



Closing the loop of Absorbent Hygiene Products

Blueprint for the replication of the EMBRACED recycling model



This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No. 745746

GENERAL INTRO

The product category “Absorbent Hygiene Products” (AHP) includes all types of disposable baby diapers, feminine care pads (e.g. sanitary pads/napkins and panty liners) and adult incontinence products (e.g. panty liners, adult diapers and under-pads).

AHPs have become essential everyday products to society and their use has increased substantially. As with every consumer product, also AHPs end up in solid waste after their use. Every year, worldwide 30 million tons of used Absorbent Hygiene Products (AHP), representing 3-4% of Municipal Solid Waste (MSW), end their life in landfills or incinerators. Over the past 20 years there has been great progress by AHPs manufacturers to reduce the environmental impact of AHPs, for example, the average weight of baby diapers was reduced by

around 50%. However, to meet society’s needs for sustainable consumption there is further innovation required: FaterSMART, the business unit of Fater Spa, Italian joint venture between Procter & Gamble and Angelini group, has developed and patented an innovative recycling solution for post-consumer AHP waste creating secondary raw materials for high value applications. This is already demonstrated through a first-in-the-world industrial scale plant (10,000 t/year capacity) up and running in Italy in partnership with Contarina.

This Report (Deliverable I.7 “Blueprint for the replication of the AHP pretreatment technology”) provides guidelines for the replication in Europe and Worldwide of this unique AHP waste recycling solution.

EMBRACED

Establishing a Multi-purpose Biorefinery for the Recycling of the organic content of AHP waste in Circular Economy Domain

With a continuous research activity that aims at reaching breakthroughs in every field, the next step through the EMBRACED project is the further valorization of the secondary raw materials and of all the process by-products into high value bio-based materials and products, as a perfect example of Circular Economy.

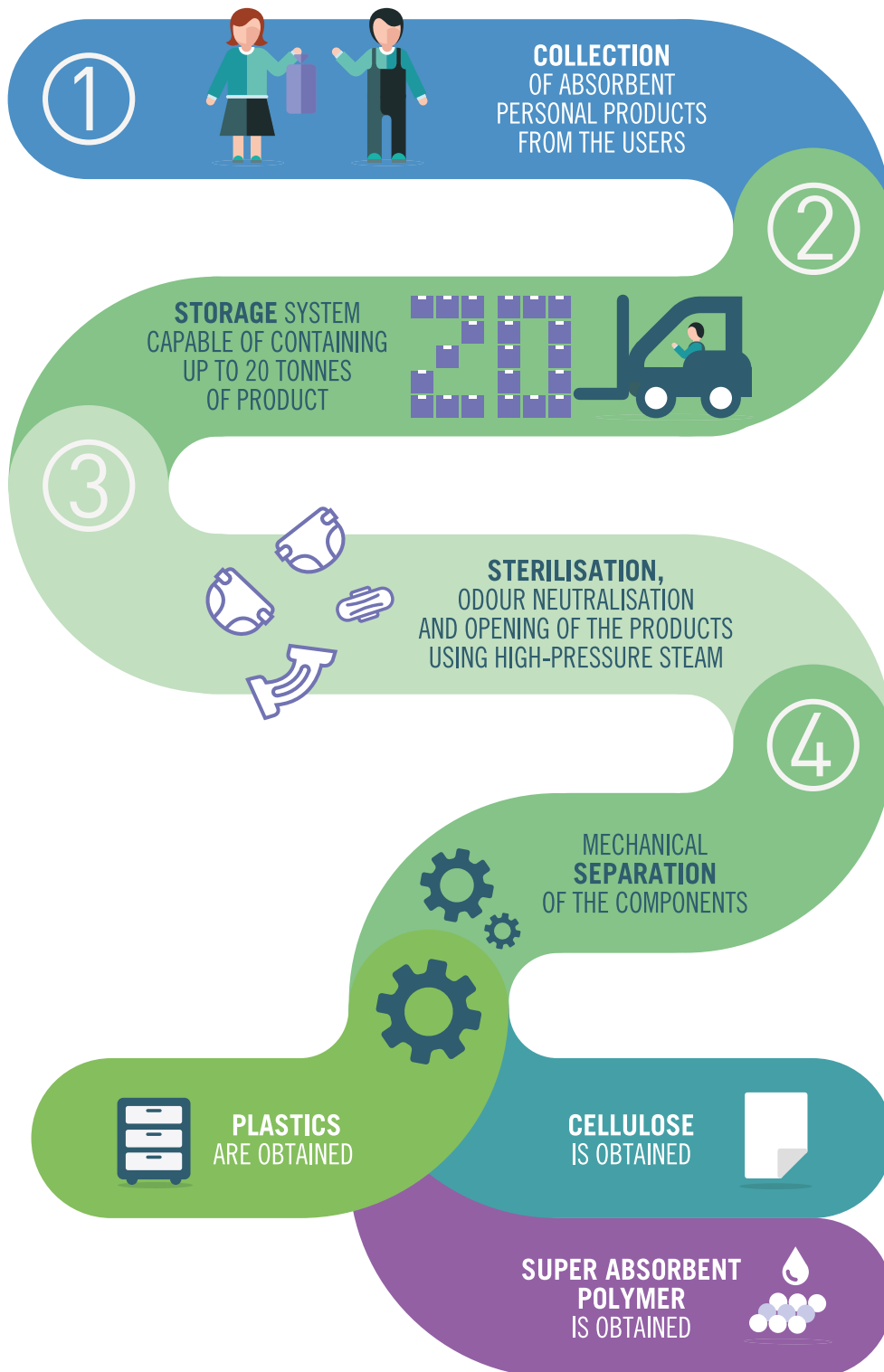
Embraced is an EU funded project, involving 13 partners from businesses, academia, and research institutions. The objective of the project is the establishment of a first-of-its-kind demonstration plant of an integrated biorefinery in Amsterdam, based on the valorization of the cellulosic fraction of post-consumer AHP waste towards the production of bio-based building blocks, polymers and fertilizers. Embraced will operate valorizing all the fractions from

the process to obtain marketable end-products fully competitive in terms of cost, quality and sustainability.

Importantly, the project will follow a circular economy approach, closing the cycle of raw materials and minimizing the use of primary resources, through the establishment of virtuous models of cooperation among all the involved stakeholders. This project has received funding from the Bio-Based Industries Joint Undertaking under the European Union’s Horizon 2020 research and innovation programme under grant agreement No. 745746.

For further information:
www.embraced.eu/
www.linkedin.com/company/embracedproeu/

THE AHP RECYCLING PROCESS



AHP WASTE COLLECTION

A pre-requisite for the implementation of AHP recycling is the set-up of separate collection services for this waste stream from households or other relevant producers (nursing homes, hospitals, day care centers), in order to secure a stable input flow to the recycling plant.

As the EU moves towards its recycling targets, AHP waste has quickly risen to represent already up to 15-25% of the residual waste in some territories, where residual waste drops to 30% or less of all MSW produced. Consequently, and due to the nuisance associated to this waste stream, many municipalities across the EU are already implementing separate collection schemes for AHP waste and a quick growing trend is observed, in particular in areas where collection frequencies for the residual waste are low (fortnightly or even lower) and Pay-As-You-Throw charging systems are in place. In Italy, for example, already 12 million inhabitants in over 800 municipalities are covered by AHP waste collection services, even where no recycling solution is yet in place.

The amount of AHP waste collectable in a given territory is driven by many different factors, i.e. population distribution by age, AHP's use habits,

potty-trained age, presence of big producers (nursing homes, hospitals, day care centers), environmental awareness, waste collection system in place etc. However, on average it can be assumed that a territorial area of about 1 million inhabitants can generate approximately 10.000 t/year of AHP post-consumer waste.

Different collection schemes can be applied to AHP waste, including door to door collection services, bring site systems with street bins or smart bins located in strategic sites, containers located at municipal waste collection centres or at the big producers sites. The service is generally provided to registered users and the choice of the collection scheme largely depends on the waste collection system in place for the other waste streams. Currently, the most applied scheme is a door-to-door collection, often combined with the collection of bio-waste with dual-chamber trucks, but successful good practices with bring site schemes are also in place. A review of some exemplary case studies is provided in the following fact sheets.

AHP WASTE COLLECTION SURVEY: PARTICIPATING COUNTRIES



Procter & Gamble, TerraCycle and FaterSMART



TERRITORY

Municipality of Amsterdam – Zuidoost and Oost neighbourhoods (Holland)

NUMBER OF HOUSEHOLDS/ USERS SERVED

Pilot test with 9 smart-bins: over 200 active users. The users join the service through a dedicated app. The App presents the consumer with an overview of the environmental benefits of recycling diapers and guides the consumer through the recycling programme. It locates the nearest available Smart bin to the consumer and generates a bar code to unlock the bin. When the Smart bin closest to the consumer is full or under maintenance, the consumer can pick in the App the second nearest bin. After dropping their AHP waste, consumers can track their personal contribution to the environment as well as the collective contribution of their neighbourhood through the App.



TYPE OF COLLECTION

Street collection with Smart bins located in front of day care centres and stores. The smart bin hosts a standard HDPE 360 LT wheelie bin for waste collection that can be emptied by standard waste collection vehicles with rear load.

More information available at: recycling.pampers.nl/

COLLECTION FREQUENCY

The Smart Bins are emptied 2 to 3 times per week

TYPE OF VEHICLE USED

During the pilot test with 9 smart-bins a Van has been used. The employed staff switches the wheelie bin: pick up full one and install empty one.

TYPE OF TARIFF

Free for users

EMPLOYED STAFF

1 driver

QUALITY OF THE COLLECTED WASTE

Non targeted materials (mainly plastic bags and wipes) < 2%

PHOTO OF THE TRUCK

PHOTO OF THE BIN/BAGS(S)

Ivarem



TERRITORY	We collect hygienic waste in the municipalities who have PAYT. Those are: Berlaar, Bonheiden, Duffel, Lier, Putte and Willebroek (Belgium).
NUMBER OF HOUSEHOLDS/ USERS SERVED	The population in those 6 municipalities is 125.000 inhabitants. We estimate it to be around 52.000 households.
TYPE OF COLLECTION	The hygienic waste is collected in bags which the households bring to the recycling center.
COLLECTION FREQUENCY	The containers (1100 litres) on the recycling centers are emptied every week simultaneously with a non-recyclable waste collection door-to-door. There is no separate truck emptying just the containers.
TYPE OF VEHICLE USED	Standard garbage trucks
TYPE OF TARIFF	Households pay for the bags
EMPLOYED STAFF	The containers (1100 litres) on the recycling centers are emptied every week simultaneously with a non-recyclable waste collection door-to-door. There is no separate truck emptying just the containers. So depending on the truck it will be 2 or 3 employees.
QUALITY OF THE COLLECTED WASTE	No data. There is always a risk for radioactive 'material' in the hygienic waste from medication or radiation.

PHOTO OF THE TRUCK



PHOTO OF THE BIN/BAGS(S)





TERRITORY	Municipality of Argentona (Spain)
NUMBER OF HOUSEHOLDS/ USERS SERVED	5.500 addresses/12.000 inhabitants
TYPE OF COLLECTION	Door to door collection in all the territory
COLLECTION FREQUENCY	For diapers, daily pick-up (7 days/week), except for urbanizations (6 days/week).
TYPE OF VEHICLE USED	The diapers have to be left outside the door, next to the other fraction that touch pick that day, always inside the free standardized bag (if it is a domestic user). During the collection the diapers are collected in the same time as the other fractions, but they are deposited in a different part of the vehicle to avoid mixing them with the other fractions.
TYPE OF TARIFF	Free for domestic users. The big (non-domestic) producers (nursing homes, nurseries for small children) have to use a standardized payment bag (the same which is used for rejection or non-recyclable).
EMPLOYED STAFF	For the domestic collection, the staff used is the same of the other fractions, and it is not an expense added. There are 2 vehicles, 6 people. In the collection of the non-domestic producers, where the service is specific, there is more staff used, a medium vehicles and an operator.
QUALITY OF THE COLLECTED WASTE	There is no data, but subjectively it can be said that the bag collected with diapers have inside almost 100% of diapers, without other mixed fractions.

PHOTO OF THE TRUCK



PHOTO OF THE BIN/BAGS(S)



TERRITORY	Municipality of Celrà (Spain) 5.390 inhabitants
NUMBER OF HOUSEHOLDS/ USERS SERVED	2.067 households + 4 great producers (2 kindergartens, 1 geriatric residence and 1 healthcare center).
TYPE OF COLLECTION	The diapers, sanitary towels (pads) or animal excrements are collected every day door to door in a plastic bag with a distinctive adhesive. This bag is placed above the bin of the waste fraction that is collected according to the calendar.
COLLECTION FREQUENCY	Every day
TYPE OF VEHICLE USED	Satellite vehicles
TYPE OF TARIFF	Free, included in the fixed tax
EMPLOYED STAFF	1 per collection truck
QUALITY OF THE COLLECTED WASTE	The percentage of impurities has not been quantified.

PHOTO OF THE BIN/BAGS(S)



Ajuntament Sant Esteve Palautordera



Ajuntament de
Sant Esteve de Palautordera

TERRITORY	1 Town Sant Esteve de Palautordera, Valles Oriental, Barcelona (Spain)
NUMBER OF HOUSEHOLDS/ USERS SERVED	1.176 users served
TYPE OF COLLECTION	Door to door, 2 waste bin, one brown for the organic waste, one white for the selective waste, and adhesive levels for nappys
COLLECTION FREQUENCY	5 days a week door to door
TYPE OF VEHICLE USED	Rear loading truck of 10 m ³
TYPE OF TARIFF	Fixed annual rate
EMPLOYED STAFF	2 employees for collection truck, one driver and one operator
QUALITY OF THE COLLECTED WASTE	The percentage of impurities has not been quantified.

PHOTO OF THE TRUCK



PHOTO OF THE BIN/BAGS(S)



Ajuntament de Tiana



Ajuntament de Tiana

TERRITORY	Municipality of Tiana (Barcelona, Spain)
NUMBER OF HOUSEHOLDS/ USERS SERVED	8.981 inhabitants (users served) 3.200 households
TYPE OF COLLECTION	We collect diapers in a trash can (240L) closed with key only in areas where neighbours request for it.
COLLECTION FREQUENCY	In an ordinary way once a week (the same day that we collect non-recyclable waste in door to door collection) but if the trash can is full or almost full, we can empty the garbage any day.
TYPE OF VEHICLE USED	We use a large truck for large and wide streets and satellite vehicles for small, thin streets.
TYPE OF TARIFF	Free
EMPLOYED STAFF	Large truck 2 employees (driver and collector) and satellite vehicle with 1 worker.
QUALITY OF THE COLLECTED WASTE	We don't have data of percentage of impurities.

PHOTO OF THE TRUCK



PHOTO OF THE BIN/BAGS(S)





TERRITORY	City of Vacarisses (Spain)
NUMBER OF HOUSEHOLDS/ USERS SERVED	3.400 users
TYPE OF COLLECTION	Door to door collection
COLLECTION FREQUENCY	4 times per week
TYPE OF VEHICLE USED	Vehicles with different sections, one specific for the residual waste
TYPE OF TARIFF	Fee for the residual waste
EMPLOYED STAFF	2 persons per vehicle
QUALITY OF THE COLLECTED WASTE	The percentage of impurity has not been quantified

PHOTO OF THE TRUCK



PHOTO OF THE BIN/BAGS(S)



TERRITORY	City of Vilablareix (Spain)
NUMBER OF HOUSEHOLDS/ USERS SERVED	2.986 inhabitants
TYPE OF COLLECTION	Door to door collection: bag with stickers for the waste identification
COLLECTION FREQUENCY	Daily collection
TYPE OF VEHICLE USED	Vehicle with a specific box for the residual waste
TYPE OF TARIFF	Pay-as-you-throw system
EMPLOYED STAFF	2 persons per vehicle
QUALITY OF THE COLLECTED WASTE	The percentage of impurity has not been quantified

PHOTO OF THE TRUCK



PHOTO OF THE BIN/BAGS(S)



Ascit Servizi Ambientali S.p.A.



TERRITORY	6 municipality in the province of Lucca: Altopascio, Capannori, Montecarlo, Pescaglia, Porcari, Villa Basilica (Italy)
NUMBER OF HOUSEHOLDS/ USERS SERVED	Altopascio: 6.317 Capannori: 18.585 Montecarlo: 1.799 Pescaglia: 2.359 Porcari: 3.516 Villa Basilica: 1.033
TYPE OF COLLECTION	Door to door collection
COLLECTION FREQUENCY	Once per week + one per week when required Twice per week in Pescaglia and Villa Basilica
TYPE OF VEHICLE USED	ISUZU 55 q.li/Porter Piaggio - satellite vehicle
TYPE OF TARIFF	Fee in the municipalities of Porcari, Altopascio, Villa Basilica and Pescaglia Free in the municipalities of Capannori and Montecarlo
EMPLOYED STAFF	1 person per vehicle
QUALITY OF THE COLLECTED WASTE	Impurity percentage: <2%

PHOTO OF THE TRUCK



PHOTO OF THE BIN/BAG(S)



A&T 2000 S.p.A.



TERRITORY	50 municipalities in the province of Udine and 1 municipality in province of Trieste (Italy)
NUMBER OF HOUSEHOLDS/ USERS SERVED	103.000 inhabitants
TYPE OF COLLECTION	Door to door collection with special green bags This service is provided to users that ask for it
COLLECTION FREQUENCY	Once per week
TYPE OF VEHICLE USED	Different types of vehicles, from satellite vehicle to compactor
TYPE OF TARIFF	Free for municipalities without pay-as-you-throw system For the for municipalities with pay-as-you-throw system, users that produce diapers pay an amount per year
EMPLOYED STAFF	1 or 2 person per vehicle
QUALITY OF THE COLLECTED WASTE	Impurity percentage: <1%

PHOTO OF THE TRUCK



PHOTO OF THE BIN/BAGS(S)



ESA-Com Spa



TERRITORY	20 municipalities in Verona Province (Italy)
NUMBER OF HOUSEHOLDS/ USERS SERVED	35.300 domestic users; 5.000 non domestic users
TYPE OF COLLECTION	Door to door collection
COLLECTION FREQUENCY	Twice per week, together with the organic waste. Once per week together with the residual waste.
TYPE OF VEHICLE USED	Satellite vehicles, roll-off truck
TYPE OF TARIFF	Pay-as-you-throw system for the residual waste; fixed cost for the diapers collection.
EMPLOYED STAFF	Vehicle for the organic waste collection with a specific box for the diapers.
QUALITY OF THE COLLECTED WASTE	Impurity percentage: 1%

Contarina Spa
Non domestic users
(geriatric residences)



TERRITORY	12 municipalities in Treviso province (Italy)
NUMBER OF HOUSEHOLDS/ USERS SERVED	12 non domestic users: geriatric residences
TYPE OF COLLECTION	Door to door collection using a roll-off
COLLECTION FREQUENCY	It depends on the request: once per week, every two weeks, on demand
TYPE OF VEHICLE USED	Roll-off truck
TYPE OF TARIFF	Pay-as-you-throw system (€/ton + €/discharge)
EMPLOYED STAFF	1 person per truck
QUALITY OF THE COLLECTED WASTE	Impurity percentage: <2%

PHOTO OF THE TRUCK



PHOTO OF THE BIN/BAGS(S)



Contarina Spa

Domestic users: door to door collection test



TERRITORY	4 municipalities in Treviso province, the nearest to the recycling plant (Italy)
NUMBER OF HOUSEHOLDS/USERS SERVED	27,426 domestic users
TYPE OF COLLECTION	Door to door collection using a bin (120 lt)
COLLECTION FREQUENCY	Once per month
TYPE OF VEHICLE USED	Satellite vehicle
TYPE OF TARIFF	Pay-as-you-throw system
EMPLOYED STAFF	1 person per vehicle
QUALITY OF THE COLLECTED WASTE	Impurity percentage: <2%

PHOTO OF THE TRUCK



PHOTO OF THE BIN/BAGS(S)



AHP WASTE RECYCLING PLANT

FaterSMART has developed and patented an innovative recycling technology to transform post-consumer AHP waste into high value secondary raw materials. This revolutionary technology is live in Italy, near Treviso, where a first-in-the-world industrial scale plant has been installed in partnership with Contarina.

The process requires the presence of steam to be used during the sterilization phase and electrical energy to run all motors and pumps.

A supervision system makes sure all the process parameters are constantly monitored. Below, there is a detailed description of all the different phases of the process.

FaterSMART diaper treatment process consists of 4 main steps:

1. Storage
2. Sterilization
3. Drying
4. Separation and extrusion



STORAGE OF INCOMING WASTE

Trucks coming from the source segregated collection of diapers unload the waste on a conveyor, which conveys waste into a closed storage chamber designed to reduce as much as possible the dispersion of odorous substances.



AUTOCLAVE

After the AHP waste bags have been collected and stored, they are transported from the storage to the autoclaves by a set of conveyors and cochlea. The autoclave is a jacketed metal tank where the combined action of the rotation and temperature, generated both by the injected steam (contact steam) and the steam circulating in the jacketed part (no-contact steam), produce the total sterilization of the products. The patented process of sterilization within the autoclave does not require preopening the bags before the autoclave.



SHREDDER AND BUFFER

Right after the autoclave treatment, diapers are sent to a battery of shredders necessary in order to send suitable material to dryer and separators. The shredded material is then stored in a buffer unit and treated for potential drug residuals removal.



DRYER

Shredded material is sent to the air dryer which is made up of five different “floors” where diapers are heated up by hot air coming from a heat exchanger and by a battery of microwaves. A proper heating of the material is important to improve separation efficiency. Exhausted air is sent to a scrubber in order to remove cellulose particles and other contaminations.



SEPARATION SYSTEM

Dried diapers are sent by a cochlea to a battery of separators, the first two operate the separation of a mix of cellulose/SAP from plastics, the third one separates the cellulose from SAP. The separation is mechanical-based and the material obtained is stored in big bags (approx. 1 ton) and sent to the warehouse.



OPTICAL SEPARATOR AND EXTRUSION

Plastics coming from mechanical separation are sent to an optical separator, which optically sorts PP and PE from PET and cellulose residuals. Once the plastics have been separated from the rest of the components, they are pelletized through the use of an optimized extruder. .



THE SECONDARY RAW MATERIALS AND THEIR APPLICATIONS

The diaper recycling plant has a capacity of 10.000 tons/year of AHP waste and is able to recover 100% of the three main components of an absorbent hygiene product:

- Cellulose

- Plastic
- Super Absorbent Polymer

Cellulose represents 50% of the recovered material, plastic 25% and super absorbent polymer 25%.



Recycled Cellulose

COMPOSITION	MIN %	TARGET %
Kraft cellulose	≥ 90%	≥ 95%
Super Absorbent Polymer (SAP)	≤ 5%	≤ 5%
Plastics (Polypropylene/polyethylene)	≤ 5%	Traces



HEALTH CRITERIA. THE MATERIAL MEETS THE MOST STRINGENT HEALTH AND HYGIENE CRITERIA, SPECIFICALLY:



MICROBIOLOGICAL

The material has been sterilized following same international norms used for surgical instruments (UNI EN ISO 17665, 11138,14161 e UNI EN 285)

CHEMICAL/DRUGS

The process is designed to eliminate any potential pharmaceutical residues

CYTOTOXIC

Academic studies show no evidence of any types of cytotoxic activity induced by the material

CUTANEOUS

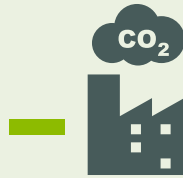
Third party HRIPT (Human Repeat Insult Patch Testing) with Challenge Test exclude any phenomena of skin irritation and sensitization induced by the most critical material

Other Technical Specifications

Criteria	Analytical method	Measure	Value - Min	Value - Target
Moisture	UNI 10667-16	%	< 20	< 10
Absorbency	French standard NF V19-002	Water absorbed	> 5x (dry weight)	>10x (dry weight)



For each ton of virgin **Cellulose** substituted with **SMART-C**



you save **0.4 tons of CO2**



equivalent to the CO2 absorbed every year from **27 trees**

CELLULOSE IS IN **FLUFF/LOOSE** FORMAT AND IT IS DELIVERED EITHER IN **BIG BAGS OR BALES**





Recycled Plastics

The material has a high content of **polyolefins**.
Within polyolefins, **Polypropylene/Polyethylene**
share is **85/15**



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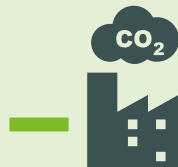
Other Technical Specifications

Criteria	Analytical method	Measure	Value
MFR @ 190°C/2,16 kg	ASTM D 1238	g/10'	4
MFR @ 230°C/2,16 kg	ASTM D 1238	g/10'	10
Humidity	ISO 10667-16	%	1.0
Density	ASTM F 2025	g/cc	1.1
Tensile Module	ISO 527-2	Mpa	970
Tensile Strength	ISO 527-2	Mpa	13
Izod – unnotched	ISO 13802/180	Kj/m ²	21





For each ton of virgin **Plastic** substituted with **SMART-P**



you save **2.04 tons of CO2**



equivalent to the CO2 absorbed every year from **136 trees**

MATERIAL FORM IS GRANULATE – AND IT IS DELIVERED IN **BIG BAGS**





Recycled Super Absorbent Polymer

COMPOSITION	MIN %	TARGET
SAP (Super Absorbent Polymer)	≥ 80%	≥ 95%
Kraft Cellulose	≤ 20%	≤ 5%
Plastics (Polypropylene/polyethylene)	Traces	Traces



HEALTH CRITERIA. THE MATERIAL MEETS THE MOST STRINGENT HEALTH AND HYGIENE CRITERIA, SPECIFICALLY:



MICROBIOLOGICAL
The material has been sterilized following same international norms used for surgical instruments (UNI EN ISO 17665, 11138,14161 e UNI EN 285)

CHEMICAL/DRUGS
The process is designed to eliminate any potential pharmaceutical residues

CYTOTOXIC
Academic studies show no evidence of any types of cytotoxic activity induced by the material

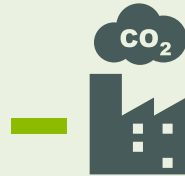
CUTANEOUS
Third party HRIPT (Human Repeat Insult Patch Testing) with Challenge Test exclude any phenomena of skin irritation and sensitization induced by the most critical material

Other Technical Specifications

Criteria	Analytical method	Measure	Value - Min	Value - Target
Moisture	UNI 10667-16	%	< 20	< 10
Non-Absorbing matter	UNI 10667-16	% (dry weight)	< 5	Traces
Bulky density (loose dry material)	Weight on reference volume	g/cc	> 0,2	> 0,4
Absorbency	French standard NF V19-002	Absorbed de-ionized water	> 40x (dry weight)	> 50x (dry weight)



For each ton of virgin **SAP** substituted with **SMART-S**



you save **1.07 tons of CO2**



equivalent to the CO2 absorbed every year from **116 trees**

MATERIAL FORM IS **GRANULAR** AND IT IS DELIVERED IN **BIG BAGS**





Establishing a Multi-purpose Biorefinery for the Recycling of the organic content of AHP waste in Circular Economy Domain

Word Package I – Optimized waste logistic and feedstock preparation
Deliverable number 1.7 – Blueprint for the replication of the AHP pretreatment technology

Grant Agreement No.: 745746

Call (part) identifier: H2020-BBI-JTI-2016

Topic: BBI-2016-D06 – Valorisation of the organic content of Municipal Solid Waste and contributing to the renewable circular economy

Starting date of project: June 1st, 2017

Duration: 60 months



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