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D4.6 Pilot plant integrated at IDE

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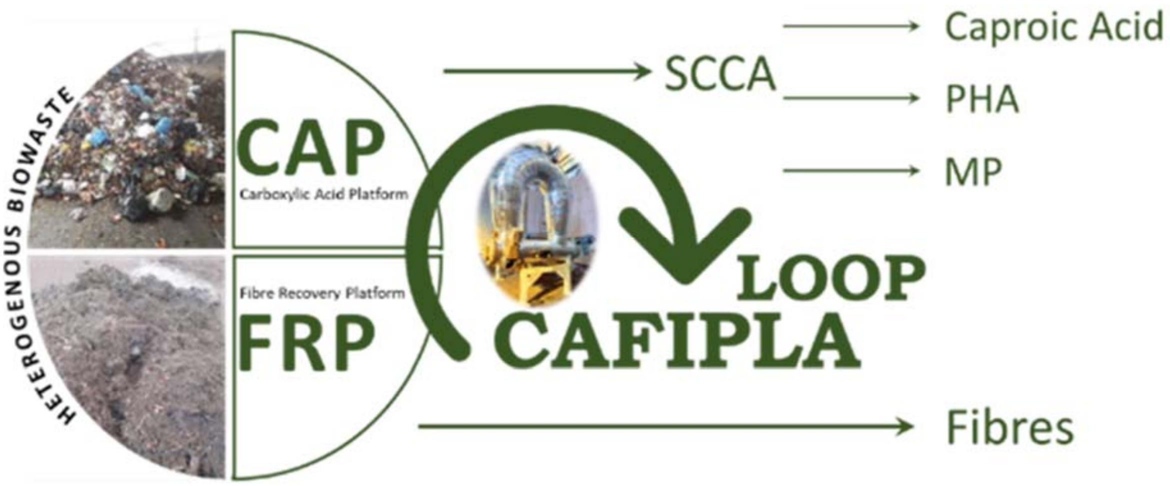
EXECUTIVE SUMMARY

The project CAFIPLA aims to develop two platforms for the bioconversion of the maximum content of the municipal solid biowaste fraction or/and of local organic waste from other industries. These CAP/FRP platforms targeting the recovery of carboxylic acids and fibres characterise the pilot that will be implemented at TRL5. The pilot is integrated in the existing anaerobic digestion and composting facilities of a public industrial waste treatment plant located in the south of Belgium. The key to successfully exploit and valorise the most of the biowaste input streams resides in the variety of the different product applications and the broad range of feedstock that can be used. The previous CAFIPLA work performed during the WP1, 2, 3 and beginning of WP4 gave results on the different feedstock tested, on the impact of the pre-treatment, on the potential of specific enzymes combination to apply, as well as, on the effect of the solid/liquid ratio's on the output quality during the initial separation step for CAP/FRP platforms. These results helped to design the pilot (D4.5) that is build and assembled as shown in this current deliverable (D4.6). The purpose of this document is to provide an honest and complete view on how the pilot is assembled and linked to the existing industrial processes of the IDE plant. First, the deliverable gives explanations on how the organic municipal solid waste (OMW) is separately collected and prepared before to feed the "classic" anaerobic digester. The parallel between the current and the new CAFIPLA processes is presented. The study of the best location for the pilot related to the plant activities as well as the pilot feeding challenges are developed to expose the transparent work carried out by the project partners to reach the project's goal. Security of the workers, respect of the environment, budget and deadlines are factors that strongly impact the pilot integration inside an existing waste treatment plant. Lots of pictures have been included in the present public deliverable to make it easily understandable to readers of any profession. The final step of the WP4 will be to validate the integrated CAP/FRP pilot demonstration at the IDE site by producing new raw materials further used by the partners of WP5.



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Abbreviations

AD	Anaerobic digestion
CA	Caproic Acid
CAP	Carboxylic Acid Platform
FRD	Fibres Recherche Développement
FRP	Fibre Recovery Platform
IDE	IDELUX Environnement
LCA	Life Cycle Assessment
NADES	Natural Deep Eutectic Solvents
OMSW	Organic Municipal Solid Waste
OWS RF	OWS Research Foundation
PHA	Polyhydroxyalkanoates
SCCA	Short Chain Carboxylic Acids
TEA	Techno-Economic Assessment
TRL	Technology readiness level

1 INTRODUCTION

In a period of 3 years, the CAFIPLA project proposes an alternative or a parallel way of treating municipal organic waste. There are currently very few commendable alternatives to anaerobic digestion or composting. This is mainly due to the fact that our organic trash can is very heterogeneous. A family rarely eats the same menu as their neighbours, neither do they every week, so this is even much less the case across a whole province. Current biomass use comes at a high cost, either in terms of land use or energy and chemical use. On the other hand, biowaste is massively produced in an urban and rural context but not much valorised, or solely in low-value applications. The CAFIPLA project aims to radically alter the biomass pre-treatment approach for bio-economy applications. CAFIPLA aims to go further by developing an integrated biomass valorisation strategy that combines two recovery platforms. Treating our municipal organic waste differently depending on what is easily or more slowly biodegradable. For example, the green waste from the garden (vegetable fibres) compared to leftover chocolate cake (sugars and fats). The idea is, said more scientifically, to recover organic waste in the form of Short Chain Carboxylic Acids (SCCA) and nutrients in solution through the carboxylic acid platform (CAP) and insoluble fibres from the remaining biomass fraction thanks to fibre recovery platform (FRP). These products will then be reinjected into industry as new raw materials. In the CAP, research will focus on process control strategies to obtain specific spectra of short chain carboxylic acids (SCCA) to feed into bioproduction of microbial protein, PHA or caproic acid biooil. In the FRP, fractionation into different fibre ranges will result in intermediates that can be valorised as packaging material or insulation. A technology readiness level (TRL) 5 pilot will demonstrate the CAFIPLA upscaling potential.

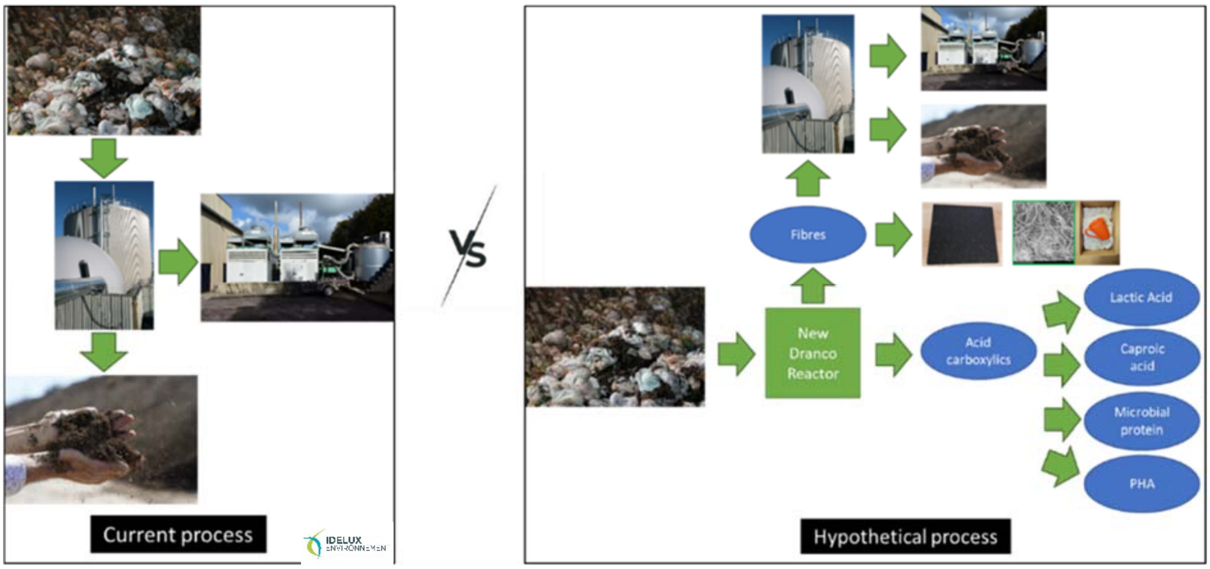

Figure 1: Introduction of the CAFIPLA project objectives

As a part of Work Package 4 - CAP/FRP process integration and demonstration, Task 4.4 – Pilot test case implementation at TRL 5, focuses of the implementation of the CAP and FRP at IDELUX site in Tenneville (Belgium) using available biomass sources (separate collected organic waste, green waste) as feedstock for the CAFIPLA approach. In a first step, a technical design plan for the IDE pilot was developed as explained in the D4.5 "Pilot final implementation plan". This deliverable also contains the process flow diagram and detailed P&IDs. The following task of the current deliverable D4.6 is to describe how the pilot will be specifically designed to be run at the IDE site of Tenneville in Belgium.

The pilot system will be in operation to validate the conditions for optimal pre-treatment in an industrial environment. The pilot is designed to treat up to 10 tonne bio-waste per year, which will consist of the IDE separately collected bio-waste and 2 other locally available substrates (as defined in T1.3). The pilot integrates the initial separation, SCCA production (mixed culture system) and fibre recovery. The demonstrator will be operated on working days (5/7 days) for the initial separation and FRP, and 7/7 days for the CAP. Continuous monitoring will allow the follow-up of carbon conversion efficiency, production of gaseous compounds and quality of the output products, as well as other parameters relevant for the LCA (Life Cycle Assessment) and TEA (Techno-Economic Assessment) (D4.9). The SCCA pilot will be run in different regimes to produce effluents with different SCCA profiles for validation tests by the partners. Obtained fibres will be forwarded to task 5.4 for fibre application.

2 PILOT INTEGRATION TO THE EXISTING AD PLANT AT IDELUX

2.1 PRESENTATION OF THE TEST CASE: IDELUX ENVIRONNEMENT (IDE)

IDELUX Environnement is the partner providing the test case industry of the project. IDE is an intermunicipal in the group of IDELUX that gathers 5 different intermunicipal with the same mission of helping the Belgian Luxembourg area flourishing. Each intercommunal is managed by a general assembly and a board of directors. The entire Group is managed by the Group Unit (Management Committee). IDELUX Environnement is managing household waste within the province of Luxembourg representing 44 municipalities and 11 municipalities from the province of Liege. In 1996, it has been decided to instore the separation in the collection and treatment of the municipal waste in the province of Luxembourg. After some years of experiences, the citizens were used to this waste sorting and IDE invested with two other intermunicipal, BEP (Namur) and Intradel (Liège) in an anaerobic digester of the Dranco technology. This led to have 2 geographically separated plants that are now specialised in the treatment of the two different compartments of the citizen’s bin: organic or residual waste.

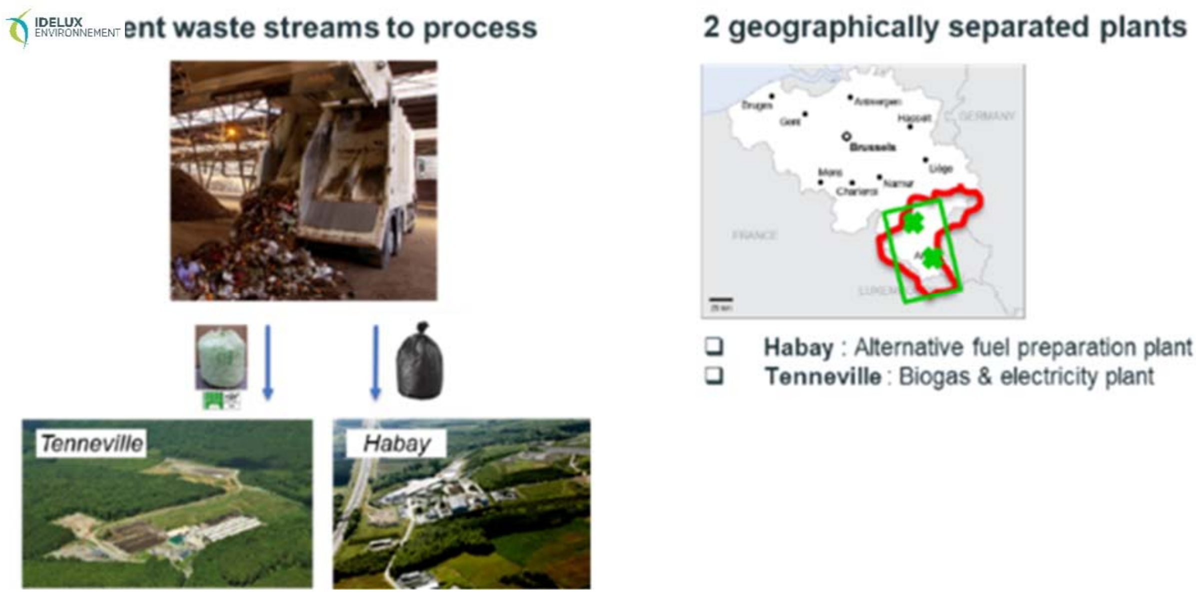

Figure 2: Two waste treatment plants for 2 different waste municipal streams treated at IDE

The specialised separately collected municipal organic waste treatment plant of Tenneville is welcoming the CAFIPLA pilot plant. This little town is located in the province of Luxembourg in Belgium.

Its location is at the border of three European countries, Germany, Luxembourg and France. The closest big towns are Arlon, Namur, Charleroi or Liège with a maximum average distance of about 80 to 110 km.

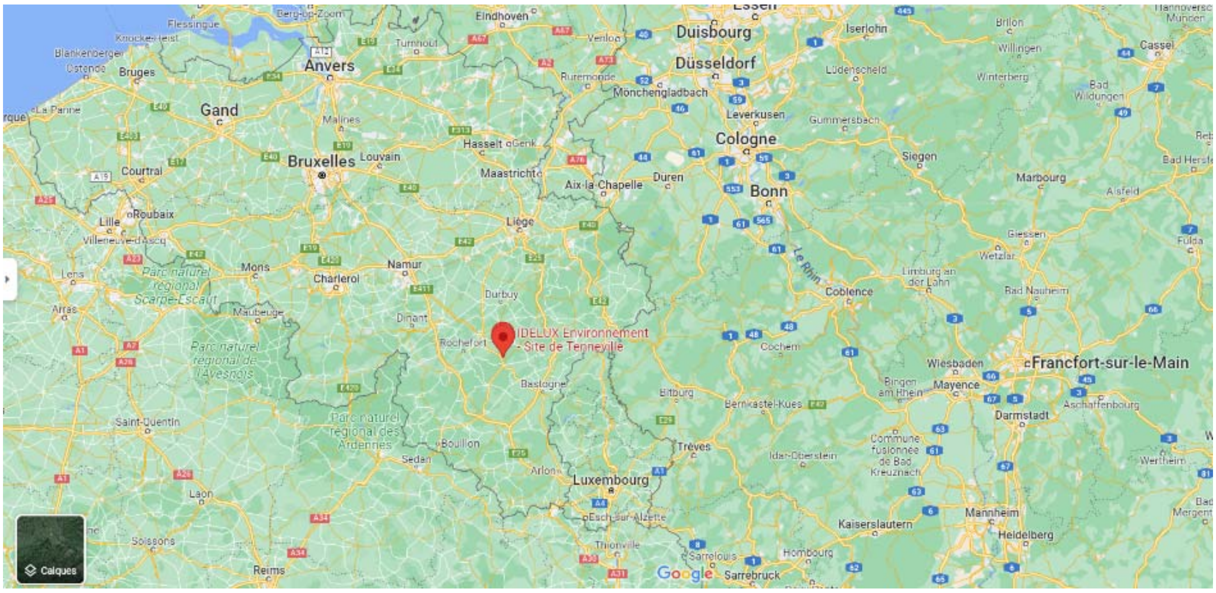

Figure 3: Location of IDE's plant where the pilot TLR 5 is going to be operated (Source: Google map)

The plant is not located in an industrial area, neither around houses. It is rather surrounded by the forest. This location far from everything appears to be ideal when treating waste as smell, dust or the truck traffic can be seen as big disturbances for the neighbours.

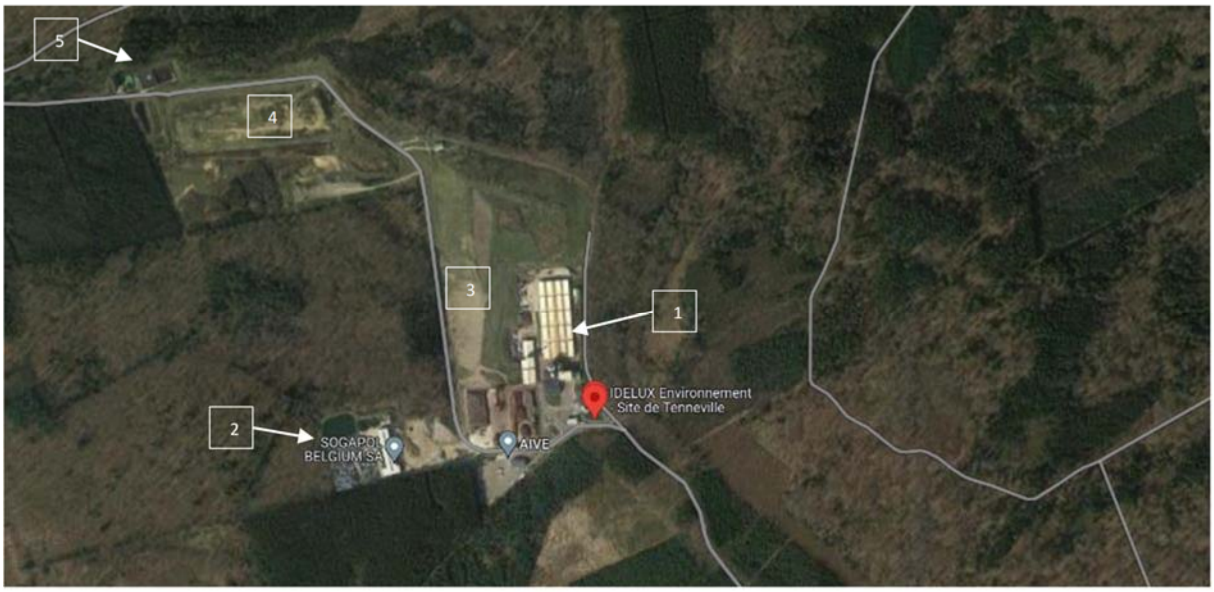

Figure 4: General overview of IDE's plant in Tenneville. 1: Composting facility, 2: Sogapol company, 3: old technical landfill being rehabilitated, 4: closed technical landfill, 5: waste water treatment plant (Source: Google map)

Figure 5: More detailed overview of IDE's plant in Tenneville. 1: Truck entrance, 2: Truck weight, 3: biowaste storage hall, 4: Dranco AD reactor referred to as "classic AD", 5: storage balloon of biogas, 6: 2 gas motors, 7: Composting hall, 8: Raw green waste, 9: shredding and sorting of green waste, 10: compost, 11: garage, 12: offices, 13: Lenz dryer containers

2.2 The current process of biowaste in IDE

At the site of Tenneville in Belgium, around 35000 t of OMSW is annually collected and treated. The plant processes organic waste from door-to-door collection from households and some schools and small enterprises (kitchen and garden waste) into biogas.

Figure 6: Separately collected organic municipal solid waste (OMSW) stored in the IDE's biowaste storage hall (left) and Green waste collected in the municipal container parks and stored before treatment at IDE's plant.

Gas engines convert this biogas efficiently into electricity and heat. The plant produces about 8-10 000 000 kWh/year. The heat (7 500 000 kWh/year) is used to warm the own premises of the site of Tenneville but also to heat the leachates in the biological wastewater treatment plant, dry the sewage sludge, heat the air slab of the composting facility and dry the refused fraction of compost inside the Lenz dryers.

After a pre-treatment step, the organic fraction is treated in the anaerobic digester and the resulting digestate is composted together with green waste. The plant yearly produces ± 5-6 million Nm³ of biogas and 25000 t/year of digestate. Collection is typically done by local collection trucks with a frequency of every week by the municipalities.

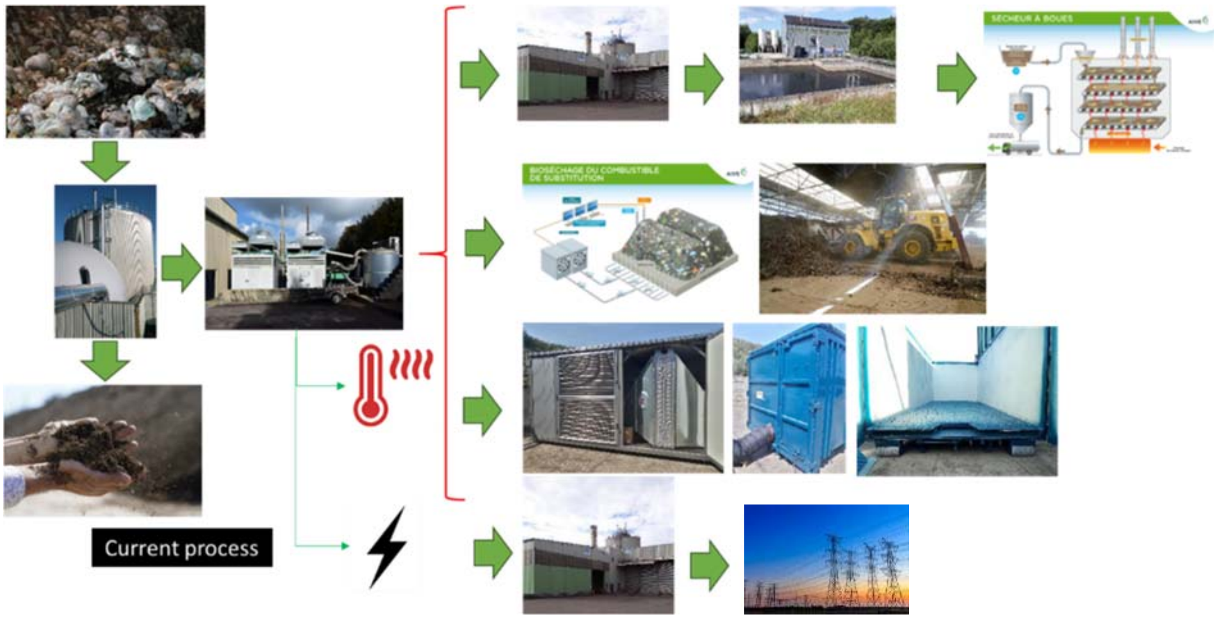

Figure 7: illustration of the heat and electricity uses in IDE's plant in Tenneville

2.2.1 Organic Municipal Solid Waste (OMSW) pre-treatment

The OMSW is shredded and then selected through a screen for 60 mm particle sizes. The largest fraction (> 60 mm) is rejected and sent to incineration (off-site). The fraction below 60 mm is sent through a magnet to remove ferro metals and then sent to the dosage unit before to reach the anaerobic digester.

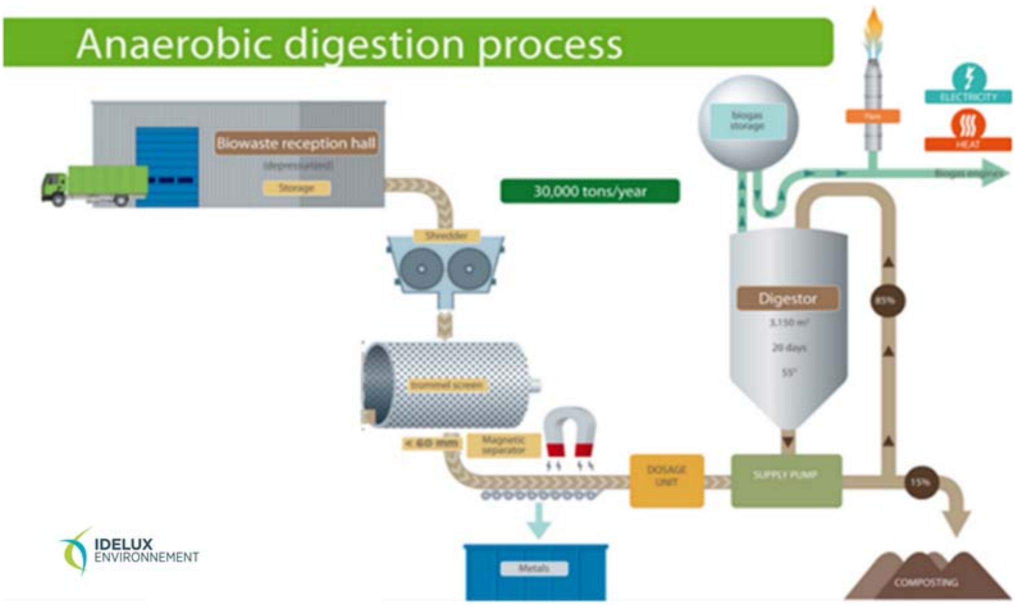

Figure 8: Illustration of the treatment of organic municipal waste in IDE's plant

Figure 9: Fill in the feed hoper of the shredder with organic municipal waste in IDE's plant

The pre-treatment sorts some sorting mistakes made by the citizen, mostly made of plastics (bags and food packaging but not only), metals, rocks and glass. The necessity of this pre-treatment is undeniable.

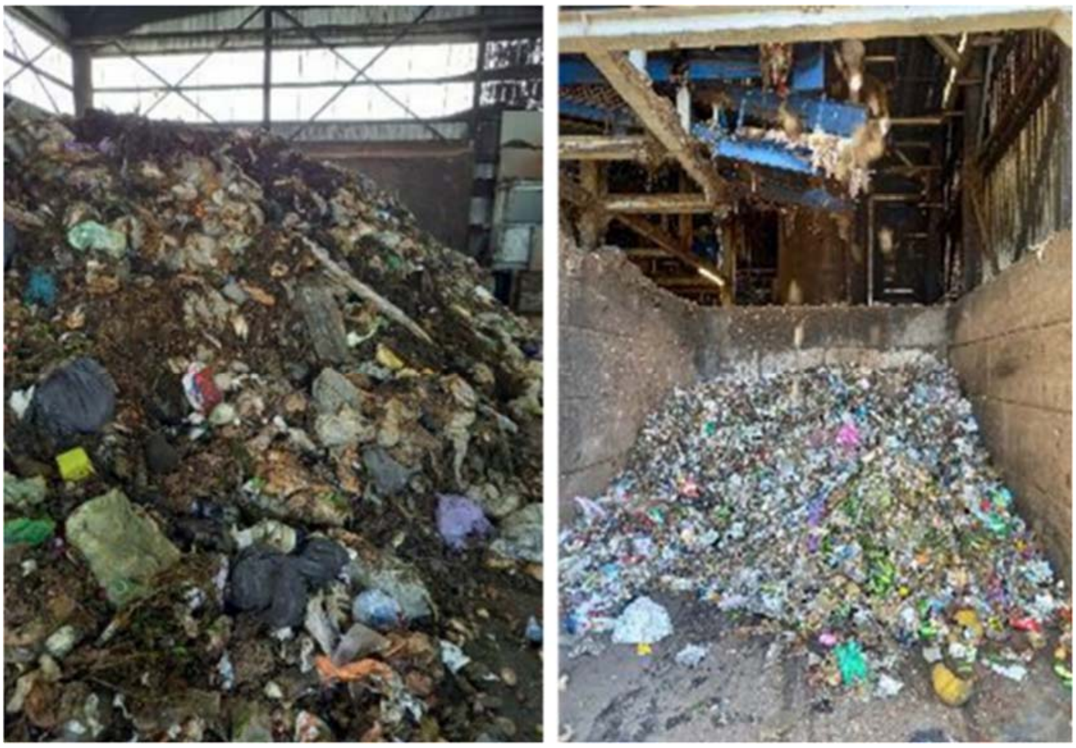

Figure 10: Illustration of the initial separately collected OMSW (left) and illustration of the rejected fraction from the pre-treatment (right). The current fate of the removed fractions (>60 mm) is incineration (off-site)

The <60 mm fraction is sent to the digester with a residence time of approximately 20 days. A part of the digestate (85%) from the digester is fed back with new organic waste. The other part (15%) is mixed with the green waste streams and composted.

2.3 Green waste preparation for composting with the digestate

Around 20 - 25 000 t of green waste are annually collected in the plant of Tenneville. These green wastes are shredded through a Crambo and sieved with a Terex or a L3 depending on the maintenance of these machinery. The bigger fraction, over 60 mm, is used as feedstock for biomass boiler. The other fractions are used for the composting process.

Figure 11: Illustration of green waste treatment

A recipe between the medium sized, the low sized and the digestate is prepared and let resting for 3 weeks inside the covered area of the composting hall.

Figure 12: Illustrations of the Tebbe and the compost preparation by the mixture of green waste and digestate

After 3 weeks, the compost is sieved around 8 mm. The fraction below 8 mm is compost (fertilizer) and the bigger particles are fed back to the composting process and partially sent to the biomass power plant.

Figure 13: Collection of the compost sieved at 8 mm

The post-treatment (shredding and sieving till 8 mm) guarantees the quality requirements of the compost. The compost will mature for 3 months outside and be controlled by an independent laboratory for legal quality parameters before to can be sold to farmers. Finally, a total of around 25 000 t of quality compost is produced every year.

Figure 14: Illustrations of the composting process (left) and the final compost (right) made of green waste and digestate

Rejected fraction of the composting process, after several uses, are full of non-organic contaminants. These fractions are dried in the Lenz containers feed with the heat of the HCP motors before to be carried by trucks to incineration (off-site).

Figure 15: Illustrations of the rejected fraction of the compost (left), full of non-organic contaminants

2.4 THE LOCATION OF THE PILOT

Initially, when preparing the project proposal, it was planned to connect two containers in front of the hall of biowaste storage as first choice or next to the gas motors and last option was next to the AD plant.

Figure 16: Overview of the site of IDELUX Environnement at Tenneville with the first CAFIPLA pilot plant location marked with red cross. 1: Dranco AD reactor referred to as “classic AD”, 2: storage hall of biowaste, 3: Composting hall, 4: offices

In a first step, the location for the CAFIPLA pilot was identified taking into account biowaste, energy and water supply. However, after some technical meetings, the necessity to cover the pilot and protect it from the weather of Belgian’s winter was inevitable. The location of the pilot was chosen following the final design decision. Indeed, the pilot would not fit, as initially planned, in containers. So, IDE explored the different options they could provide to install the pilot.

Two different covered spaces (options 1 and 2 on the figure 17) were available to welcome the CAFIPLA pilot.

Figure 17: Overview of the site of IDELUX Environnement at Tenneville with the 2 options for a covered space to welcome the CAFIPLA pilot plant marked with red square or arrow. 1: Dranco AD reactor referred to as "classic AD", 2: storage hall of biowaste, 3: Composting Hall, 4: offices

The second option, a storage shed located quite far from the daily activities, has been rejected for practical and security reasons.

Positive points:

- Weatherproof
- Available electrical power (medium and low voltage)
- Useful area
- Away from any existing activity (no co-activity risk)

Cons:

- Slope access, dangerous in winter to get off with a forklift
- Lack of lighting
- Prior cleaning required and no real option to store the current equipment
- No internet network
- The water supply is freezing in winter and needs improvement to avoid leaking
- Being away from the operating site is listed in the positive points but it is also a disadvantage

Figure 18: Pictures of the second option for a covered space to welcome the CAFIPLA pilot plant

The first option was the new hall for P+MC storage. It seems to be the best opportunity and has been validated by the security department of IDELUX Environnement for several reasons including:

- Weatherproof
- Working area available
- Parking space and places for one or more containers, on a concrete and safe surface or inside the building.
- Presence of surveillance camera
- Internet access
- Guaranteed security for users (needs to finance master block to delimit the space to be secured).
- Close to the offices and exploitation site (saves daily time for pilot management)

Cons were that the electric power available was only at low voltage and needed to be improved. Also, the water connection was inexistent.

Figure 19: Pictures of the first option for a covered space to welcome the CAFIPLA pilot plant

2.4.1 SECURITY VALIDATION

The Internal service for prevention and protection at work department of IDELUX Environnement made some recommendations on the pilot localisation inside the hall P+MC. This hall is first built for the storage of the blue bag content which is composed of the plastics, metals and tetra pack from municipal food packaging. Trucks goes in and out on regular basis to unload the municipal food packaging waste inside the hall. The first space area has been validated to contain all the material for the CAFIPLA project with the highly recommended advice to secure the work area with masterblocks.

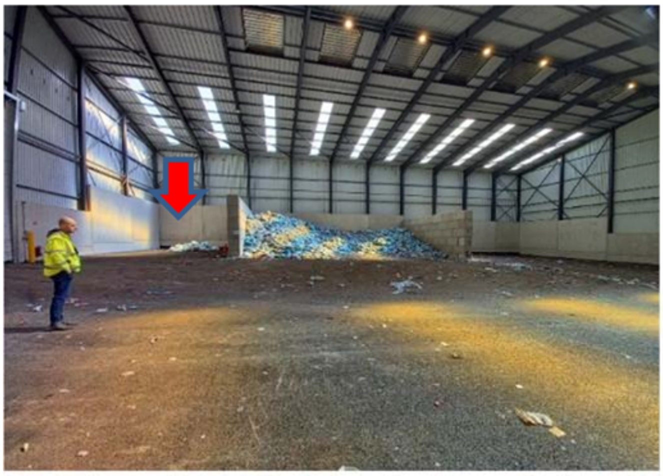

Figure 20: Picture of the first area, ready to welcome the CAFIPLA pilot plant

The Internal service for prevention and protection at work of IDELUX Environnement is present for each important step of the pilot building inside the IDE plant in Tenneville and gives his recommendations to ensure the security of everyone.

2.4.2 SPACE ADJUSTMENT FOR THE DIFFERENT PART OF THE PILOT

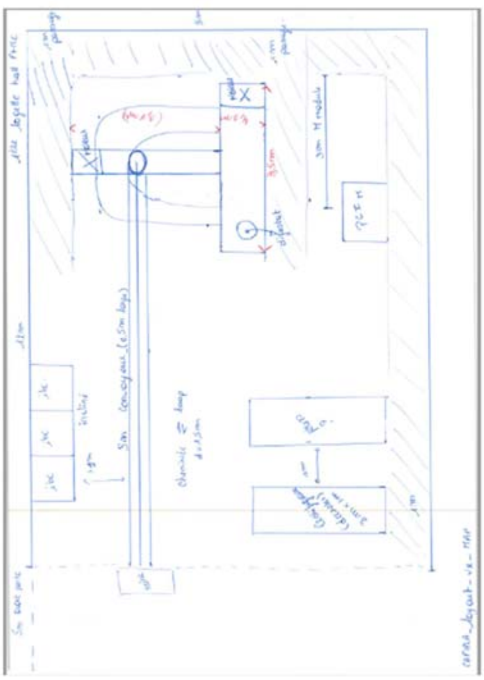

Figure 21 (left): Plan of the P+MC storage hall, the area welcoming the CAFIPLA pilot plant is in the red square.

Figure 22 (right): Draft layout for the 1st area and the different part of the CAFIPLA pilot plant

3 PROCESS FLOW SCHEME

After several online meetings between OWS RF, Tecnalia, FRD and IDE, an agreement on the general process-flow scheme was agreed (Figure 23). Based on the experiences at lab scale with different process lay-outs, a choice was made for a semi-continuous reactor for the carboxylic acid platform (CAP). Three different routes are engaged simultaneously for the fibres recovery platform (FRP) to analyse all the possibilities that offers the pilot and will include the study of green waste treated separately from the CAP to compare the valorisation levels this specific platform can reach based on the feedstock and its process.

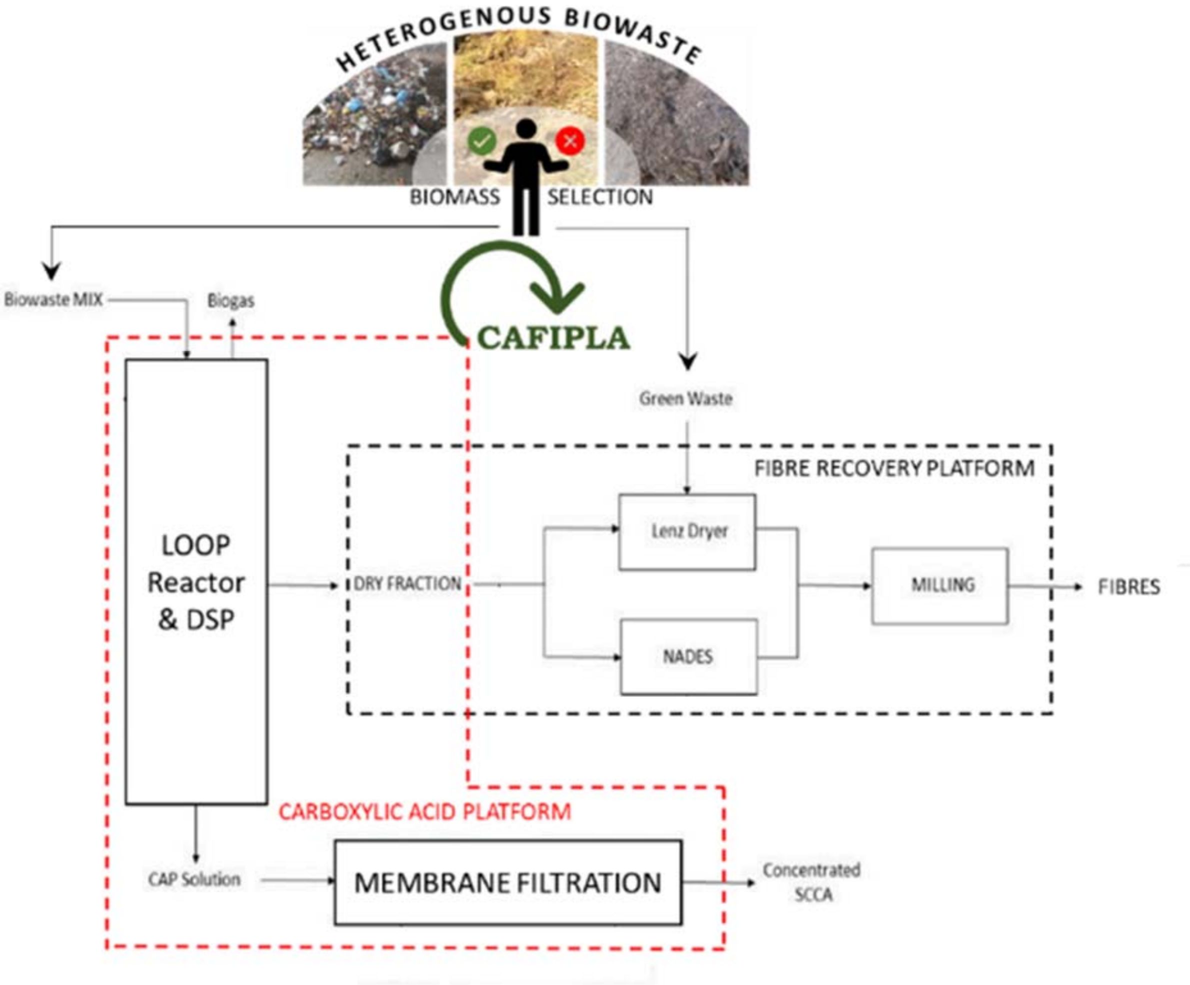

Figure 23: Generic process flow scheme of the pilot TLR 5 to be operated at IDELUX (Ref: CAFIPLA – D4.5 (2022))

In this set-up, the separately collected organic municipal solid waste are shredded and sieved at 60 mm in the installation of IDE. A magnet collects some metals from the conveyor belt transporting the shredded organic waste material (<60mm) to feed the pilot dosage unit of the AD. These pretreated biowaste will feed the Loop reactor and be mixed with water. After approximately two days of retention time inside the loop, the digestate will be dewatered in a press (sieve). The liquid fraction will contain the Short Chain Carboxylic acids (SCCA) and the solid fraction will contain the fibres. A centrifuge (decanter) is rent to further reduce the water content but most importantly, the output is dewatered to separate as much as suspended solids as possible to avoid membrane fouling later in the process. The centrifuge cake can either be sent to the AD reactor for biogas production or to the composting facility or recycled to the FRP. This solid output will be tested directly through Natural

Deep Eutectic Solvents (NADES) process or after drying in the Lenz Dryer containers as a rich fibre stream. The current residence time in the classic AD is around 20 days, which is expected to be sufficient to fully degrade the more recalcitrant residual biomass inside this solid fraction after the dewatering of the press/sieve. The CAP solution containing the SCCA in solution is either used directly by the partners involved in WP5 or further purified using a membrane filtration process.

During SCCA production, CO_2 and H_2 production is expected (measured during lab tests). This hydrolysis gas could be used in future project exploitation like a reinjection inside the classic anaerobic digester where it can be biologically converted to methane. Because of the presence of the H2 gas, a risk assessment will be performed in order to execute the tests in a safe working environment.

4 PILOT IMPLEMENTATION

Based on the results, as described in D2.1; 2.2; 2.3 and D3.1 and D4.1, a lot of lab scale experiments were performed. The optimal parameters to guide the implementation were analysed and determined. With the data of these lab scale experiments in mind and the decision taken on the design of the pilot to be built at TLR 5 (see D4.5), the preparation of the pilot could start in OWS RF from June 2022. The Loop reactor has been upgraded with many adaptations to make it suitable inside IDE's plant in order to reach the project's goal.

IDE separately collected and shredded organic municipal waste will be mixed together with water until a certain total solid content is reached. Besides water, co-substrates will be added at certain period. These co-substrates were selected based on the results obtained in D2.4. Co-substrates are to be added to steer the produced SCCA spectrum in a certain direction. After the mixture is initially added, the reactor is set to ferment the mixture 2 – 3 days after which a certain amount is to be removed from the reactor. This amount of biowaste mixture depends on the SCCA spectrum that is to be created.

As the purpose of this pilot is to produce a detailed spectrum of SCCA, no detailed gas analysis is to be implemented. Thus, only the amount of gas will be monitored using a gas flowmeter (Ref: CAFIPLA – D4.5 (2022)).

The LOOP-reactor is a semi-continuous type of reactor.

4.1 MOVING THE PILOT INTO THE PLANT OF TENNEVILLE

The pilot moved from Brecht (Belgium) to Tenneville. The special transport required two different handling machines including one with a loader crane.


Figure 24: Entrance of the special transport in IDELUX Environnement's plant at Tenneville

Figure 25: Entrance of the Loop reactor inside the P+MC hall

The Loop reactor was split in three parts and needed to be mounted with the loader crane truck carefully.
First the feet needed to be adjusted because the ground was not level rather sloping.

Figure 26: Pictures of the positioning of the feet of the Loop reactor

The second part was the reactor itself that needed to be fixed properly on the feet.

Figure 27: Pictures of the positioning of the Loop reactor

Finally, the last piece was the smallest one but maybe the most difficult to fix to the pilot because of the height.

Figure 28: Pictures of the positioning of the last piece of the Loop reactor

4.2 THE HEATING SYSTEM

The loop reactor is now equipped with a mechanical thermostat to easily set a given temperature. The temperature is monitored to maintain certain temperature parameters which is used to create the right SCCA spectrum. The heating itself will be automated to maintain a steady temperature. This temperature range was implemented based on the lab scale experiments, depicted in D2.3 (Ref: CAFIPLA – D4.5 (2022)).

Figure 29: Pictures of the heating system installed on the Loop reactor by OWS RF

Finally, to protect the loop from the cold and to keep as much as possible its temperature during winter, the reactor has been isolated with rockwool and aluminium tape as shown in the figure below.

Figure 30: Pictures of the isolation of the Loop reactor

4.3 THE PILOT FEEDING SYSTEM

As the design of the pilot changes several times as explained in the D4.5, the feeding system also needs to adapt for the quantity of biowaste required and also to carry this volume of OMSW to the pilot plant. The assessment of two challenges are currently on-going related to the feeding of the CAFIPLA pilot plant.

First, the preparation of the biowaste to feed the pilot. The location of the pilot is not so close anymore to the pre-treatment hall of the OMSW. In IDE's plant, the separately collected biowaste are first stored in a hall (storage hall) before a Caterpillar is loading it into the shredder (B). The shredded biowaste is sieved at 60 mm (C) inside a trommel and is transported by a conveyer belt through a metal separation (D). The resulting shredded biowaste fraction is fed in a dosage unit for the AD (Ref: CAFIPLA – D4.5 (2022).

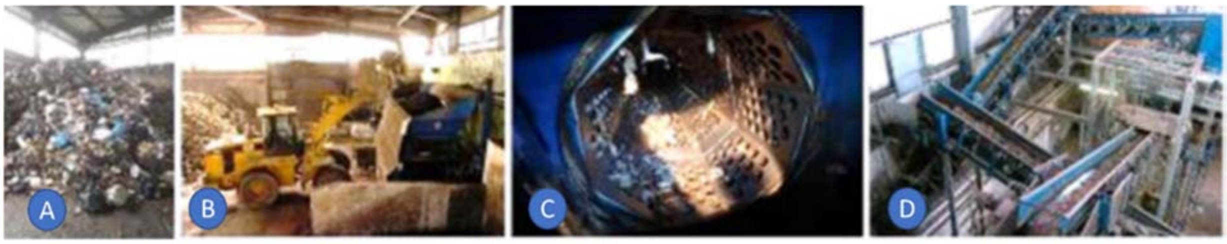

Figure 31: Biowaste pre-treatment at IDELUX used for the CAP

Currently on-going is the assessment on how the process has to be modified to have access to the biowaste mix after the shredder.

The current option is to manually collect the biowaste before they fall inside the dosage unit. This is time consuming and the opposite of a comfortable task, but IDELUX Environnement has publicly launched a job offer to fill in this important position for the project.

Figure 32: Manual collection of the pre-treated OMSW before it fall inside the dosage unit to feed the "classic" Dranco AD plant

The other option is to update a conveyor belt that collect the biowaste directly after the trommel (C) as shown in figure 33. This conveyor belt can't work for this specific purpose in its current state but could be modified to bring the shredded and sieved OMSW outside the pre-treatment hall inside a tank, ready to go to the pilot plant. The deadline before to start working with the pilot and the expense of this work are the limiting factors for this option still currently under review.

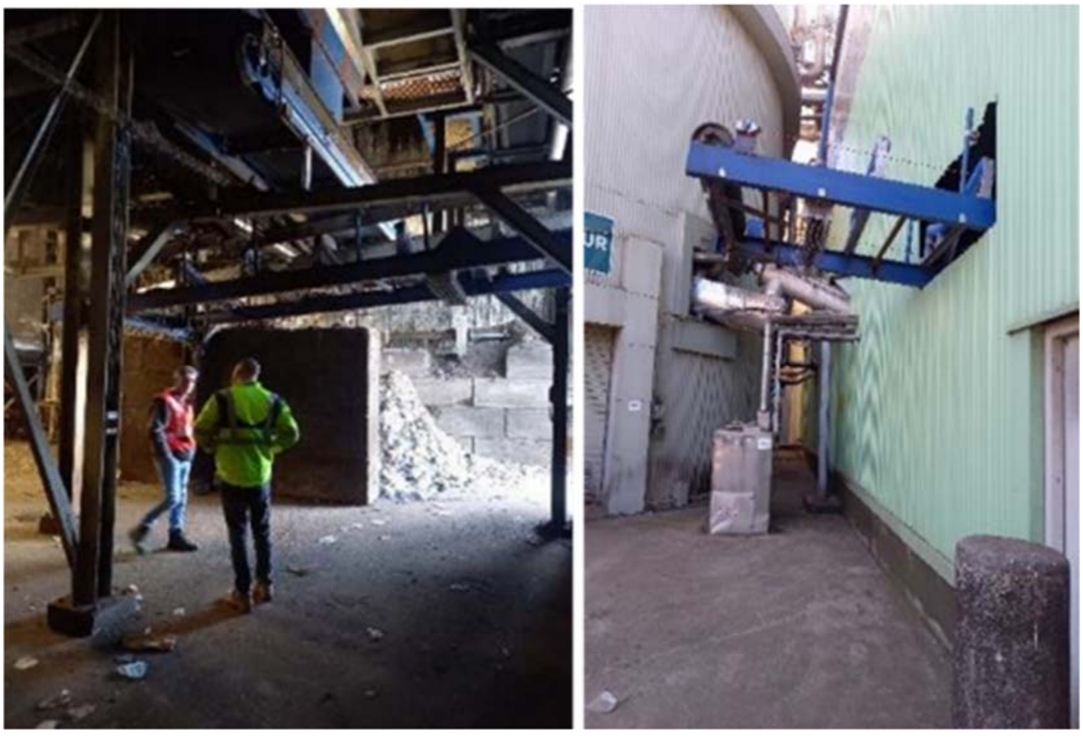

Figure 33: The conveyor belt that could be modified to extract the pre-treated biowaste for the pilot plant

Second, biowaste and water are going to be inserted at the top of the reactor through a feeding conduct or chimney located approximately at 4m height from the ground. Initially, a scale was planned to put the feedstock inside the pilot plant but quickly, as the daily amount of organic material required increased, a work lift, then screw conveyor and, finally a conveyor belt were assessed for the task.

Figure 34: Height of the feeding conduct

IDELUX Environnement as well as OWS RF contacted several suppliers of service to finally decide to buy a second-hand conveyor belt.

Figure 35: The second-hand conveyor belt reception at IDELUX Environnemnet's plant at Tenneville

After reception of the Loop reactor at Tenneville, IDELUX Environnement is working with suppliers of service

- to install this second-hand conveyor belt along the pilot in order to be able to feed the pilot's chimney
- to create 2 hoppers (round-square) for the supply of organic matter at the bottom of the conveyor and the supply of the chimney at the top of the conveyor
- to provide metal height support for electrical cable entry
- to secure the reactor's 4 mounting legs to the ground

A technical meeting gathered industries with the project managers of IDE and the representative of the Internal service for prevention and protection at work department as well as the plant foreman to discuss different aspect of the pilot implementation including how to improve the stability of the loop reactor despite the ground slope.

Figure 36: Visit and presentation of the complete pilot plant idea for the implementation

4.4 THE IMPLEMENTATION OF ELECTRICITY SUPPLY

Once the Loop reactor finally moved in the plant of IDE then the integration work could start. It is time to look for the installation of the electricity supply of the complete pilot plant. Some parts are still investigated by OWS RF but the big picture has already been presented during the visit of the pilot plant.

Figure 37: Presentation of the complete pilot plant idea for the electricity implementation

It has been decided to split the electricity supply between the loop reactor and the rest of the plant by using the initial electrical panel for the reactor and add the new equipment on new additional electrical circuits.

Figure 38: Additional electrical features to the Loop reactor

Finally, a measure of the electrical consumption will be installed to know the energy consumption of the pilot plant. This is an important factor regarding the LCA end TEA performed in the WP6.

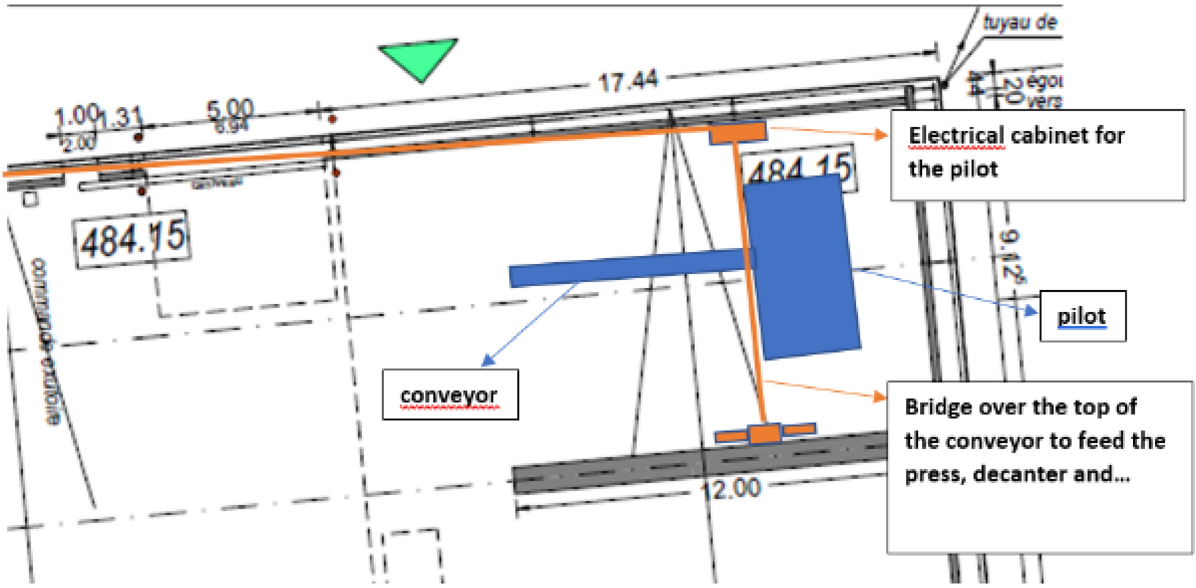

Figure 39: Electricity supply location.

4.5 The implementation of water supply

The reactor will be fed with biowaste (from the pre-treatment of IDE's plant) or with tap water. Water connection has been installed in the hall for the only purpose of the pilot plant. A flow meter will be installed on the water inlet hose to know the volume injected over time.

Figure 40: Tap water supply in the P+MC hall to feed the CAFIPLA pilot plant

4.6 The screw press

For digestate processing a screw press is used. We are using a screw press with the following characteristics: height of 198cm, width of 107cm and length of 205cm.

4.7 The decanter/centrifuge

After a successful separation, the wet fraction will be further purified by using a decanter. A decanting step is necessary because a lot of solids and molecular complexes are still present. This is however to be removed in order to prevent fouling problems with the filtration systems. The solids waste stream is to be further applied for FRD purposes. The resulting purified liquid fraction is the CAP solution to be applied to the filtration units (Ref: CAFIPLA – D4.5 (2022).

4.8 The membrane filtration process

There is a cascade membrane filtration process to be carried out in the downstream processing of the SCCA rich CAP solution. The filtration process includes several filtration steps. The first ones are used to separate macromolecules, biomass, solids while last step is implemented. to further concentrate the liquid. The concentrating of the solution is necessary to provide the partners with a high and clean concentrate of SCCA.

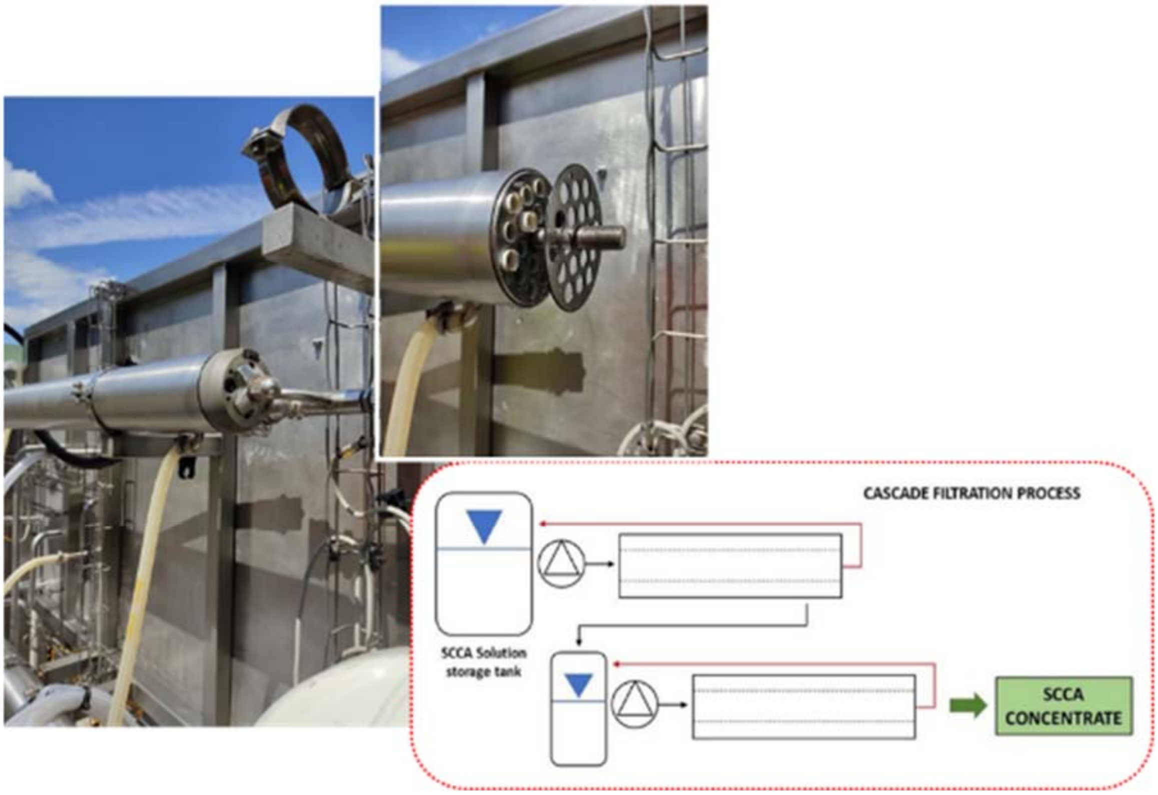

Figure 41: Pictures of Membrane Filtration Process (left) and tubular membranes and Filtration process scheme (right down)

4.9 THE ENZYME FEEDING SYSTEM

IDELUX Environnement shared information related to the "classic" Dranco AD plant with Biopract who analysed the biogas, digestate analysis and daily operation data of the year 2021. The idea was to assess the use of the selected enzymes from the WP2 task 2.1 and WP4 task 4.1 inside the CAFIPLA pilot plant but also inside the industrial reactor of 3000m³. The results of this first assessment were shared by Biopract during a virtual meeting. After several phone calls, and discussion between the partners, including Tecnalia and OWS RF, Torsten Unmack from Biopract visited IDELUX Environnement to establish where to install the dosage pump to add the enzyme inside the "classic" Dranco AD. Discussion are now still ongoing on that specific topic.

Figure 42: Technical meeting between IDELUX Environnement and Biopract

4.10 The NADES (Natural Deep Eutectic Solvents)

The fibre rich solid fraction obtained from the CAP after screw press will be forwarded to fibre extraction via application of NADES. As the process requires the use of bigger amounts of NADES at low pH a chemical laboratory is needed for safety issues. Therefore, the fibre recovery via NADES will be implemented at the external part of the pilot at TECNALIA facility.

The pilot extraction will use stirred glass reactors for NADES preparation and fibre extraction.

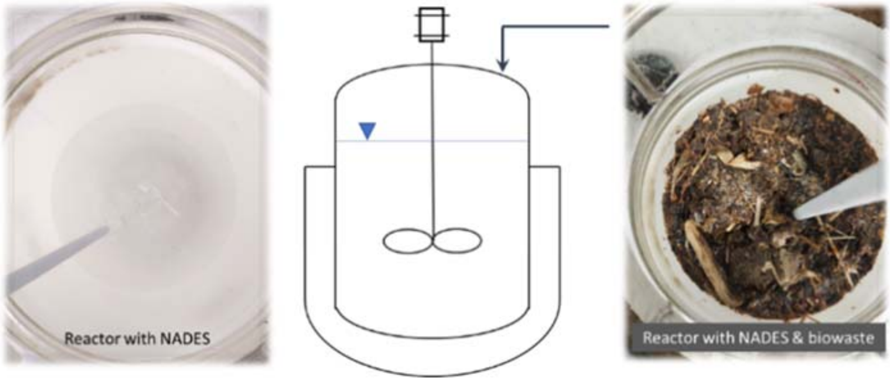

Figure 43: NADES extraction of fibres from biowaste

After extraction, fibres will be recovered by centrifugation using Sorvall Bios 16 (Fa. Thermo Scientific) with a capacity of 6 * 2.000 ml. (see Figure 44).

Figure 44: Centrifuge Sorvall Bios 16 (Fa. Thermo Scientific) used for fibre recovery (Tecnalia)

The recovered fibres are dried using the pilot fluidised bed dryer W1200 (Fa. Glatt) available at TECNALIA (see Figure 45).

Figure 45: Pilot fluidised bed dryer W1200 (Fa. Glatt) used for CAFIPLA pilot implementation (left) and dried fibres (right)

4.11 The Lenz dryer

The green waste has been tested shredded through the Crambo of Tenneville's plant or in their raw format. For logistic and practical reasons, it would be easier to first shred the green waste before to dry it. This step can easily be performed in any organic waste treatment plant. After this, the process of the extraction of the fibres occurred through a drying and milling step described here after. First the container is loaded with the organic material to be dried like raw green waste for example.

Figure 46: The Lenz container is loaded with the raw green waste to be dried

Figure 47: The Lenz container is loaded on a truck

The container is loaded on a truck to be weighted at the weight truck scale. The empty weight of the container is known by the operators of the plant.

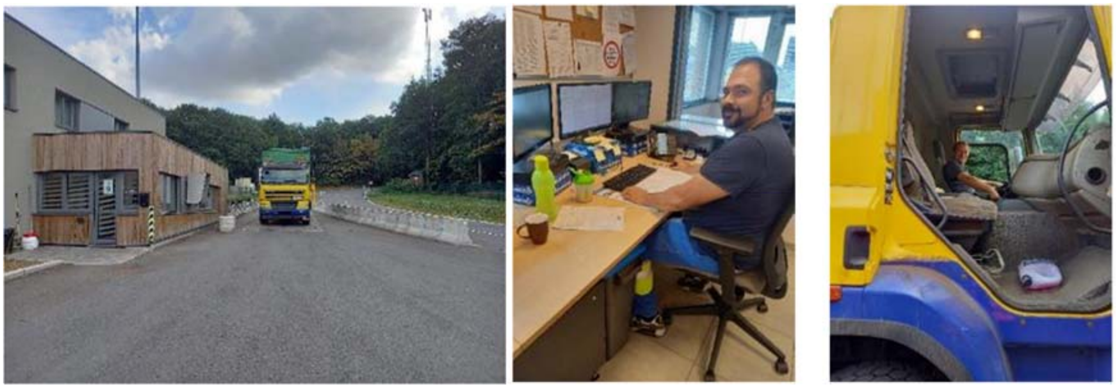

Figure 48: The truck goes on the weight scale for measurements

The container is unloaded from the truck and fixed to the Lenz dryer system fed with the heat of the CHP gas motors of the AD plant. The container is generally left there for 3 or 4 full days. They are loaded on the Tuesday and unloaded generally on the Friday to be left like that for the entire weekend.

Figure 49: The Lenz containers are attached to the heating system

The container is loaded on a truck to be weighted at the weight truck scale. The difference of weight corresponds to the evaporation of the water.
The container is unloaded in a covered area and prepared for shipment to the partner FRD for more milling and preparation of a good fibre fraction.

Figure 50: The Lenz container is unloaded in a covered area

The empty container can be now loaded with the next organic material to be dried.

Figure 51: The empty container can leave to be loaded again

The dried raw green waste is now manually collected to fill in the cubic meter packaging that will be later send to FRD in France.

Figure 52: The dried raw green waste needs to be manually collected for shipment packaging

For such shipment, the carrier needs to be autorised to manage non hasardous waste. The cubic meter packaging needs to be well fixed on a europallet. The weight of each packaging is measured directly on the truck weight scale or with the forklift weight scale.

Figure 53: Samples ready for shipment to the partner FRD

The tricky part is now to find a not to expensive carrier that will ship the big bags in a reasonable period of time to the specific partner.

4.12 The fibre extraction made at FRD

At FRD, the dried raw green waste is received in much larger quantity than for the lab scale tests, as seen below in Fig. 54.

Figure 54: Samples received at FRD, lab scale shipment (left) and Pilot shipment (right)

Both raw green waste and shredded green waste (Fig. 55), dried by the lenz-dryer, are received here, and the content is check as dried after the transportation with specific moisture measurements. Those fractions are then studied at FRD to optimize the pilot road for the green waste.

Figure 55: Samples of green waste: raw (left), and shredded (right)

The materials are then shredded to a finer size, then depending on the test grinded at a specific fine size (Fig. 56).

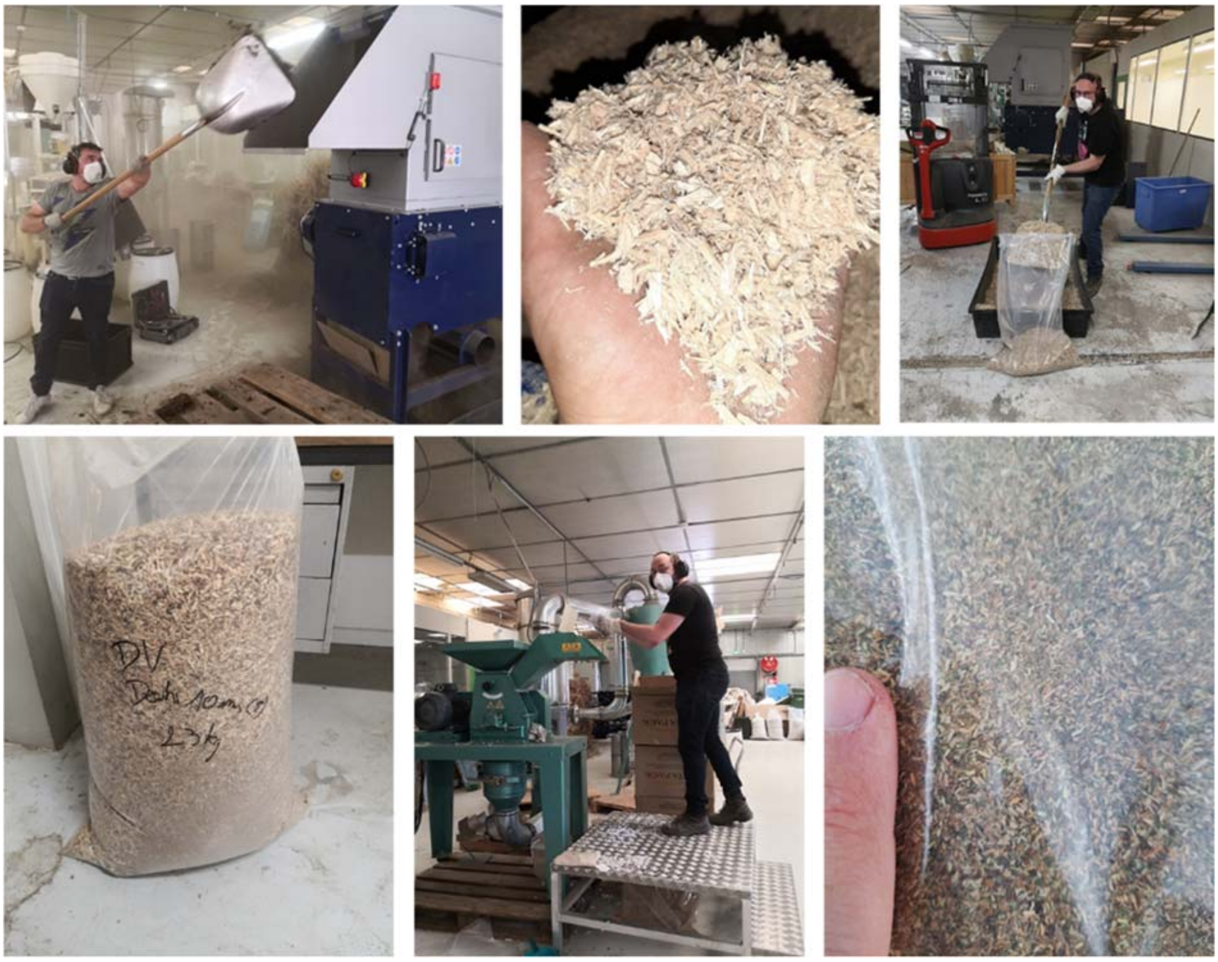

Figure 56: Shredding and grinding process of green waste

A specific attention was made on the pollutant's nature and ratio, as it can hinder the devices. With the amount of material received at pilot scale, more time and effort were used to remove as much pollutant as possible to prevent accidents. The pollutant content is described in the task 3.3, like the metallic pollution which is not yet removed by magnet. Without a constant vigilance, some pollutant can be shredded and become even harder to remove during the grinding process to the finest size, as shown in the Fig 57.

Figure 57: Metallic waste after few seconds in the grinder, and a small ignition of vegetal fibres in the grinder after.

Those fractions are analysed as expected in other tasks.

5 THE PILOT TEST VALIDATION AND CONCLUSIONS

Once the pilot plant has been fully integrated inside IDE's plant, the following tests are foreseen:

- 1 month of testing and optimising procedure
- 1 or 2 months of production for the other partners including several weeks of Membrane filtration process
- The rest of the time will be used to test the different co-substrates and the different parameters to test the limit of the system

Samples of every output stream will be taken on regular basis. For the watery output, this might be every two weeks but for the press cake and centrifuge cake, it would rather be a sample taken every week. The potential in biogas production and composting will be analysed on those specific samples in relation to the task 6.1. Analysis on the wet fraction will be taken every two weeks as we want to know the SCCA spectrum.

So far, the integration and implementation of the pilot inside the existing AD and composting plant of IDE is on track. Several practical and logistic aspects are still to be dealt with but nothing that was not foreseen or seem to jeopardize the project's objectives.

6 References

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