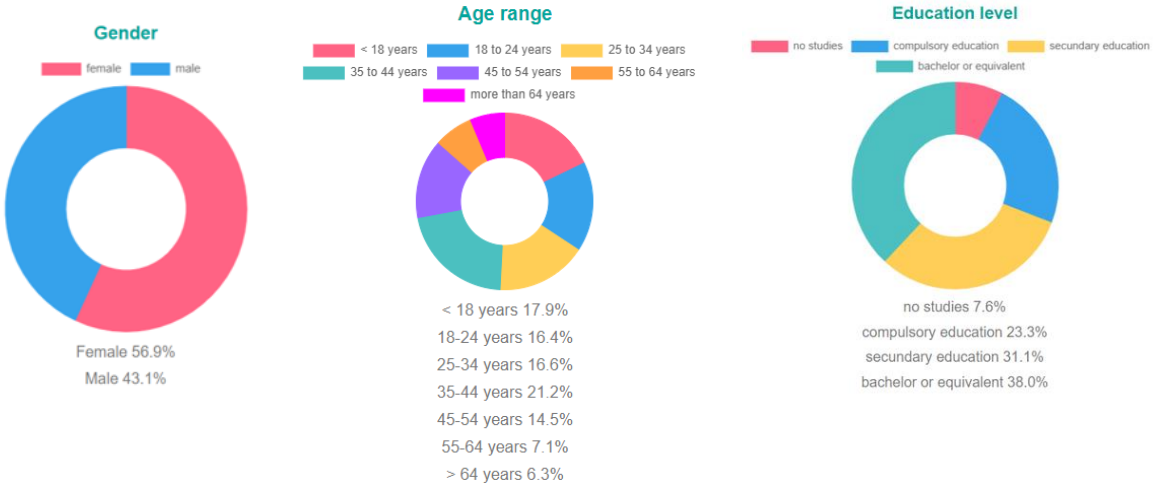


Figure 44 Demographic data (gender, age range, education level)

The number of registrations followed an upward trend in July, in the weeks following a sponsored Facebook campaign where people were invited to register, and recorded a significant peak in September 2020 when a campaign was launched using street informers who assisted people with online registration on the spot.

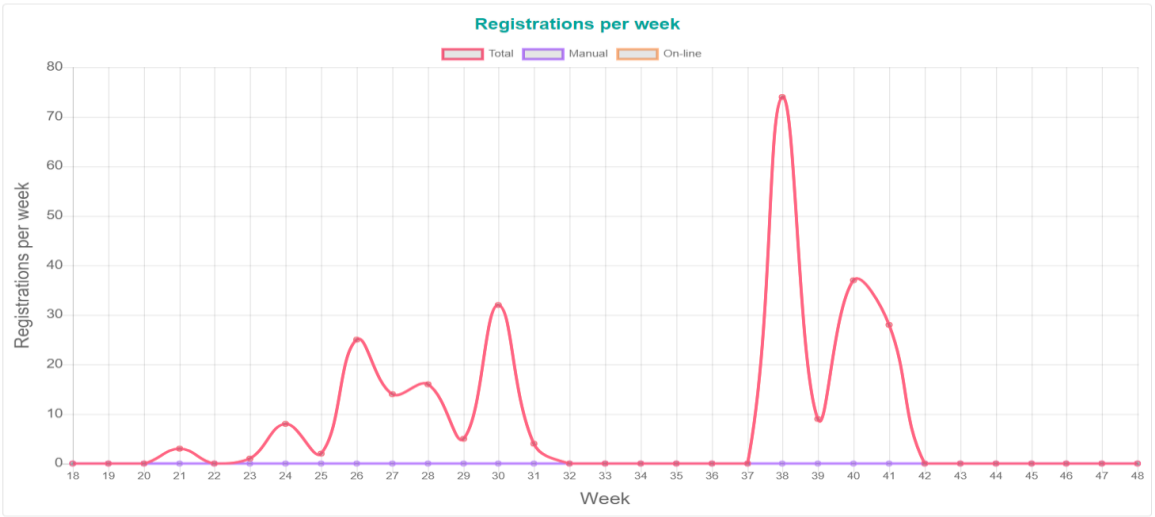


Figure 45 Trends in registration per week

Registrations recorded declines in August, when the reliance on the online registration process showed its limits and many individuals went on annual leave after the lock-down was lifted, and in October, when registrations were closed.

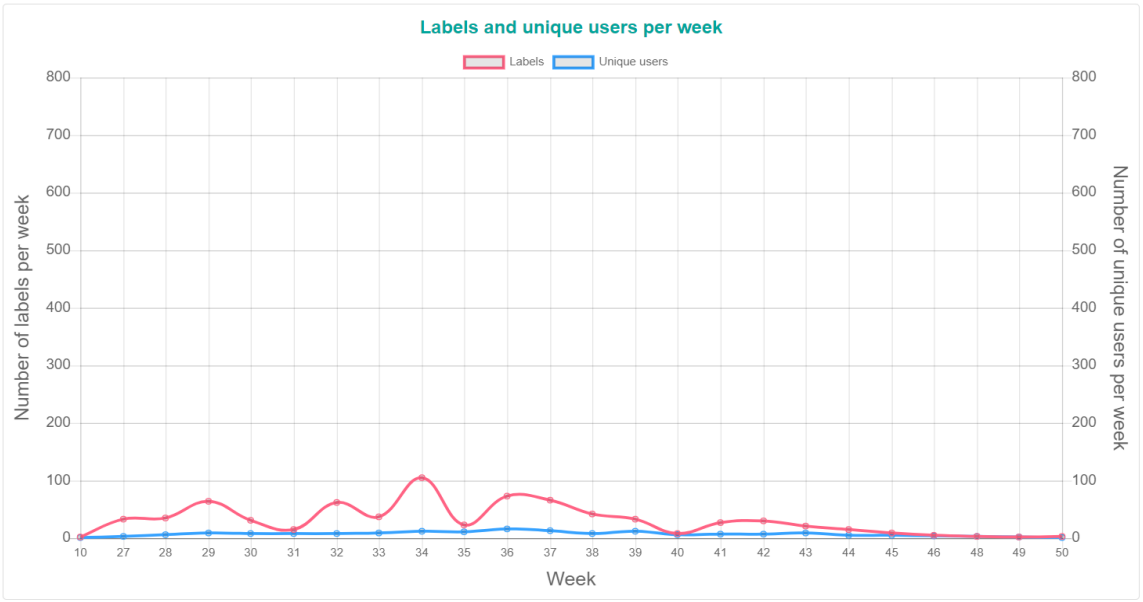


Figure 46 Trends in labels and unique users per week

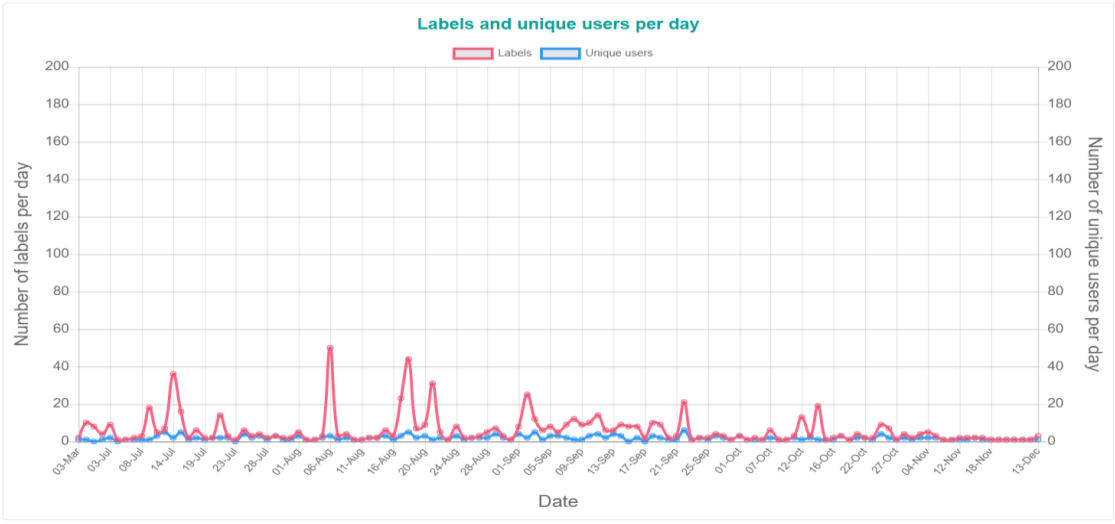


Figure 47 Trends in labels and unique users per day

The graphs for the number of weekly and daily generated labels shows a limited number of labels and a low number of unique users accessing the labelling devices installed on containers – this is explicable if we consider and subtract labels generated for tests and maintenance of identification modules.

K15 Number of visits to web

Our dedicated website https://plasticircle-albaiulia.ro/ was initially prepared in March 2020 and improved after the declaration of the COVID-19 national state of alert. The improved version included much more information about the project, our activities and general aspects regarding plastic recycling, together with improved areas for registration (based on a better integration with platform), general terms and confidentiality, being launched on June 15th.

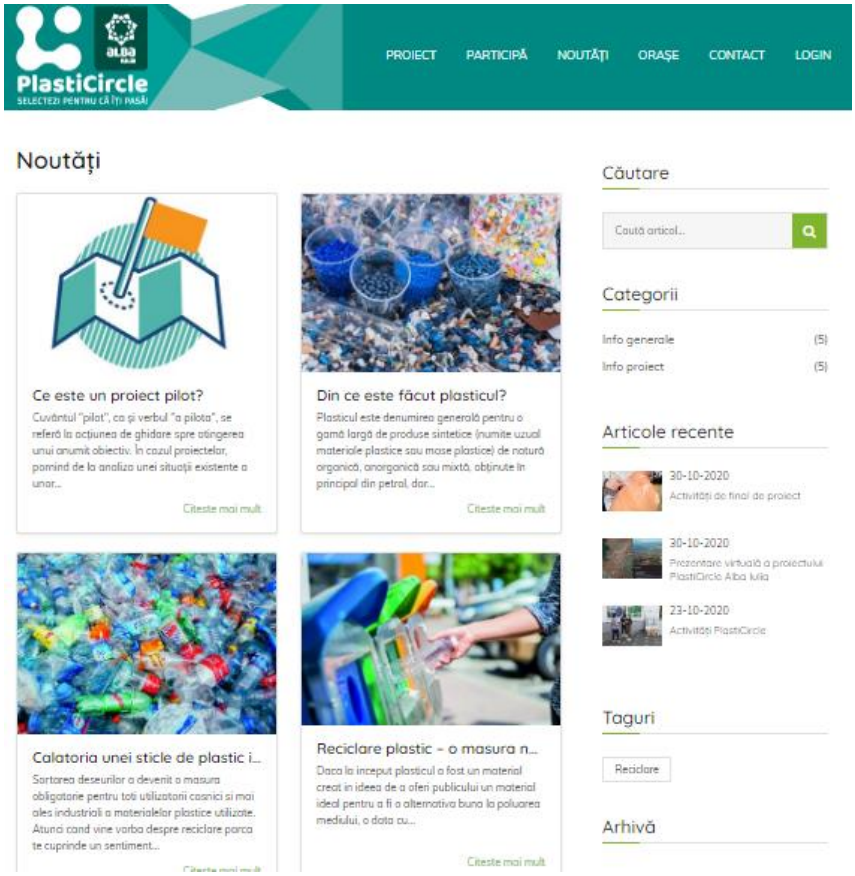


Figure 48 Local webpage with general info about plastic recycling

The pilot website recorded 2184 visits, new visitors accounting for the largest share of visits (78%), followed by registered users.

Videos and presentations:

- General video: https://plasticircle-albaiulia.ro/orase/alba-iulia
- Presentation: https://plasticircle.eu/news/news?c=search&uid=clDrIXfx
- https://earth.google.com/web/data=MicKJQojCiExdVlISlFLV2QwNGhOcnM1UjkwR3NNeDdRU2REZ0JseEg

K16 Number of followers and engagement in social media

According to previous tests performed locally on the effectiveness of social media channels, Facebook is the most important channel, other popular channels (like Twitter or Instagram) being a minority. That is why we decided to create a dedicated Facebook page https://www.facebook.com/PlastiCircle-Alba-Iulia-111169163954409/, including information, communication, activities and links to the registration platform and informative materials from our webpage. For the initial promotion of the PlastiCircle page, we used other municipality Facebook pages:

- The official page, where we posted several articles;
- The projects information page "Value Added Administration" where we posted several other articles;
- Stakeholders' personal Facebook pages like the mayor's personal page;

- Other organizations' pages, e.g., https://expertdeseuri.ro/articole/20-de-containere-inteligente-vor-fi-instalate-la-alba-iulia/; and
- Personal pages.

In the second phase, we used a sponsored promotion of our Facebook page, which boosted our visibility in July.

As shown below, the social media page for the Alba Iulia pilot gathered a total of 329 followers as of December 2020, starting from June 2020.

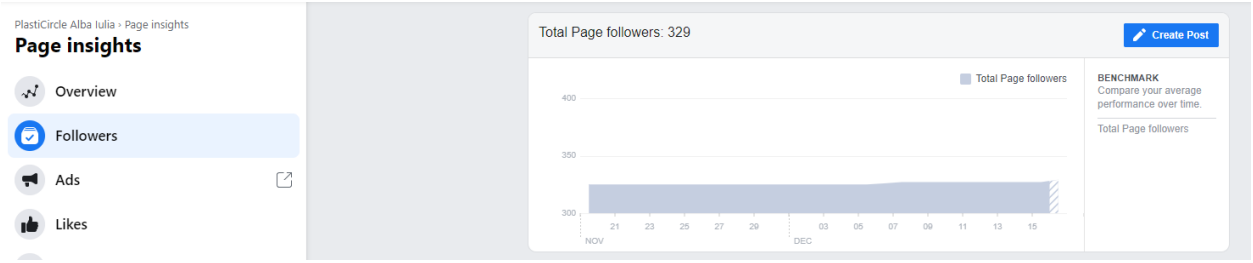


Figure 49 Trends in labels and unique users per day

The screenshots below show the reach of every post made on Facebook, as well as the engagement. The highest figures were of course reached by a sponsored post inviting people to register (40.8 K reach and +11 K engagement). Apart from this post, the organic cumulated reach for all the other posts was +15k and the organic cumulated engagement for all the posts was 1,385.

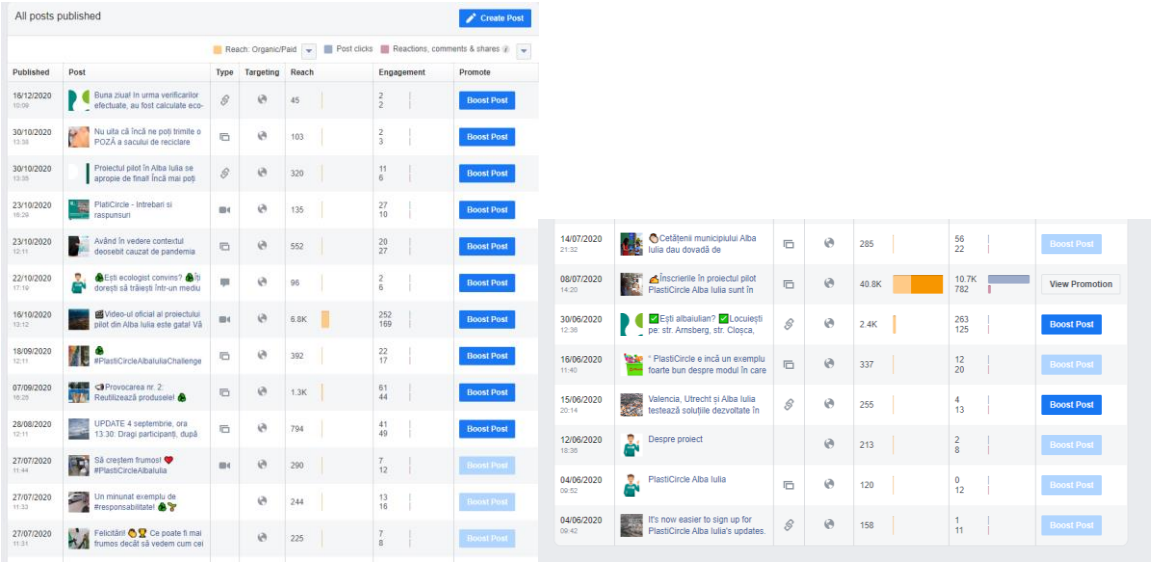


Figure 50 Trends in labels and unique users per day

K17 Number of people attending meetings organized such as events or conferences

Given the restrictions imposed in response to the Covid-19 pandemic, only one event could be organized - a workshop for block administrators held mid-June 2020.

Other planned events, like those with block associations, with local organizations, with students or pupils, had to be cancelled as indoor activities were not possible and schools were closed. The substitution of events for online activities, like information and Q&A events on Zoom and Facebook, was not very successful, even when the target audience was notified beforehand by email.

Events	People attended
Block administrators and project team pre-pilot workshop	23
Presentation 1 Zoom - online	2
Presentation 2 Zoom - online	3
Presentation 3 Facebook - online	8
Training for advertisers and info kiosk team	6
EU Circular week – virtual visit presentation on-line	47
People receiving info at delivery of welcome kits or at temporary info kiosk	>500

Table 5 Events and participation

Communication results are centralised in table below.

Parameter	Value
K14: Number of people registered/ citizens participations in the project	254/ 476
K15: Number of visits in web supports	2184
K16: Number of followers and engagement in social media	329/ 1385 - organic and 11k sponsored engagement
K17 Number of people attending meetings organized such as events or conferences.	148
Off-line communication	
Posters at block entrance and shops	>150
Informative flyer	3200
Correct recycling flyer	2600
Brochures	400

Table 6 KPI's communication results

3.2 Smart container

3.2.1. Identification module

The identification module is a complex prototype, able to read user's RFID card, generate and read an associated label barcode for bags' labels and transmit data to the local dedicated LoRA receivers. The module is very important, as data is transmitted via GSM – GPRS to the project platform in Valencia and processed in order to allocate eco-points for the number of labelled bags placed in containers. As containers in Alba Iulia are small and mobile, we were expecting some problems caused by various technical components requiring maintenance. When these problems occur, labels are not generated or data is not received correctly.

a) Bad usage of identification module

Figure 51 Examples of bad usage of identity modules

Some modules' malfunctions were caused by improper usage, like:

- Breaking the label roll
- Pulling the label roll outside the device
- Breaking the exterior box – water pouring inside
- Moving the containers and inside roll
- Moving the container near a metallic one and obstructing radio transmission

b) Technical issues

These aspects appeared under specific local conditions and usage terms of the modules, more frequent being:

- Movement of label roll inside module, especially during emptying operations; this movement was limited with a simple spring, applying pressure on donor and reception wheels for the labelling roll

Figure 52 Movement of labels roll inside device after emptying container and limiting spring

- Drained or defective batteries - batteries were charged during their installation in May to last for a medium usage of over 3 months; as pilot had to be postponed for July, the majority of batteries had to be recharged or changed if defective during the pilot, and tested together with main connections and voltages
- Data transmission problems - appeared in some cases when the RFID reader was not properly positioned, labels were not properly read, or coverage had fluctuations

		Day		
Location	Containers id	12/10/2020	19/10/2020	New Label dispenser
A55	1	27/09/2020	14/10/2020	1
A48	2	01/10/2020	18/10/2020	2
G84	5	12/10/2020	12/10/2020	5
G80	6	12/10/2020	12/10/2020	3
G81	8	12/10/2020	12/10/2020	8
A53	13	19/09/2020	14/10/2020	13
G79	14	19/09/2020	17/10/2020	14
A49	15	08/10/2020	14/10/2020	15
G83	16	12/10/2020	12/10/2020	16

G85	18	12/10/2020	13/10/2020	18
A51	19	11/10/2020	14/10/2020	19
A54	22	22/09/2020	14/10/2020	22
A52	23	Missing	No data in october	23
A46	24	15/09/2020	No data in october	24
A50	25	24/09/2020	Replaced by 9	9
G86	26	22/09/2020	BROKEN CONTAINER	26
G78	28	12/10/2020	17/10/2020	28
A47	29	Missing	No data in october	29
A45	30	Missing	No data in october	30
Back-up	11	12/10/2020	14/10/2020	
Back-up	3	12/10/2020	13/10/2020	

Table 7 Example of parallel test in platform, in order to improve data transmission

We were able to partially solve this kind of problems through testing and maintaining devices, moving containers, testing parallel transmissions to platform from the same location (one from container and one from a mobile identity module placed nearby) with partners, or completely changing the device when back-up was available.

3.2.2 Transceiver nodes

These devices are of major importance, because they receive data on LoRA from containers and assemble them for transmission to the project platform, using GSM – GPRS. As the pilot area is dense in high buildings (blocks) and has narrow streets, we were expecting coverage problems and we could not use administrative offices, usually placed at ground floor, or institutions (not very present in area). The initial install comprised 8 transceivers placed in the apartments of our colleagues from the city hall living in the pilot area. In a second phase we installed the remaining 3 back-up transceivers in institutions (school, transformer and kinder garden), in an attempt to improve coverage.

Figure 53 Transceivers locations (red - initial, green - second stage)

Latitude	Longitude	No.	Installed in
46° 4'11.32"N	23°33'36.28"E	T1	Private apartment
46° 4'4.96"N	23°33'48.85"E	T2	Private apartment
46° 4'15.21"N	23°33'32.62"E	T3	Private apartment
46° 4'16.91"N	23°33'45.19"E	T4	Private apartment
46° 4'14.65"N	23°33'37.12"E	T5	Private apartment
46° 4'7.00"N	23°33'26.33"E	T6	Private apartment
46° 4'15.80"N	23°33'42.21"E	T7	Private apartment
46° 4'7.02"N	23°33'39.04"E	T8	Goldis School
46° 4'8.68"N	23°33'28.68"E	T9	Private apartment
46° 4'7.92"N	23°33'49.57"E	T10	Transformer
46° 4'21.08"N	23°33'32.23"E	T11	Kindergarten

Table 8 Transceiver details - locations

Theoretically, under good conditions, each transceiver is able to cover an area defined by a radius of up to 250m, but due to local terrain conditions, this area

is smaller. If we consider just an 100m coverage radius for a transmitter (as in figure bellow), we can see that some containers (G81, A52, A53, A54) are at coverage limit, or have just one transceiver in the area. Indeed, this phenomenon of "shrinking" coverage in some conditions was identified during the last month of the pilot, but it was difficult to change transceivers locations, so we moved containers a few meters away from other objects. Also, in several cases with transceivers offline, we had to ask colleagues to put the transceivers back in the power outlet.

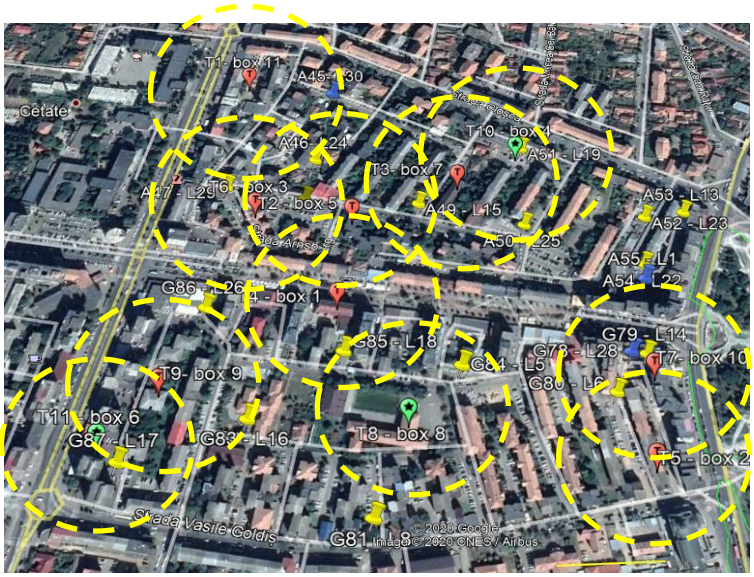


Figure 54 Area covered by LoRA receivers if considering just 100 m coverage radius

3.2.3 Filling level sensor

The sensors installed on the containers are ultrasonic commercial sensors (TSTwaste products, same as in Valencia). As previously mentioned, the first issue we encountered (i.e., lid mount was not recommended) was solved with a metallic bracket for lateral mount, followed by successful tests for accuracy, considering that the containers' volume is much smaller than in Valencia. As the containers are small and filling fast, the sensors and platform had to be adapted at a higher frequency reading (1 hour instead of 8). This came with a calculated cost, because electricity consumption increased and internal batteries are expected to have a shorter functioning period. The containers' lids are frequently left open so we covered the sensor with insulating tape upfront as a protective measure against the rain. However, two sensors were affected by water getting inside and had to be replaced with back-up ones.

Generally, the sensors proved to be viable, sending filling levels to the IoT platform in order to provide information for truck route optimization. As the existing transport system is already based on the daily emptying of the containers in apartment block areas, no major changes were implemented in terms of the frequency of emptying the containers.

Figure 55 Filling sensors; a) Supplementary insulation; b) Forced (tilting) sensor bracket; c) Sensor with water inside

The information of the filling level sensor is accessible in the IoT platform and data can be download via spreadsheet files for further analysis.

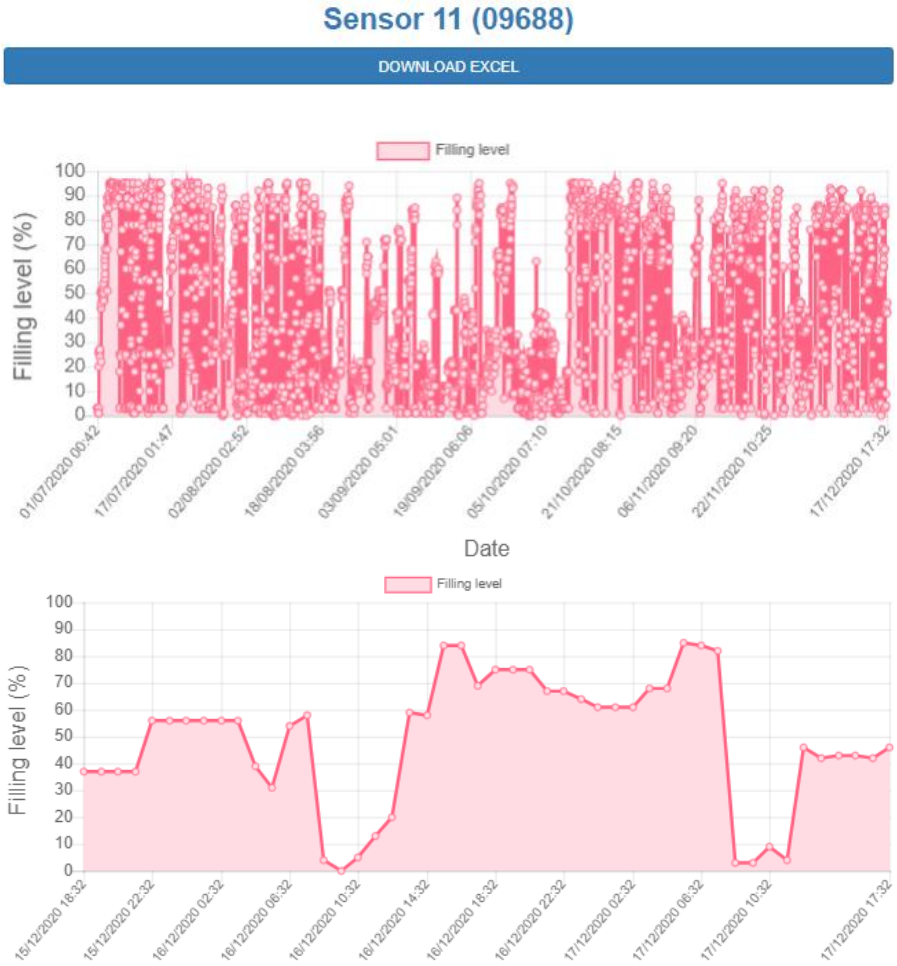


Figure 56 Filling level graphs with the option to export data into a spreadsheet file

The first graph shows the filling variation in the long term, while the second one focuses on the last two days, allowing for comparisons between containers in terms of filling speed (fast, medium and low frequency filling containers) and

recommended emptying periods, used for route optimisation.

High frequency containers

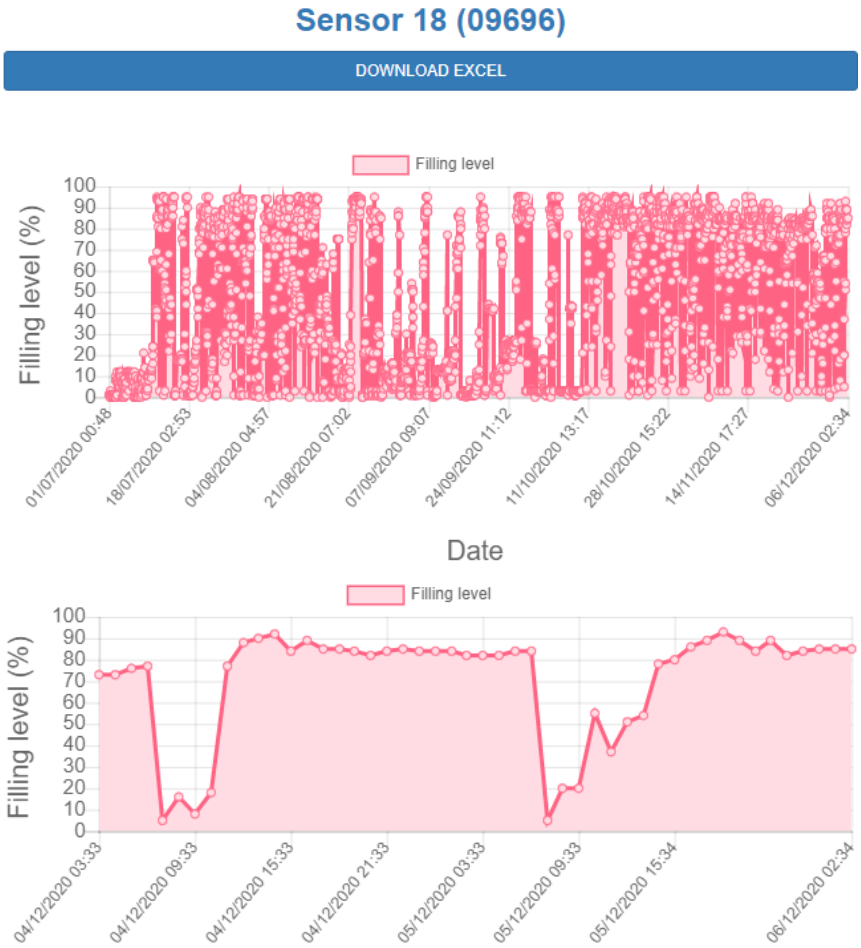


Figure 57 Example of high frequency container in Alba Iulia pilot

Medium frequency containers

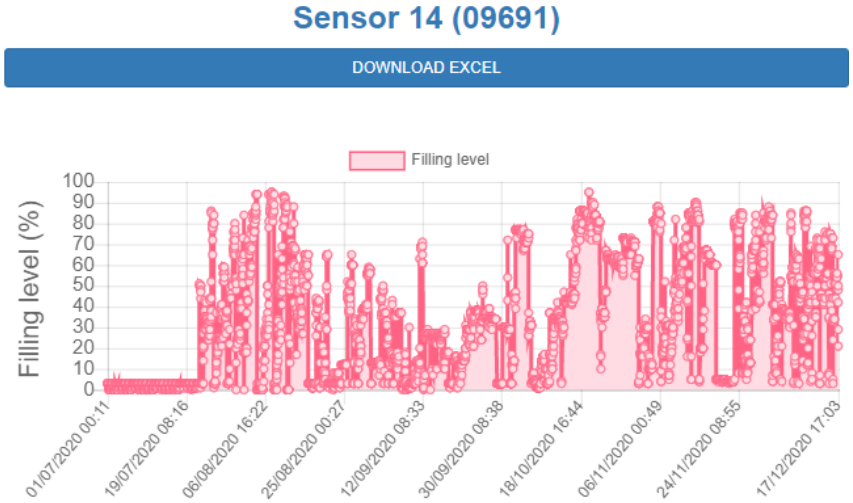


Figure 58 Example of medium frequency container in Alba Iulia pilot

Low frequency containers

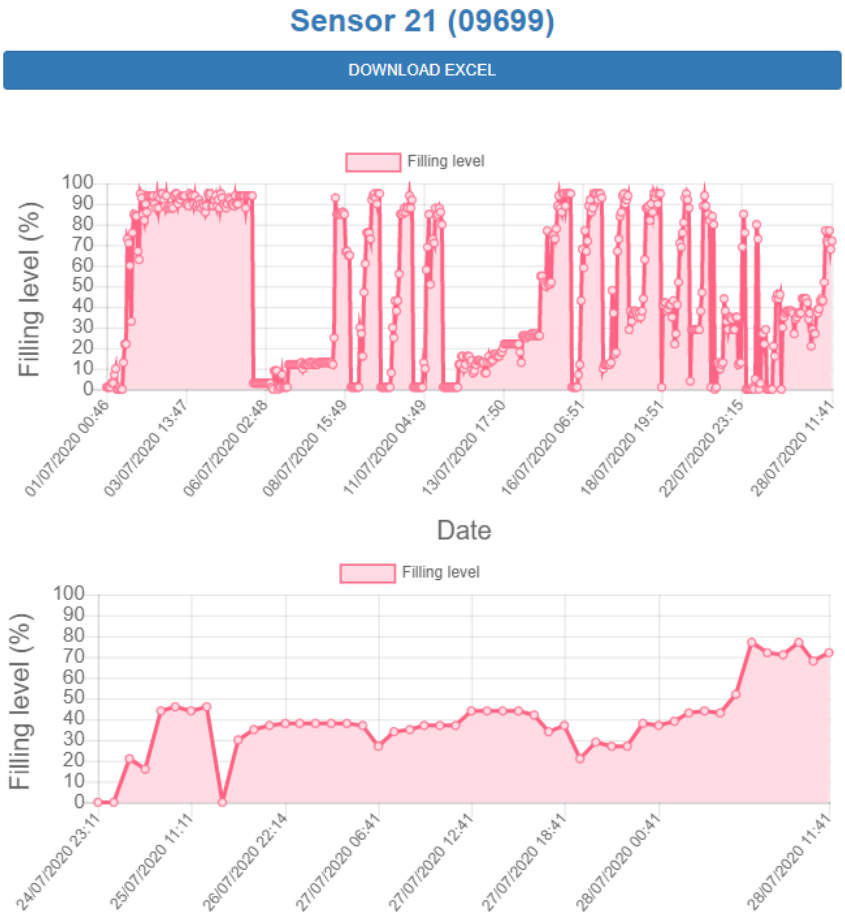


Figure 59 Filling level graphics of a container with low frequency in Alba Iulia pilot

As presented in examples above, filling frequency varies between containers from different areas, but also for the same container. Is important to note that:

- Filling frequency was lower in first pilot months, as plastic sorting was more accurate
- As transport still needs filling data from December, containers remained in place after the pilot for the citizens had already finished, but sorting quality is lower, containers being used for all kinds of waste
- Usage of available data for the entire period (July – December) contains

pilot and post-pilot data on container usage

Using all available data, the table below shows filling time for containers and estimated emptying period.

Container	Filling rate (% per hour)	Estimated emptying
G79	14.7	1 day
G84	12.6	1 day
G85	8.5	1 day
G86	8.4	1 day
A48	6.4	1 day
A49	6.3	1 day
G87	6.3	1 day
A52	5.5	1 day
G83	4.8	1 day
G78	4.6	1 day
A50	4.4	1 day
A51	4.1	1 day
A53	3.8	1 day
A46	3.7	1 day
A54	2.9	2 days
A47	2.6	2 days
A45	1.4	3 days

Table 9 PlastiCircle containers in Alba Iulia - filling rate and estimated period for emptying

As expected, the great majority of containers are filling fast and need daily emptying, while few containers have a lower rate and can be skipped in case of an optimized transport route. Conclusion on skipping some containers effect on collection and transport efficiency will be presented in deliverable D6.5, together with route optimisation results.

3.3 Transport

Waste transport activities are of major importance for waste operators' efficiency and quality of services, as transport costs (including equipment, maintenance, fuel and salaries) influence service costs, pollution and the cost of recycled materials obtained from waste.

For the pilot, transport activities were complex, including sensors, cloud platform, waste characterization protocol, truck data and traceability, route optimisation algorithm, eco driving support and applications.

Planned initially for three months (July – September), transport activities were rescheduled due to the need for technical adaptation of CAN-Bus to local Iveco trucks, delays in installation, adjustments to applications, troubleshooting

Bluetooth and data transmission.

Activities were made difficult by the absence of onsite technical support following the introduction of Covid-19 travel restrictions; only remote technical support was available.

Two important activities, related to route optimisation and eco-driving, required three implementation phases:

Phase	Route optimisation	Improvements in driver behaviour
1	Analyse actual truck route in pilot area	Install truck traceability system and collect data on driving style and behaviour in order to identify improvement areas
2	Minimise transport time and cost, based on optimisation of route for collecting all containers from pilot area	Use smart phone application in order to generate alarms when driving style can be improved
3	Further route optimisation, skipping containers not full at collection, based on filling sensors and map on smart phone	Reducing the time and fuel consumption during the containers collection

Table 10 Route optimization and eco-driving implementation stages

3.3.1 Route optimization

In order to provide an optimised route for trucks in the pilot area, a three-phase process was applied.

Phase 1: Measurement and analysis of the usual route performed by the driver when truck is collecting all the containers from the pilot area (traceability of non-optimised route)

After establishing containers locations and coordinates (already presented), we verified traffic signs in pilot area, needed for route optimisation.

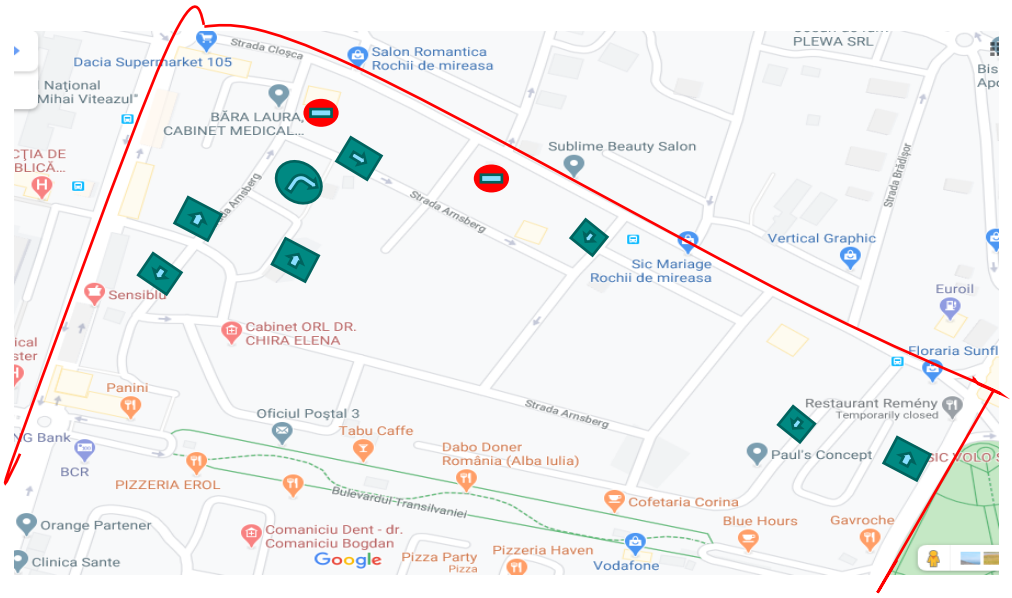


Figure 60 Traffic signs in Arnsberg pilot area

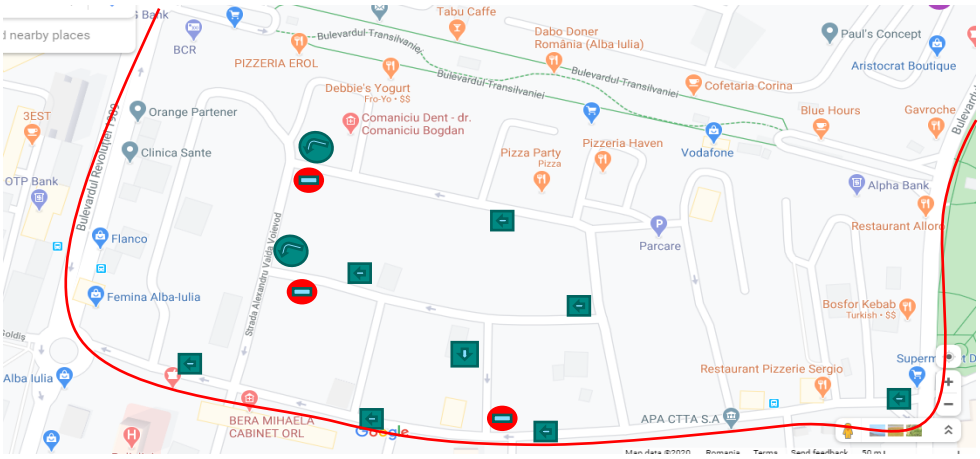


Figure 61 Goldis route signs needed for route optimisation

NOTE: A few streets are narrow and many cars are parked in the Arnsberg area, so it is possible (for a short portion) that the truck is forced to change its normal route which complies with the traffic signs.

Also, we used a map of existing truck GPS and Google Earth in order to approximate existing route distances and order of collection of waste from containers.

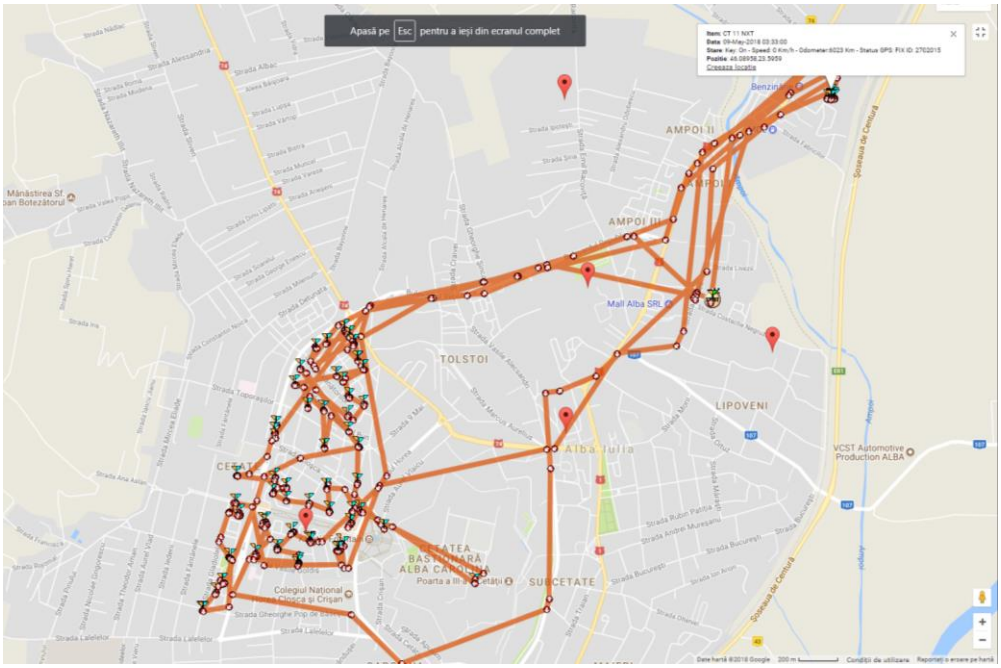


Figure 62 Truck actual collection route including pilot area (existing truck GPS)

This map revealed that the truck is able to collect waste from a larger area than the pilot one (36 containers), because it has high capacity and hydraulic compression. That means that all PlastiCircle containers can be operated by a single truck in one trip, even without compression of waste.

Container Distances Arnsberg				**Container Distances Goldis**			
Revolutiei	A45	47	m	Goldis	G87	57	m
A45	A47	90	m	G87	G86	204	m
A47	A46	122	m	G86	G83	169	m
A46	A48	163	m	G83	G85	201	m
A48	A49	143	m	G85	G84	108	m
A49	A51	161	m	G84	G81	214	m
A51	A50	190	m	G81	Goldis	20	m
A50	A52	192	m	Goldis	G79	427	m
A52	A54	104	m	G79	G80	80	m
A54	A53	93	m	G80	Goldis	104	m
A53	Closca	38	m				
Total inside		**1343**	m			**1584**	m

pilot area							
Start point (Livezii) to Goldis		**2962**	m				
Goldis-Arnsberg		**693**	m				
Arnsberg – transfer ramp		**5514**	m				
Ramp – technical HQ		**5217**	m				

Table 11 Theoretical distances from start to end point, including distances between containers and order of collection

The estimated theoretical distance for collecting all containers from the pilot area is estimated at 12,096 m (17,313 m back to starting point), with 3,620 m inside the pilot area. Average collection duration for the existing truck route is estimated at 120 min. Considering the average of 54 l/ 100km, we estimate that consumption for one trip is 9.4 l of diesel.

After the truck was equipped with a special CAN-Bus module in August, new GPS and other data (time, distance, consumption, engine rotation, etc.) became available. These data points were sent and registered in the IoT cloud platform, in order to obtain the real truck route inside the pilot area and real routes to and from pilot area to start and end point.

a) **Trip from start point (Polaris technical point) to pilot area**

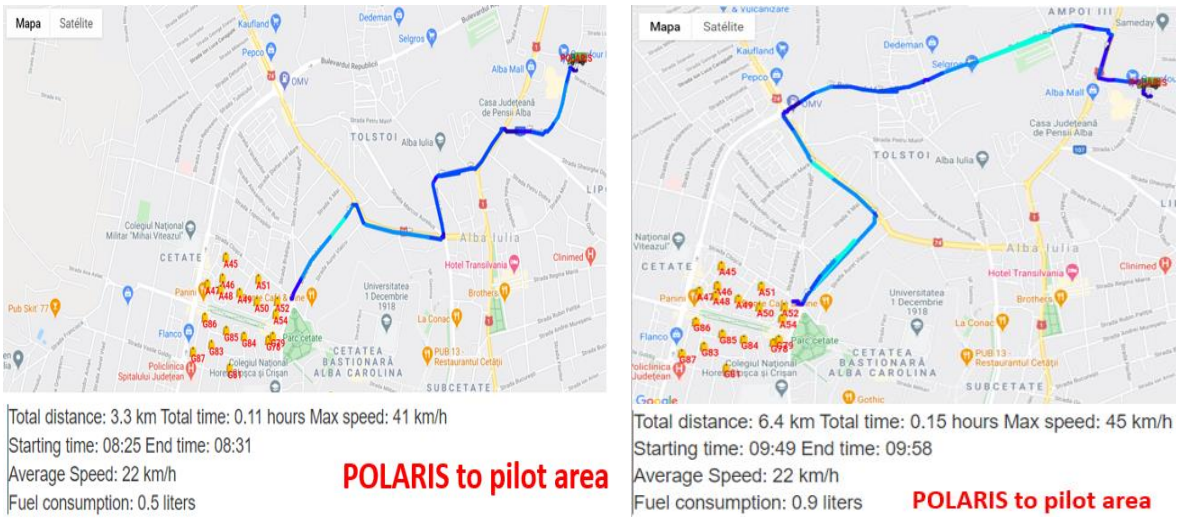


Figure 63 Shortest and longest route from start point (Polaris technical point) to the pilot area

This part of the route is inside the city limits; there are no big differences in terms of average speed, but distances, time and consumption report significant differences.

b) **Trip from pilot area to end point (Polaris technical point and transfer ramp)**

Figure 64 Different routes from the pilot area to end point

There are important differences for this portion, which may include access to transfer ramp (higher speeds allowed on city belt).

c) Trip inside pilot area

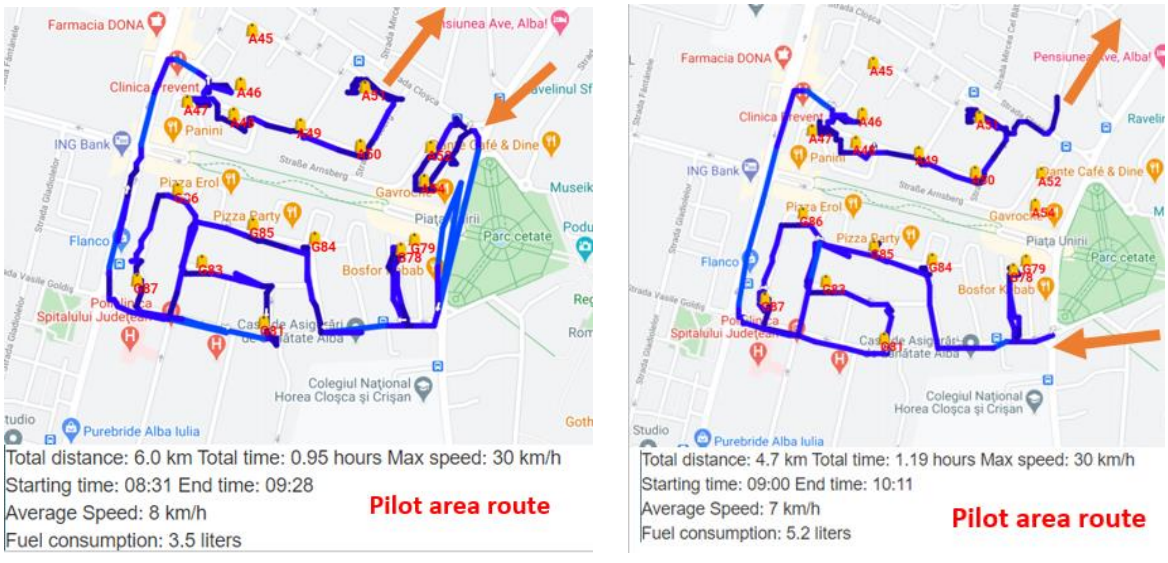


Figure 65 Different routes inside the pilot area

The results obtained based on CAN-Bus data, are summarised below.

	Real vs. Theoretical	Distance (km)	Time (hours)	Consumption (litres)	Average speed (km/h)	Max speed (km/h)
Polaris - pilot area	Real Min	3.3	0.11	0.6	19	40
	Real Max	4	0.14	0.6	20	41
	Average	3.5	0.13	0.6	20	41
	Theoretical	3				
	Difference	14.29%				
Pilot area	Real Min	4.4	1.06	3.9	7	27
	Real Max	6	0.95	3.5	8	30
	Average	**4.9**	**0.835**	**3.5**	**7**	**29.5**
	Theoretical	3.7				
	Difference	24.49%				
Pilot area - Polaris	Real Min	11.8	0.47	2.1	20	58
	Real Max	15.6	0.83	3	10	58
	Average	**15.6**	**0.83**	**3**	**10**	**58**
	Theoretical	10.8				
	Difference	30.77%				

TOTAL - real average		**24**	**1.8**	**7.1**	**12.3**	**42.8**
Theoretical		17.5	2	9.5		

Table 12 Min and maximum routes, compared with theoretical estimations

Compared to theoretical estimations, results based on real CAN-Bus data show that distances are bigger than estimated, but duration and consumption are lower. While distances within the pilot area are short, there is still a 20% difference between the minimum and maximum routes; therefore, there is room for improvement based on route optimisation. Major differences appear on trip distances and duration outside the pilot area, reflecting different routes adopted by different drivers. Very low average speed in pilot area reflects the duration needed for emptying the containers, while route to the transfer ramp includes portion of city belt, allowing higher speed, but much lower than legally allowed or being considered excessive.

Phase 2: Optimization of the current route using the PlastiCircle technology for collecting all the containers in the pilot area, in order to minimize time and associated cost. In this phase, an optimised route is calculated based on theoretical calculations and algorithms, including distances and timing for the best theoretical route inside the pilot area (results presented below), before being tested in real life.

Phase 3: Supplementary optimization of the route using real time information from the filling sensors and the specific filling rate of each container measured previously, in order to collect only containers with a filling level over 80% and skipping containers estimated to be filled in the following days.
NOTE: Containers are small and the majority report high filling rates (as presented at 3.2.3), therefore we estimated that the optimisation based on skipping empty containers will have limited results in the case of the Alba Iulia pilot. Even so, results are important considering the future local projects based on four recyclable fractions, for which the containers' filling rate is expected to be lower.

To implement this phase an original PlastiCircle application (CAN –bus Eco-driving) was developed for Android smart phones/ tablets.
Initial tests and updates included adaptation of OS, display resolution, menu language, Bluetooth connection with CAN-Bus and data mobile communication with platform (3G/4G), before installing a smartphone on the dedicated truck and providing instruction to drivers. The application has two main modules:

- The first one displays the route map to be followed by the driver for emptying full containers, including the detailed pathway between containers and possibility to manually select "next" and "previous" container details; this is possible only with a good mobile communication between the truck and the platform, in order to actualise the situation in real time (application sends

map, containers positions, optimised routes and receives GPS info and commands);

- The second module uses information from the CAN-Bus sent on Bluetooth to the smart phone, in order to emit sound alarms when eco-driving parameters are exceeded

The application developed by SAV is very easy to use, as seen in images below, and is allows for the configuration of the truck's number and driver's name, in order to coordinate truck fleets.

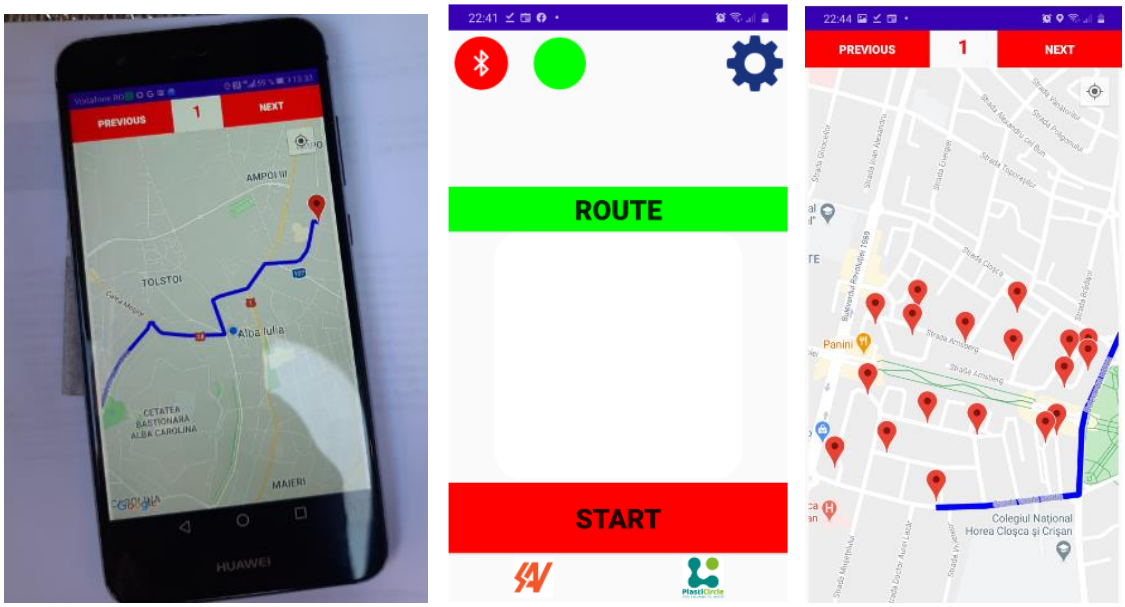


Figure 66 Start screen and route map

Results obtained in pilot area after using route optimisation and skipping containers will be analysed in deliverable D6.5.

3.3.2 Truck traceability and efficient driving

PlastiCircle is proposing truck-and-trace control of the collection trucks using GPS – GPRS, combined with the container's identification and an algorithm based on real time nodes (full containers) and arches (streets) integrated in a cloud platform, in order to minimise distances and cost of collection. Also, after analysing general techniques on efficient and ecologic driving and their demonstrated effect on fuel consumption, a mobile application was developed (Deliverable 3.3) in order to provide guidance and feedback to drivers during collection routes.

The application is developed for Android OS, is installed on a smart phone (tablet), and is able to communicate with the cloud platform (3G/4G) and receive data from the truck CAN-Bus through an ODB II reader and a Bluetooth connection.

The application uses primary data collected by CAN-Bus/ ODB II like:

- GPS location

- Speed (Km/h)
- Revolutions per minute (RPM)
- Engine load (%)

and communicates with the platform in order to calculate other important data:

- Acceleration (based on velocity)
- Excessive idling (speed is 0, rotation is > 0 and <800 rpm for more than 20 sec.)
- Emptying of containers (speed is 0, revolutions >900 rpm for more than 20 sec.)

The Android application retrieves truck data every second, temporarily stores it in an SQLite database and uses mobile data connection to the IoT cloud platform, sending Java script (JSON) data packages.

In order to guide drivers in adopting an eco-driving style, several alarms were configured and adapted to the local truck type, in the following order:

1) Excessive idling (over 120 sec.)
2) Aggressive acceleration / braking (> 7m/s)
3) Excessive speed (> 80km/h)
4) Excessive engine rotations (RPM > 1300 rpm)
5) Overuse of power take off (PTO; speed is 0, > 900 rpm, > 50 sec.)

Alarms are visual and audible, with just one type of alarm triggered and registered in platform for further analysis and feedback at a given time.

NOTE: Truck data availability was affected by some truck maintenance activities and by the COVID-19 pandemic, especially beginning with October when we experienced a high fluctuation in available drivers and therefore had to switch focus to ensuring waste collection from the entire city through longer shifts.

Based on registered alarms, an analysis of eco-driving results will be included in deliverable D6.5.

3.3.3 IoT Platform

a) Truck traceability and eco-driving application

As presented in previous chapters, the IoT platform includes maps, container location and filling level data, but also CAN-bus data (location, speed, engine RPM and load) in order to calculate, display and guide drivers step by step on an optimized route and generate alarms when several parameters exceed the predefined thresholds, in order to improve drivers' behaviour.

b) Individual characterisation module

Includes a small application (web browser access) translated and adapted from that of Valencia, where the composition of PlastiCircle bags is entered, based on the recognized labels generated by the containers when the RFID card is used. Data regarding bags' content and sorting quality are manually introduced and allocated points are calculated and saved in the reporting platform area for each

user.

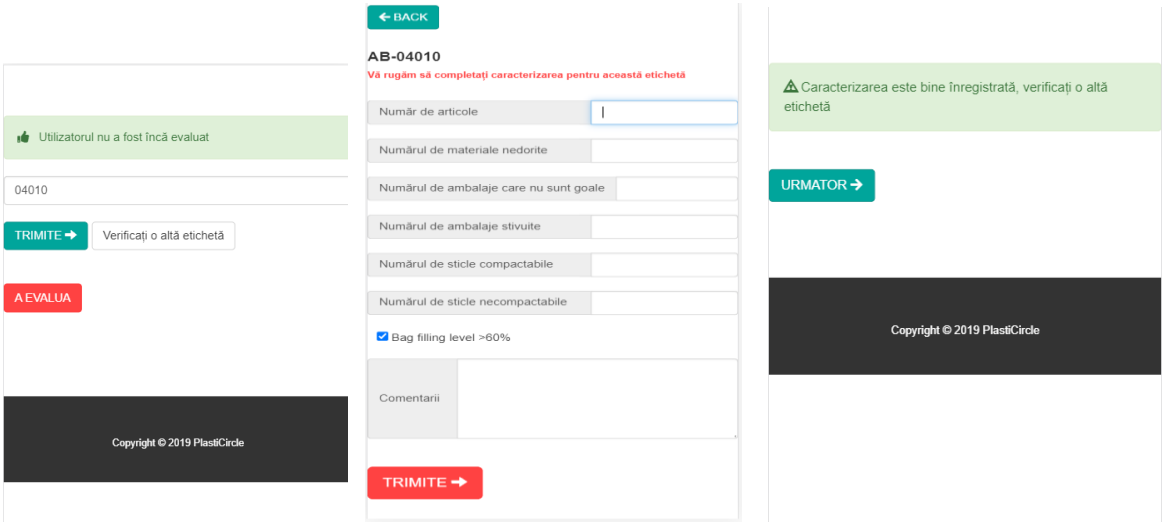


Figure 67 Individual characterisation application (filling label number, introducing data of bag content, confirmation screen)

Individual characterisation is calculated and saved in the administrative area of the platform, together with edit and download reports functions.

c) Participants registration

This module can be accessed from the pilot web page at the click of a button located below the sections presenting the main activities, terms and conditions and confidentiality considerations.

Figure 68 Web site link to registration portal and registration form

This area was translated and redesigned, in order to obtain participants' acceptance and confirmation (over 18 years of age, read Terms and Confidentiality) and filter participants with apartments in the pilot area.

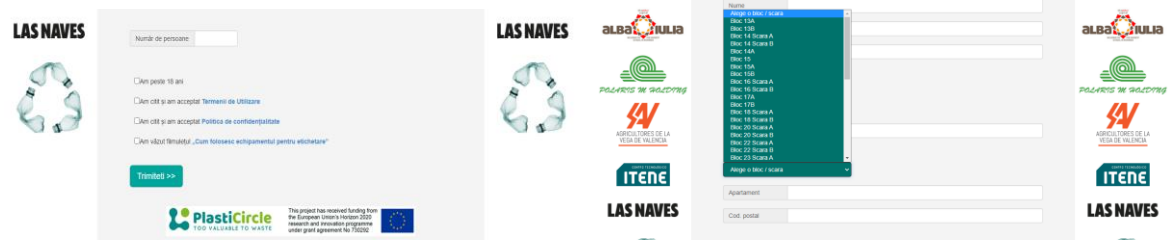


Figure 69 Terms and conditions check boxes and drop-down selection of block

The sociological data for the participants and their families was also translated, simplified with drop-down lists and integrated with surveys, in order to eliminate the need for repeat data entry, obtain fast reports and allocate eco points.

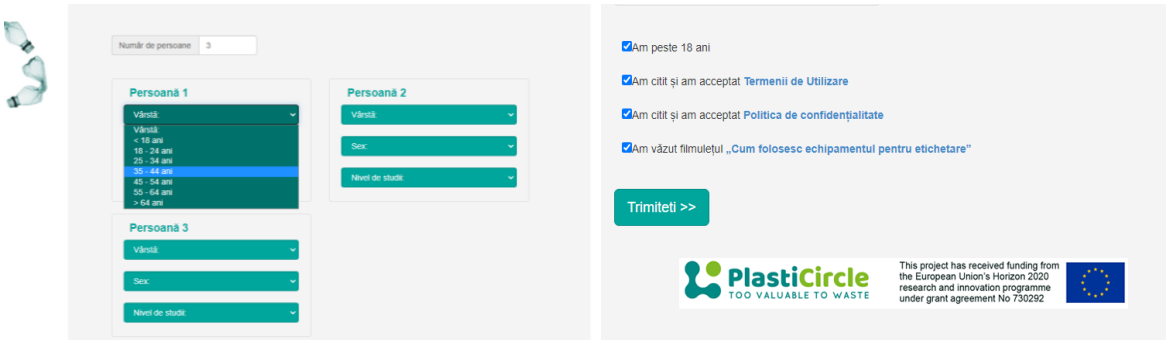


Figure 70 Drop down lists for sociological data (age, sex, education) and registration "Submit"

After completing the required information, ticking the checkboxes and pressing "Submit", the platform sent a welcome message from contact@plasticircle-albaiulia.ro, including a personal 4-digit code and password for login into the dedicated area.

d) Participants area

After the registration process is complete, participants can use the "Login" tab from the web page to access their dedicated area, based on unique code and password.

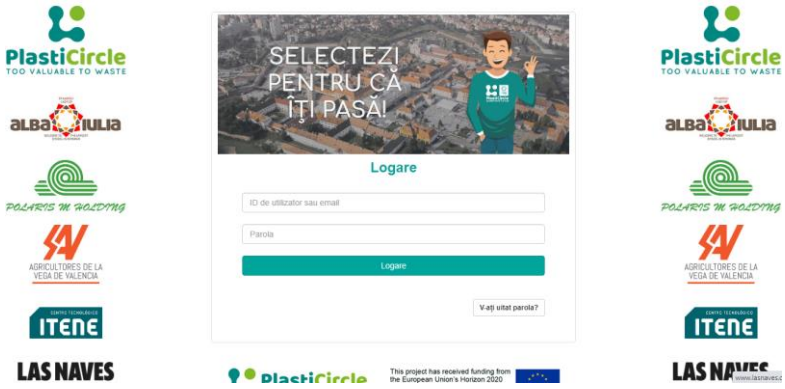


Figure 71 Participants platform login page

The initial page displays the User ID, number of eco points, eco points system and information regarding correct plastic sorting for recycling.

Figure 72 Participants eco-points Tab

Eco points are allocated for:

- Sorting quality (based on individual characterisation)
- Quantity (number of labelled bags)
- Participation in social media activities
- Participation at info/ presentations/ webinar activities

- Answers to surveys

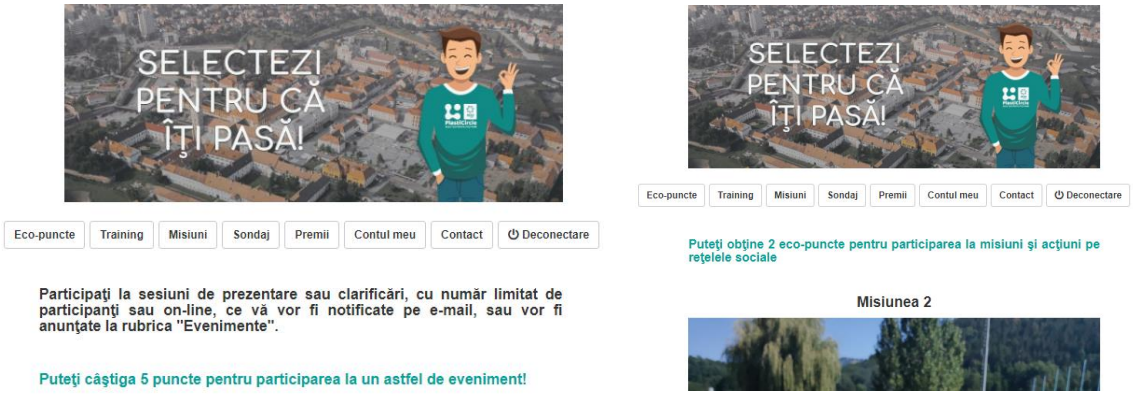


Figure 73 Invitations to training and social media activities tabs

The second tab, "Training" shows the available webinars (also announced via email) and "Missions" (social media activities on Facebook).

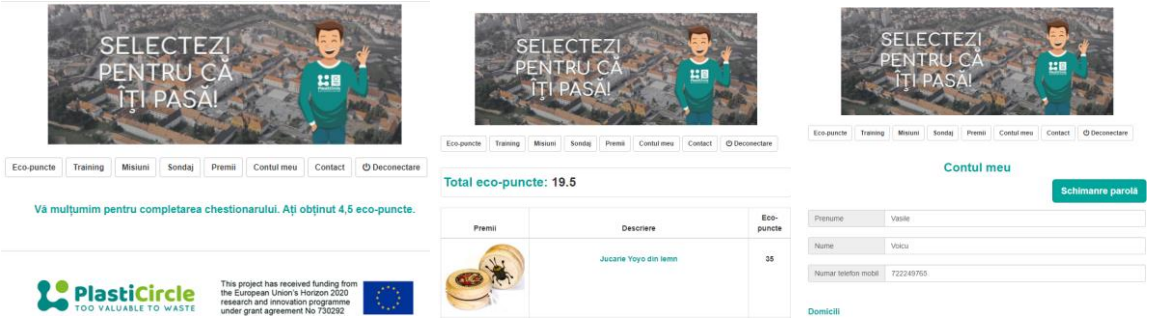


Figure 74 Surveys, Rewards and My account details Tabs

The next tabs are dedicated to: surveys (displaying available surveys and eco-points); possible rewards as a compensation for activities and personal eco points; and My account, for editing personal details and changing the password.
Finally, the participant portal includes contact details and the log-off button.

e) Admin portal

This area is reserved for dedicated people, with administrative rights, based on special username and password.
The initial start page is dedicated to Statistics, offering general data about the participants. On the left side, we have a panel for selecting different administrative sections.

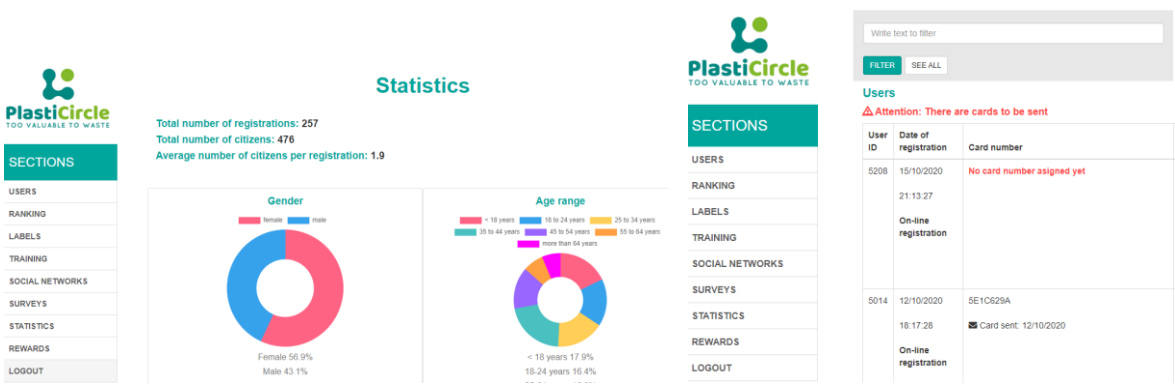


Figure 75 Statistics and Users administrative platform sections

The Users section displays the User IDs, registration dates and RFID cards allocated when users receive the welcome kit, after a manual registration process.

NOTE: To ease the card allocation process for the personnel of the info kiosk a special access was defined that allowed the saving of the card number in the platform, without granting access to other administrative areas.

The Ranking section displays the users in order of accumulated eco points, while Labels displays information about labels and characterisation points.

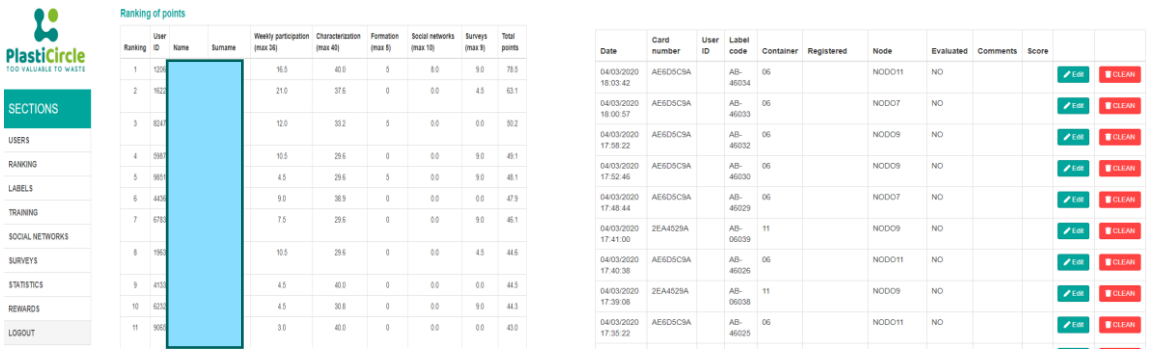


Figure 76 Ranking and Labels Sections

The next two sections require manual entry of the IDs of participants to informational and training activities (Training section) and social media activities (Social networks section) which they provided in their Facebook comments (all comments were required to include # and their 4 digits user ID).

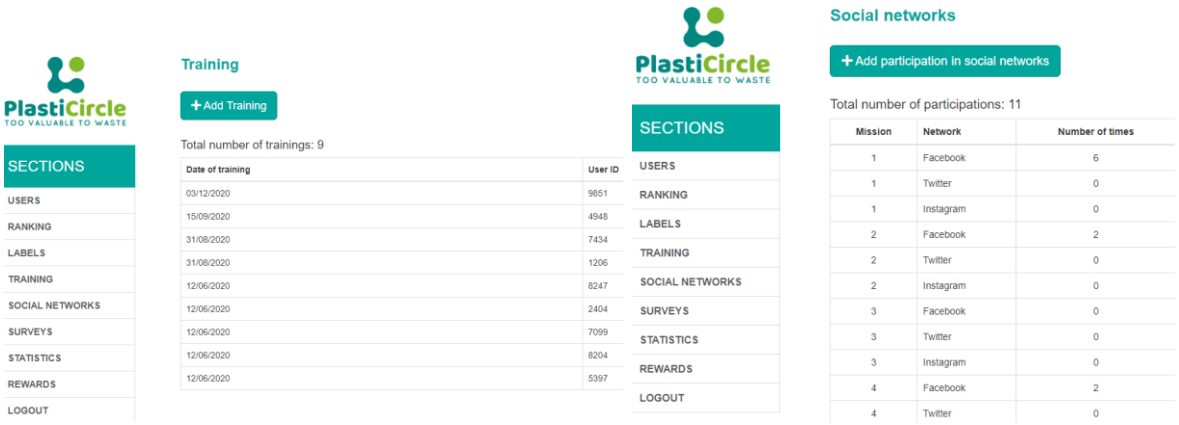


Figure 77 Training and Social media sections of administrative panel

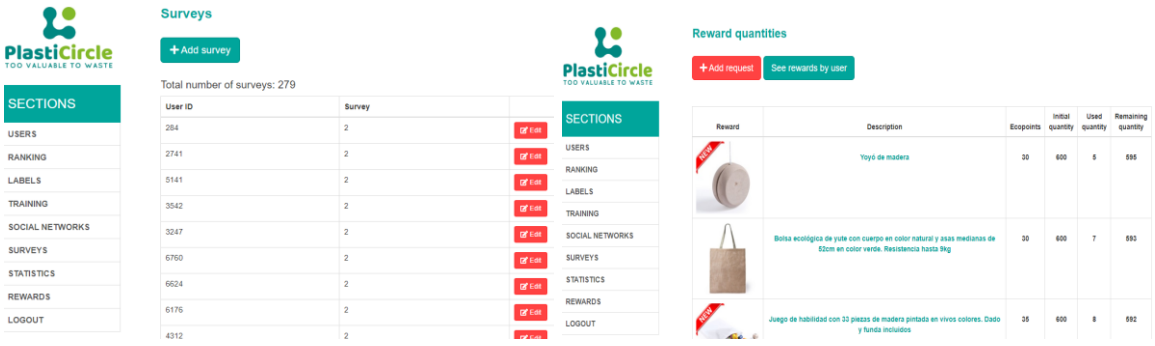


Figure 78 Surveys and Rewards administrative sections

The last sections of the administrative panel display the IDs of survey participants

and facilitate the allocation of rewards.

3.3.4 List of KPIs

For the environmental evaluation related to transport of our project, the selected environmental key performance indicators (KPI) are described below:

- **K1: Distance travelled**: the existing distance from a starting point (A) to a point of arrival (B) of the planned route and the units will be kilometres (km).
- **K2: Time travelled:** it is the time since the vehicle leaves the waste manager depot, until it returns to the facilities once the route is completed. The units are minutes (min) or hours (h).
- **K3: Collections performed:** number of containers collected during the route. The unit will be the total number of containers served.
- **K4: Relative CO_2e emission:**
  K4.1 = CO_2e/Tonne collected
  K4.2 = CO_2e/driven distance (km)
- **K6: Fuel consumption:** amount of fuel consumed by the vehicle to carry out the programmed route. The units are litres of diesel (l).
- **K13: Filling level.** % fill level when trucks unloads

3.3.5 KPI's Performance

Results for each transport related KPI's will be presented in D6.5, for route not optimized, optimized route and route with skipped low frequency containers.

3.4 Waste characterisation

Waste characterisation provides important data regarding the composition of waste in the pilot area and verifies possible improvements in the quality of sorting of plastic packaging in the case of pilot participants. Accordingly, one process for general characterisation and one for individual characterisation were developed. Both of them require important manual processing of waste, implemented by the waste operator (Polaris), with information, training, and support ensured by the Alba Iulia municipality.

3.4.1 Individual characterisation of bags

Individual characterisation is a manual process of checking the composition of the participants' waste bags, made easy by the usage of dedicated orange bags and their comparison with those of non-participants from the same area. For this comparison, in D3.5 ITENE identified 5 main factors and allocated them the following shares:

Number	Criteria	Share (importance)
1	Unwanted material (not plastic, not packaging waste)	38%
2	Bag filling level (recommended > 60%)	31%
3	Compacted plastic bottles	15%
4	Non empty packaging	8%
5	Stacked packaging	8%
TOTAL		100%

Table 13 Factors considered for individual characterisation and their importance

The process of sorting and allocating shares to different criteria is quite complicated, therefore a simple mobile application was developed (presented at 3.3.3.b) for introducing manual data and allocating eco points in the platform for participants.

In Valencia big capacity containers dedicated to recyclables materials are used, easing the comparison between users and non-users in the pilot, and orange bags are collected manually. In Alba Iulia we used dedicated PlastiCircle containers emptied during a dedicated route of the truck, without applying compression so as to avoid destroying the bags. All containers are operated in one trip so the truck is emptied at the transfer ramp for the individual characterisation of orange bags for participants and other bags for non-participants.

Figure 79 Selection of orange bags at transfer ramp and characterisation

Individual characterisation was carried out on the bags from the "dry" fraction in the pre-pilot period and on the orange bags and other bags from the PlastiCircle containers during the pilot.

For participants that label orange bags, the application can offer the following information after the 5-digit label number is introduced:

- "The user has not evaluated previously" – pressing "Proceed" opens the data introduction form;
- "The user has been evaluated previously for X times" – pressing "Proceed"

and entering data will calculate the average between characterisations;
- "The association card – label does not exist. Select another"

Individual characterisation was affected by several specific aspects:
- Manual sorting of waste, considered dangerous during pandemic alert state;
- Difficulties in sorting a few orange bags in a high volume of unwanted waste;
- Orange bags without label (users did not use or identity module did not provide label), impossible to characterise;
- Broken bags, without content;
- Platform did not recognise the association between card and label, due to possible errors on reading card, reading label or communication.

In order to improve the number of characterised bags, in the last month we offered users a procedure for sending a picture of the bag and a few details to the contact email, but with limited results.

Finally, 58 participants were identified and their orange bag sorting was compared with over 10 bags of non-users for the pre-pilot period (selected from dry fraction) and over 20 bags of non-users during pilot (from plastic fraction).

	Unwanted material (%)	Non-empty (%)	Stacked (%)	Compacted (%)
Pre-Pilot, non-users	22.3	12.6	13.4	19.6
Users (pilot participants)	8.9	8.1	7.2	64
Non-Users during pilot	18.6	11.2	12.3	20.1

Table 14 Results for individual characterisation of bags for users and non-users

Results show a better quality of plastic packaging sorting for pilot participants as compared with non-participants, and a small improvement for non-participants during the pilot.

3.4.2 General characterisation of the neighbourhood

General characterisation involves activities conducted to identify the composition of waste in the pilot area. This is important for estimating the quantities of recyclables contained in waste, together with data for future projects and for other PlastiCircle activities, especially for sorting.

Two general characterisations of the waste in the pilot location were carried out – one pre-pilot (including wet and dry fractions) and another mid-pilot (when the

waste fraction from PlastiCircle containers was analysed). A third characterisation was expected to take place in October, but was ultimately cancelled due to the second wave of Covid-19 in Romania.

To improve statistical accuracy, different trucks were used, providing over 1000-1200kg of each fraction. After two rounds of mixing and splitting each fraction, over 200kg of waste from each fraction were selected and characterised. Each sample was manually sorted in main components and weighted using big bags and an electronic scale.

Figure 80 General characterisation; a) piles of different fractions; b) mixing and splitting waste for preparing samples; c) weighting different components

Results presented in the table below show the minimum differences between wet and dry fractions, as many users do not sort different fractions properly and separately.

		PRE-PILOT GENERAL CHARACTERIZATION				DURING PILOT GENERAL CHARACTERIZATION					
		Wet fraction		Dry fraction		Wet fraction		Dry fraction		PlastiCircle fraction	
	Material	kg	%	kg	%	kg	%	kg	%	kg	%
PLASTIC			15.90%		18%		12.57%		14.52%		26.81%
PET	Bottles	8.9	3.20%	10.3	4.40%	7.524	3.38%	8.15	4.07%	24.48	12.41%
	Multilayer – trays	4.8	1.70%	4.2	1.80%	0.76	0.34%	0.66	0.33%	1.6	0.81%
HDPE	Coloured	5.5	2.00%	4.2	1.80%	7.79	3.50%	7.95	3.97%	8.5	4.31%
	Natural	2.2	0.80%	1.5	0.60%	0	0.00%	0.22	0.11%	0	0.00%
LDPE + PP foils	Films	0.7	0.30%	1.2	0.50%	3.04	1.36%	2.92	1.46%	5.7	2.89%
	Bags	8.5	3.10%	6.5	2.80%	2.28	1.02%	2.65	1.32%	3.29	1.67%
PVC		5	1.80%	7.5	3.20%	4.56	2.05%	3.85	1.92%	3.6	1.83%
Polystyrene		0.5	0.20%	0.5	0.20%	0.54	0.24%	0.25	0.12%	0.45	0.23%
Mingled plastic		7.8	2.80%	6.2	2.70%	1.52	0.68%	2.4	1.20%	5.25	2.66%
Other			0.00%		0.00%						
Organic waste	Food	51	18.30%	48	20.60%	26.98	12.11%	20.7	10.34%	18.45	9.36%
	Vegetables / gardens	31	11.10%	22	9.40%	46.36	20.81%	30.5	15.24%	24.7	12.52%
Paper/ cardboard	Paper	5	1.80%	2	0.90%	15.58	6.99%	12.9	6.42%	13.12	6.65%

	Cardboard	14.2	5.10%	11.5	4.90%	31.68	14.22%	33.8	16.89%	30.6	15.52%
Glass	White glass	3.3	1.20%	2.5	1.10%	7.22	3.24%	6.1	3.05%	8.2	4.16%
	Coloured glass	6.9	2.50%	5.85	2.50%	3.42	1.54%	5.15	2.57%	7.65	3.88%
Metals	Aluminium cans	0.9	0.30%	1.4	0.60%	3.23	1.45%	2.85	1.42%	3.2	1.62%
	Ferrous	7	2.50%	4.2	1.80%	4.94	2.22%	3.45	1.72%	3.22	1.63%
	Other	4	1.40%	1.2	0.50%	0	0.00%		0.00%	0	0.00%
Tetra Pak		3	1.10%	4	1.70%	1.14	0.51%	2.25	1.12%	1.2	0.61%
Textiles		11.2	4.00%	17.4	7.50%	4.37	1.96%	6.83	3.41%	5.28	2.68%
Wood		12.8	4.60%	0.8	0.30%	0	0.00%		0.00%	0	0.00%
Constructions	Wall paint, rubbish, dirt	25	9.00%	20	8.60%	11.02	4.95%	9.3	4.65%	0	0.00%
	Tiles	1	0.40%	2	0.90%	0	0.00%		0.00%	0	0.00%
Contaminated/ dangerous (chemical, sanitation, hygiene)		29	10.40%	20	8.60%	12.16	5.46%	15.3	7.65%	8.52	4.32%
Other		29	10.40%	27	11.60%	24.32	10.92%	28.8	14.39%	20.2	10.24%
Total		**278**		**232**		**222.79**	100.00%	**200**	100.00%	**197.2**	100.00 %
Initial		285		236		226		207		202	

Table 15 General characterisation of the light packaging containers in the whole neighbourhood

Plastic is an important waste component (over 14%), with a maximum of 26% in the case of dedicated plastic containers, due to participants in the pilot and citizens using containers for plastic. As expected, a major component is represented by PET bottles.

3.4.3 List of KPIs

- **K7: % Unwanted (Not packaging waste):** Global percentage of unwanted material found in the characterisation,
    - K7.1: % in number
    - K7.2: % in weight
- **K8: % Non-empty packaging:** Global percentage of packaging that still contain product inside, in number.
- **K9: % stacked packaging:** Global percentage of heaped packaging (one packaging inside of another), in number.
- **K10: % compacted bottles:** Percentage of the number of bottles compacted, in number.
- **K11: % selective collection rate:** Fraction of plastics packaging waste collected, in weight.
- **K12: Compaction level in container** – kg/m3

3.4.4 KPI's Performance

		PRE-PILOT	PILOT USERS	PILOT NON-USERS
K7.1	Unwanted, in number (%)	22	8.9	18.6
K8	Non-empty, in number (%)	12.6	8.1	11.2
K9	Stacked, in number (%)	13.4	7.2	12.3
K10	Compacted, in number (%)	19.6	64	20.1

Table 16 KPI's performance from the individual characterisation of bags.

		PRE-PILOT	PILOT
K7.2	Unwanted, in weight (%)	18.1	4.3
K12	Compaction level (kg/m3)	55	59
K11	Selective Collection rate (%)	18%	26.8

Table 17 KPI's performance from the general characterisation in pilot area

4. Conclusions

Alba Iulia is not just a historical city and a symbol of the unification of Romanian provinces, it is also the host of the largest national smart city pilot project which saw numerous smart solutions tested, many being replicated in other cities at present. The PlastiCircle pilot can be viewed as an extension of the IoT, cloud platforms and applications tested during the smart city project since we tested smart containers, efficient collecting, transport solutions, and the cloud management platform. Furthermore, waste management will be an important chapter in our next integrated and smart city strategies, together with environmental management. Alba Iulia is in a transition to a better waste management system (including new operators, or sorting and waste treatment at district level), and therefore the insights from the PlastiCircle pilot will be used in other projects which will provide dedicated containers for recyclable fractions or underground containers for limited space areas, efficient waste collection and sorting, in order to improve quality of services, recycling rate, local environment and economy.

Compared with previous pilots developed by large teams from partner cities

Valencia and Utrecht, the PlastiCircle pilot in Alba Iulia not only tested technical solutions in a different setting, but is the first local mid-term project providing consistent information and communication with citizens about correct recycling and its importance for local community. This is important when considering that most Romanian cities experience delays in implementing effective solutions for waste recycling and that effecting a change in citizens' attitude towards this area is a lengthy process.

Similarly to previous pilots, the PlastiCircle pilot in Alba Iulia implemented and tested solutions in two main areas, covering communication and technical aspects. It is important to note that both areas are complex and their implementation was difficult under the constant "emergency" or "alert" states and restrictions caused by the COVID-19 19 pandemic throughout the entire pilot period.

Communication and social aspects

As presented in a dedicated chapter, the communication strategy had to be adjusted to the pandemic restrictions; this involved going mainly online and cancelling important offline activities, like information sessions, workshops or events. As citizens have a different focus during this period and are not particularly fans of online and social media project activities, this strategy showed its limits after first two months of the pilot, especially in August, when partial relaxation allowed for holidays. The combination of online and offline activities at the info kiosk, whereby information, registration and welcome kits distribution were made onsite, proved to be successful, doubling the number of participants. It is important to mention that the vast majority of citizens interviewed at the info kiosk confirmed that they saw the poster or information leaflet, but did not have time to registration or clarify the main project activities. The final number of citizens involved was 476 (approximately 6% of citizens living in the pilot area), which is a good result considering the pilot implementation period and restrictions, but leaves a lot of place for improvement in citizens' involvement in such projects and activities.

We mapped the participants' households in order to identify if in some blocks we had project promoters, or a better sorting.

Figure 81 Map of apartment blocks with 3 to 7 families participating in project

Most participants live in the apartment blocks located close to the central area of the pilot location (Transilvaniei Boulevard, pedestrian area), which is to be expected since the info kiosk was located in the same area.

In some areas, containers carry high percentages of plastic, which is a good sign; however, there is still a lot of place for improvement.

Figure 82 PlastiCircle containers a) Full of PET bottles (uncompressed); b) mingled waste; c) Orange bag and plastic

Without going into details which will be analysed in WP6 – Evaluation and WP7 – Social lifecycle, we would like to include the highlights from the feedback received from participants (using pre and during pilot surveys) in this communication section. As expected, most responders were not satisfied with the existing local waste management system, expecting major improvements in terms of operation, containers accessibility and ease of use, as well as dedicated containers for several recyclables. The PlastiCircle pilot generally received positive feedback (project rated as a good idea by 80% of respondents) and reinforced the importance of recycling for local community health, environment and economy, while also proposing long term, citywide activities for informing

citizens and improving recycling processes.

Smart Container

The filling sensor proved to be viable solution, easy to adapt in different configurations (lateral mount) and for different transmission rates. Potential minor improvements identified include a better insulation and usage of a local LoRA wan network with good coverage instead of GPRS, which will improve autonomy and servicing activities. Considering the future introduction of several fractions with different filling and collection rates, the filling sensor and the IoT platform are a must for all waste management systems.
The prototype of the identity module (labelling device) is very important for the information related to the number of bags and sorting quality of different participants during individual characterisation. Various aspects (like wrong utilisation, vandalism, or technical aspects like movement of label rolls, batteries or communication) required frequent servicing and disrupted the constant correct functioning of the containers. This was reflected in participants' feedback and partially explained by the fact that most participants take their bags to the containers in the evening, while emptying and servicing activities take place in the morning. Some participants proposed the application of scheme such as "pay as you throw" and compensation for correct recycling which reinforces the importance of the identity module (with few improvements) as a basic element of a smart container.
As a local innovation, many participants proposed the adaptation of local containers to allow the unlocking of the lid solely based on a user card, which is already possible via the reader that is incorporated into the identity module.

Transport
The transport pilot results, including route optimization and eco-driving, will be fully presented in the D6.5. due to delays suffered.
As part of our transport activities, existing primary truck GPS information, was replaced with complete information collected from CAN-Bus/ODBII (like RPM, distances, consumption, speed, etc.), GPS, filling data and maps in order to optimise the route, duration, and consumption. The distances within the pilot area are small (4km), so route optimisation opportunities were first identified outside the pilot area. Considering that most containers fill fast and require daily emptying, route optimisation with skipping containers is expected to report smaller improvements than in other pilot cities. That being said, it is expected that route optimisation and eco-driving solutions will be critical to the success of near future systems with containers for different fractions with different collection routes, and increased distance (30km) to sorting facility.

Waste characterization

General characterisation revealed an important improvement in the plastic collection rate, which reported a 12% increase over the values for the pre-pilot and non-participants. As a result of the availability of correct recycling information for participants, individual characterisation demonstrated major improvements across all the parameters related to sorting and the preparation waste for recycling (unwanted, non-empty, stacked and especially for compacted, where difference is over 40%) in the case of pilot participants, as compared with pre-pilot values or non-participants.

IoT platform

Proved to be an indispensable tool for managing multiple pilot aspects. Translated, adapted and improved, the platform successfully covered the relationship with participants (registering, surveys, eco-points), individual number of bags and characterisation, technical applications (filling sensors, transport and optimisation), administrative management and reports. Is difficult to imagine effective pilot management and an updated waste management system without it.

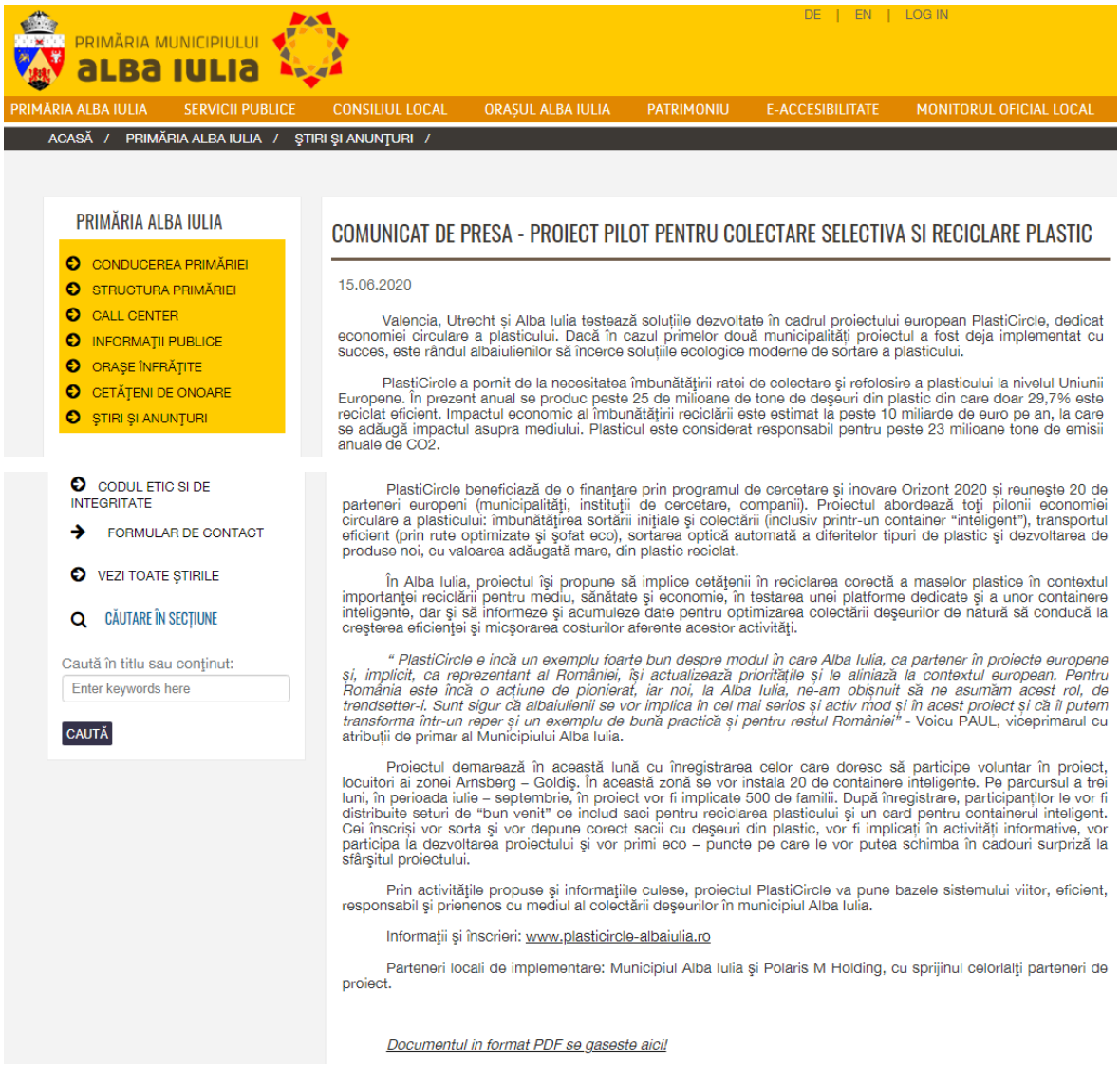
Given our numerous partners in various projects, we are convinced that the solutions tested during the PlastiCircle pilot will be highly visible to other cities working on improving their waste management systems. Romania has a limited number of automatic waste sorting equipment and recycling companies, which is why the other two pillars of the plastics circular economy tested in PlastiCircle pilot (automatic sorting and developing high value products using recycled plastics) are of major importance for closing the loop of the plastics economy on a national scale.

As a final conclusion, during the pilot in Alba Iulia we managed to successfully implement and test the solutions developed in PlastiCircle project with good results, demonstrating their viability, replicability in other contexts or settings and their importance for an efficient waste management system.

Appendices

A1. Press release

https://www.apulum.ro/index.php/primaria/detail/comunicat-de-presa-proiect-pilot-pentru-colectare-selectiva-si-reciclare-pl



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CAUTĂ

COMUNICAT DE PRESA - PROIECT PILOT PENTRU COLECTARE SELECTIVA SI RECICLARE PLASTIC

15.06.2020

Valencia, Utrecht și Alba Iulia testează soluțiile dezvoltate în cadrul proiectului european PlastiCircle, dedicat economiei circulare a plasticului. Dacă în cazul primelor două municipalități proiectul a fost deja implementat cu succes, este rândul albaiulienilor să încerce soluțiile ecologice moderne de sortare a plasticului.

PlastiCircle a pornit de la necesitatea îmbunătățirii ratei de colectare și refolosire a plasticului la nivelul Uniunii Europene. În prezent anual se produc peste 25 de milioane de tone de deșeuri din plastic din care doar 29,7% este reciclat eficient. Impactul economic al îmbunătățirii reciclării este estimat la peste 10 miliarde de euro pe an, la care se adăugă impactul asupra mediului. Plasticul este considerat responsabil pentru peste 23 milioane tone de emisii anuale de CO_2.

PlastiCircle beneficiază de o finanțare prin programul de cercetare și inovare Orizont 2020 și reunește 20 de parteneri europeni (municipalități, instituții de cercetare, companii). Proiectul abordează toți pilonii economiei circulare a plasticului: îmbunătățirea sortării inițiale și colectării (inclusiv printr-un container "inteligent"), transportul eficient (prin rute optimizate și șofat eco), sortarea optică automată a diferitelor tipuri de plastic și dezvoltarea de produse noi, cu valoarea adăugată mare, din plastic reciclat.

În Alba Iulia, proiectul își propune să implice cetățenii în reciclarea corectă a maselor plastice în contextul importanței reciclării pentru mediu, sănătate și economie, în testarea unei platforme dedicate și a unor containere inteligente, dar și să informeze și acumuleze date pentru optimizarea colectării deșeurilor de natură să conducă la creșterea eficienței și micșorarea costurilor aferente acestor activități.

" PlastiCircle e încă un exemplu foarte bun despre modul în care Alba Iulia, ca partener în proiecte europene și, implicit, ca reprezentant al României, își actualizează prioritățile și le aliniază la contextul european. Pentru România este încă o acțiune de pionierat, iar noi, la Alba Iulia, ne-am obișnuit să ne asumăm acest rol, de trendsetter-i. Sunt sigur că albaiulienii se vor implica în cel mai serios și activ mod și în acest proiect și că îl putem transforma într-un reper și un exemplu de bună practică și pentru restul României" - Voicu PAUL, viceprimarul cu atribuții de primar al Municipiului Alba Iulia.

Proiectul demarează în această lună cu înregistrarea celor care doresc să participe voluntar în proiect, locuitori ai zonei Arnsberg – Goldiș. În această zonă se vor instala 20 de containere inteligente. Pe parcursul a trei luni, în perioada iulie – septembrie, în proiect vor fi implicate 500 de familii. După înregistrare, participanților le vor fi distribuite seturi de "bun venit" ce includ saci pentru reciclarea plasticului și un card pentru containerul inteligent. Cei înscriși vor sorta și vor depune corect sacii cu deșeuri din plastic, vor fi implicați în activități informative, vor participa la dezvoltarea proiectului și vor primi eco – puncte pe care le vor putea schimba în cadouri surpriză la sfârșitul proiectului.

Prin activitățile propuse și informațiile culese, proiectul PlastiCircle va pune bazele sistemului viitor, eficient, responsabil și prietenos cu mediul al colectării deșeurilor în municipiul Alba Iulia.

Informații și înscrieri: www.plasticircle-albaiulia.ro

Parteneri locali de implementare: Municipiul Alba Iulia și Polaris M Holding, cu sprijinul celorlalți parteneri de proiect.

Documentul in format PDF se gaseste aici!

A2. Press article

"Unirea" newspaper, Sept.19, 2020

https://ziarulunirea.ro/foto-alba-iulia-un-oras-mai-verde-un-proiect-pilot-continua-eforturile-de-constientizare-ale-albaiulienilor-pentru-reciclare-650294/

- UNIREA ziar independent

- **FOTO| Alba Iulia, un oraș mai verde! Un proiect pilot CONTINUĂ eforturile de conștientizare ale albaiulienilor, pentru reciclare**

- de Ziarul Unirea 19 septembrie 2020

- **O nouă inițiativă „de bun gust" are loc chiar sub ochii cetățenilor, la Alba Iulia. Un proiect de o anvergură deosebită, menită să conștientizeze cetățenii noștri asupra colectării și reciclării plasticului, se desfășoară în inima orașului nostru. Denumită PlastiCircle, această acțiune este prezentă și în mai multe țări din Vestul continentului.**

-

PlastiCircle este un proiect pilot, finanțat de UE prin programul de inovare și cercetare Orizont 2020, dedicat reciclării responsabile a plasticului. Scopul proiectului e informarea cetățenilor și testarea de containere inteligente, pentru a îmbunătăți rată de colectare a plasticului și în special a ambalajelor de plastic. Proiectul a fost implementat și în Valencia și Utrecht unde, a avut parte de un succes foarte mare. Proiectul se desfășoară în zona Arnsberg-Goldiș și se adresează tuturor albaiulienilor care locuiest în zona și folosesc containerele de deșeuri din această zona.

- Obiectivele principale ale proiectului sunt: -Informarea, implicarea și conștientizarea cetăţenilor în privinţa modalităţilorde reciclare corectă a maselor plastice și a importanţei reciclării pentru mediu, sănătate și economie;
- • Testarea de modalităţi inovative de colectare (platformă pentru cetăţeni, containere inteligente, optimizări de trasee de colectare), capabile să crească eficienţa colectării și reciclării plasticului;
- • Culegerea de sugestii ale cetăţenilor și de date privind cantităţile, tipurile de mase plastice și posibilitatea reciclării acestora, aplicând local conceptele economiei circulare. Inscrierea se face online pe https://www.plasticircle-albaiulia.ro/ .
- După ce te-ai înscris, vei primi o parolă și un cod de 4 cifre, parolă cu care, ulterior te vei loga în contul creat iar cu codul de 4 cifre te vei prezența la standul aflat pe Bulevardul Transilvaniei pentru activarea cardului unde vei primi un set de bun venit. Se organizează și un concurs pentru cetățeni cu premii semnificative, unul din cele mai mari premii e o trotinetă electrică.