# Development of an Innovative Insulation Fire Resistant Façade from the Construction and Demolition Waste

# DEFEAT

## INTEGRATED/0918/0052

## DELIVERABLE D3.1

## REPORT ON THE DATA CHARACTERISTICS OF EACH STREAM DERIVED FROM THE CDW

The Project DEFEAT (INTEGRATED/0918/0052) has been co-funded by the European Regional Development Fund (ERDF) and the Cyprus Government, through the RESTART 2016-20 framework program of the Cyprus Research & Innovation Foundation

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## 1. Introduction

S.Netiates & H.Xenis Epixeiriseis Ltd (Netiatis) handles increasingly large volumes of incoming waste of a rather wide variety of waste streams. Indicatively in the recent years (i.e. 2019 and 2020) it handled a total incoming waste volume of 94,822 $m^3$ in 2019 and 191,603 $m^3$ in 2020.

This deliverable describes the procedure being currently employed for waste separation at Netiatis, provides an analysis of the different incoming waste types, and gives an overview of the automatic separation procedure that will be developed, detailing the process that will be followed for the development of the machine learning system that will classify material into waste types.



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## 2. Current Separation Procedure

The current separation procedure with the existing equipment of S.Netiates & H.Xenis Epixeiriseis Ltd is depicted as a flowchart in **Figure 1** together with pictures of the separation site in **Figure 2**. Through the trommel the waste is separated into:

- Mixed material of size up to 32mm, which mainly consist of soil and stones (**Figure 3**).
- Mixed material of size 32-65mm, which are further separated through magnetic and air separation into: (a) metals, (b) nylon**,** cardboard and plastic, and (c) mainly construction aggregates (i.e. concrete, stones, bricks, ceramics, tiles, etc.) (**Figure 4**)**.**
- Mixed material of size larger than 65mm, which are further separated through air separation (**Figure 5**), manual sorting (**Figure 6**), and magnetic separation (**Figure 7**).

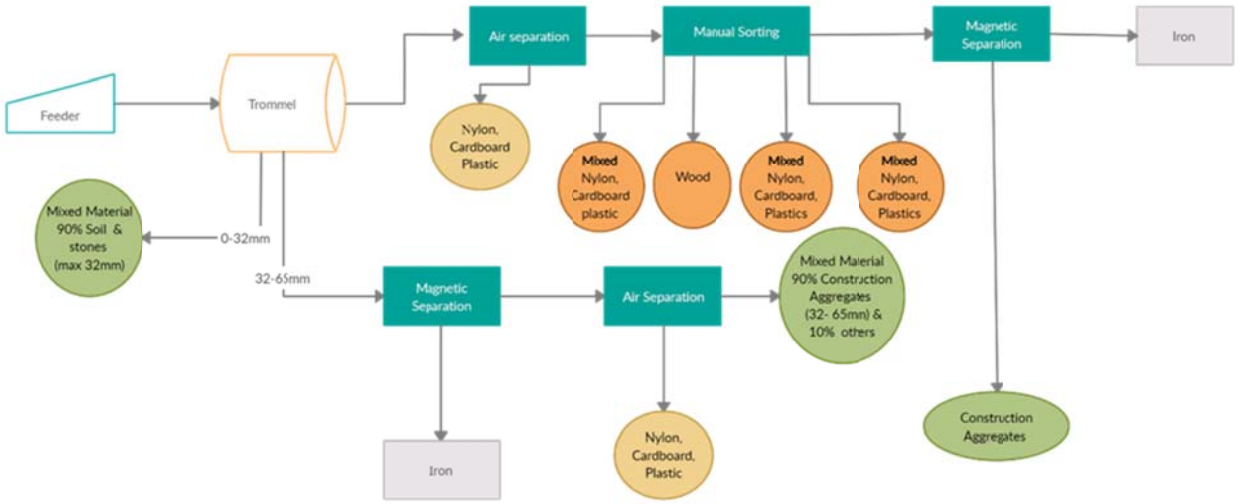


**Figure 1***:* Flowchart of current separation process



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**Figure 2:** Separation Site

**Figure 3**: Material 0-32mm



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**Figure 4**: Material 32-65mm

**Figure 5***:* Air separation



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**Figure 6***:* Manual Sorting

**Figure 7**: Magnetic Separation



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## 3. Waste Stream Analysis

There are 18 different types of incoming waste handled by S.Netiates & H.Xenis Epixeiriseis Ltd (Netiatis) outlined in **Table 1** together with their corresponding (internal) identification codes.

**Table 1**. Incoming waste types and their identification codes

| Waste Type | Code |
|---|---|
| Concrete | 170101 |
| Bricks | 170102 |
| Tiles and ceramics | 170103 |
| Mixture of concrete, bricks, tiles and ceramics | 170107 |
| Wood | 170201 |
| Glass | 170202 |
| Plastic | 170203 |
| Mixture of mineral asphalt | 170302 |
| Mixed metals | 170407 |
| Soils and stones | 170504 |
| Excavation base | 170506 |
| Insulation material | 170604 |
| Plaster based construction material | 170802 |
| Mixture of construction demolition waste | 170904 |
| Biodebodyaable waste | 200201 |
| Plot cleaning | 200202 |
| Non biodebodyaable waste | 200203 |
| Waste from Road cleaning | 200303 |

**Figures 8 and 9** show the incoming waste weight and volume by waste type in 2019 and 2020, respectively. The total incoming waste weight was 101,327tons in 2019 and 133,081tons in 2020, while the total incoming waste volume was estimated (based on the number of incoming trucks volume carrying capacity) as 94,822 m3 in 2019 and 191,603 m3 in 2020. It is worth to note that the concrete, bricks, tiles and ceramics, together with their mixture and the mixture of



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construction demolition waste types (codes 170101, 170102, 170103, 170107 and 170904) constitute 44% and 56% of the total volume of incoming waste in the two past years respectively.

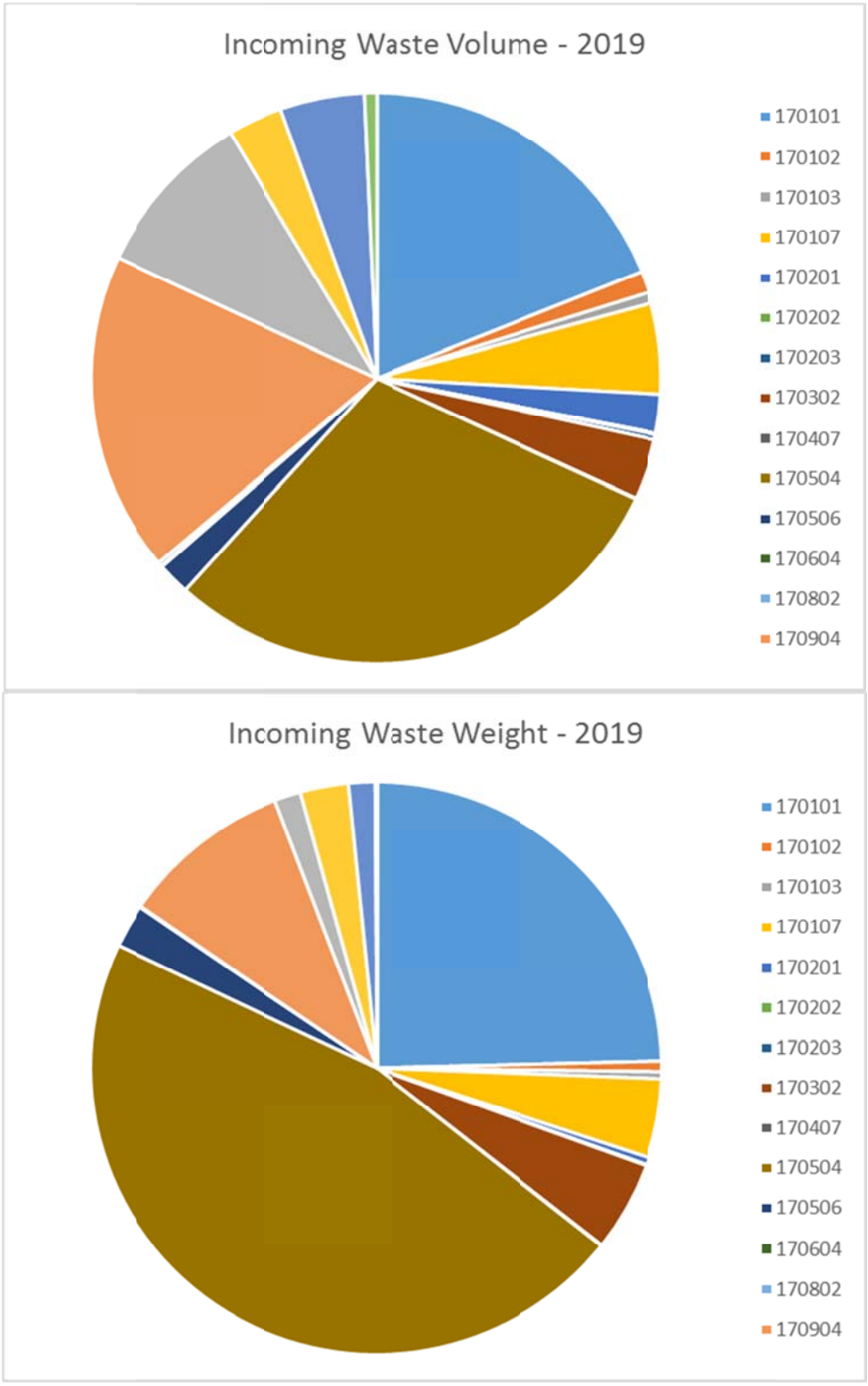


**Figure 8***:* Incoming waste type weight and volume in 2019



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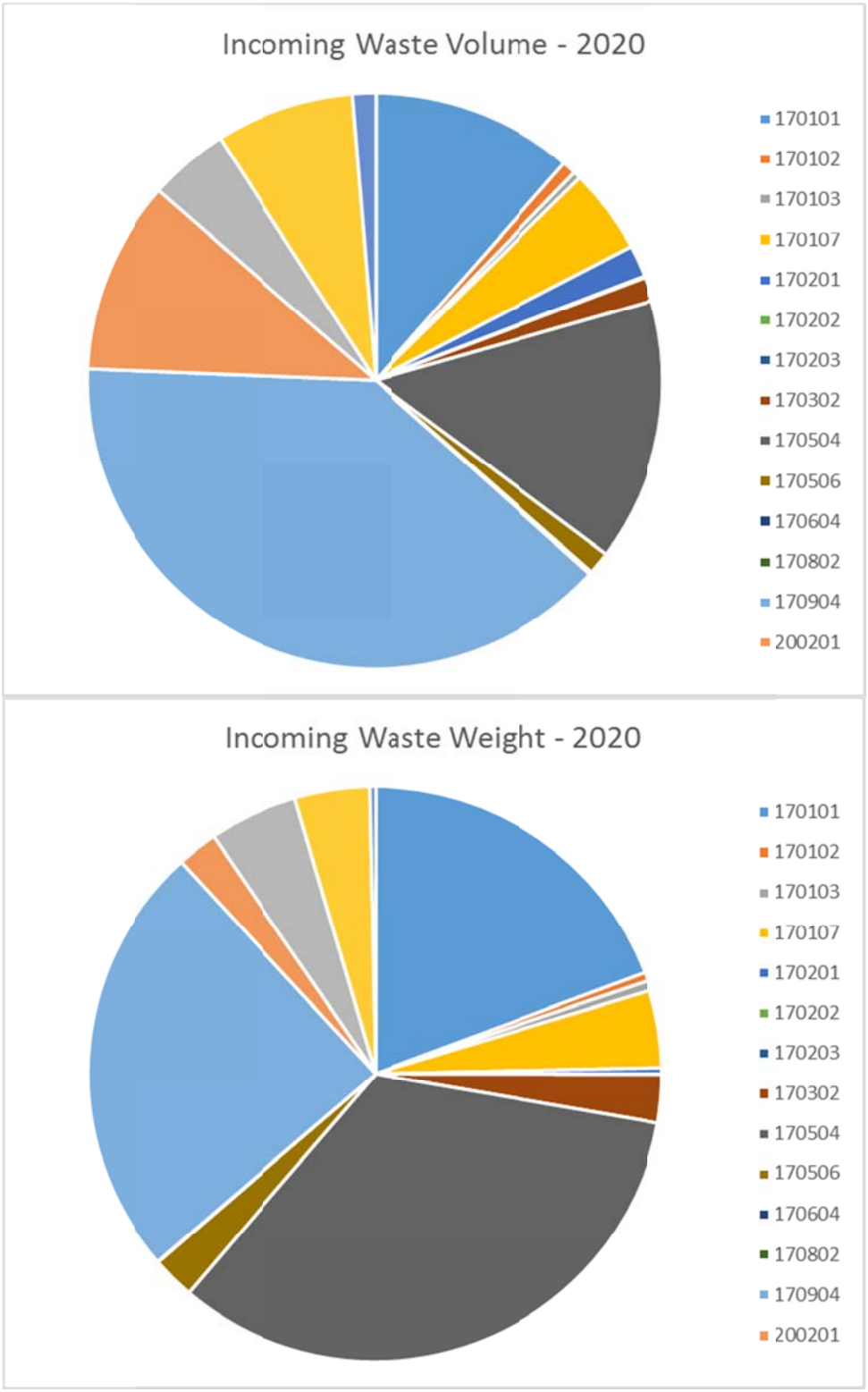


**Figure 9**: Incoming waste type weight and volume in 2020



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## 4. Automatic Separation Procedure – Methodological Approach

The automatic separation procedure to be developed will consist of a vision system frame, two robot arms with grippers and a conveyor system - **Figure 10** (a), (b) and (c) respectively. The material will be added to the conveyor and the vision system will identify the location of the objects and provide the machine learning system with 3D images of each object. The machine learning system will process the 3D images for determining the type of each object. Based on the recognized type, the robot arms will pick up each object and place it in the corresponding bin (of waste type).

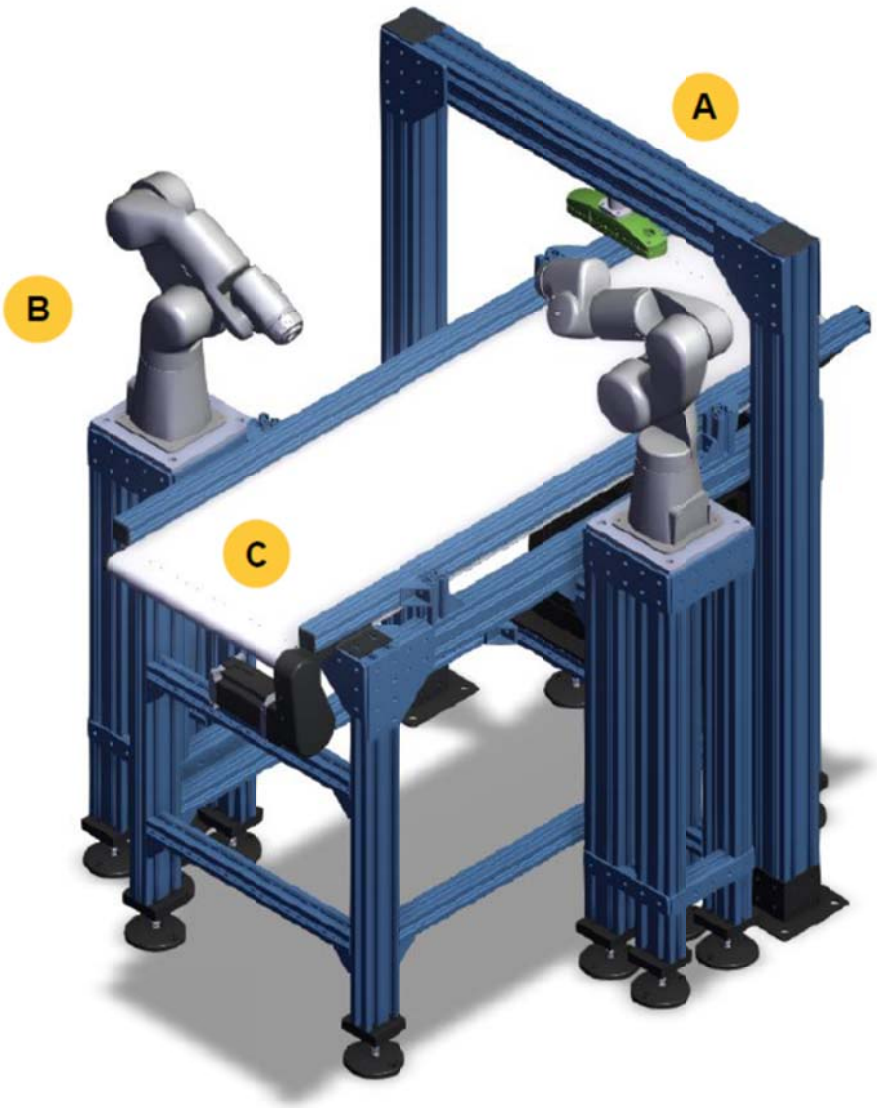


**Figure 10**: Automatic Separation System Parts



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The machine learning system will be provided with 3D images of objects in order to classify them into the different waste types - concrete, bricks or tiles/ceramics. The development of the system will be composed of the following steps:

(a) **Data Collection:** An adequate number of 3D images of the waste types of interest (i.e. concrete, bricks or tiles/ceramics) will be collected using the vision system.

(b) **Image Pre-processing:** The images will be pre-processed to identify each object and remove the remaining image background.

(c) **Feature Extraction:** A large set of candidate features will be extracted from each image, to form the basic pool of features, subsets of which will be evaluated in the next step. Colour, texture and contour features will be examined. Shape related features are not expected to be helpful in the classification of waste types, as their shape is irregular.

(d) **Feature Selection:** An experimental process will be followed to evaluate and identify the most suitable subset of features to be used as input to the classification algorithm.

(e) **Classifier Experimentation:** Various machine learning techniques will be examined for identifying the most suitable classifier and the optimal set of classifier parameters for the particular task. The machine learning techniques to be examined include Artificial Neural Networks, Support Vector Machines and Random Forests.

(f) **Provision of Confidence Information:** The most suitable classifier identified in the previous step will be extended with the use of a novel machine learning framework called Conformal Prediction in order to provide well-calibrated measures of confidence in its predictions. The provided confidence measures will be used for ensuring the degree of purity of the identified material of each waste type by separating out the objects of which the classification is uncertain.

(g) **Evaluation and Improvements:** The resulting complete approach will be fully evaluated, and possible improvements will be examined. Any problems encountered during the evaluation will be suitably addressed.



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## Acknowledgements

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