Interreg Mediterranean
EUROPEAN UNION
REINWASTE

Project co-financed by the European Regional Development Fund

REmanufacture the food supply chain by testing INnovative solutions for zero inorganic WASTE

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REINWASTE PROJECT

The European project "Reinwaste – REmanufacture the food supply chain by testing INnovative solutions for zero inorganic WASTE" was carried out from February 2018 to January 2021. It was co-financed by the European Regional Development Fund to promote the Mediterranean innovation capacities and the development of smart and sustainable growth.

The European food industry

The food industry is a pillar of the EU economy, being the biggest employer in manufacturing in more than half of the Members States, 2/3 by SMEs (FoodDrink Europe, 2016). The growing demand for food worldwide (+60% by 2050) will rise natural resources consumption and led to the production of vast quantities of co-products and wastes: organic waste but also inorganic waste and mainly plastics (films, nylon, greenhouse coverings; agrochemical packaging; food and ready-to-eat meals packaging) that are disposed of by landfill and other environmentally sensitive routes.
Between the start of the project and its end, big changed occurred in plastic: more and more people have taken heed about plastic issues and regulations have become stricter to reduce environmental impact of plastic. In order to fulfil with the regulations and complied with consumers requirements, agro-food enterprises try to improve the food processing. They focus on the most efficient and sustainable tenet of the waste hierarchy particularly on inorganic wastes, through the application of zero-waste best advanced solutions provided by Research & Innovation centers and other relevant sectors (green chemistry and mechanics).

The plastic environmental footprint

In 2017, the demand for plastics in the 28 EU Member States stood at almost 52 million tons[1]. In 2015, 30 million tons of plastic waste has been generated in EU and 54 % of this waste comes from plastic packaging. Among the 30 million tons of plastic waste, only 17 % is collected for reuse or recycling, meaning 83 % is lost[2].
Now, it is common knowledge that an important part of plastic ends up in seas and oceans. An estimate of 150 000 to 610 000 tons of plastic per year are leaking into the Mediterranean Sea according to the Mare Plasticum study[3]. To combat the phenomenon, several SMEs from the Agrofood sector through their national Federations together with Technology Transfer centers, innovative Clusters and the Academic world share a joint vision to face the challenge: finding and testing the best-advanced solutions in inorganic waste.

[1] *https://www.eea.europa.eu/publications/preventing-plastic-waste-in-europe*
[2] *https://www.eea.europa.eu/media/infographics/plastic-waste*
[3] *The Mediterranean: Mare plasticum, Julian Boucher and Guillaume Billard, International Union For Conservation of Nature, MAVA, 2020.*

OBJECTIVES

REINWASTE aims to:

1. Contribute to inorganic waste reduction at source, favouring the adoption of greener innovative concepts by agriculture and food industry, with a focus on SMEs.

2. Overcome the persistent lack of knowledge on the Best Available Technologies and the diversity and fragmentation of waste prevention procedures. But how?

Through a tailored mix of knowledge transfer services, based on a common open innovation model that will be tested by a Mediterranean network including regional bodies, R&I operators and clusters, agro-food business associations and end-users (food companies & farmers).

3. Implement specific pilot projects to test "on-the-spot" by involving a pool of collaborating companies both in agriculture and the food industry.

4. Strengthen the interaction between "clusters" of the MED area for waste prevention.

REINWASTE RESULTS

1. It fosters the technology transfer and open innovation among agrofood clusters, R&D centres, and companies in MED regions. But how?

- by increasing innovation support services to agriculture and food industry, that helps the transfer of R&D to the agro-food chain in order to respond to the market requirements.

RESULTS: 9 Transferability Plans to other Agri-food & Agriculture supply chains and Protocols for sustainable management of waste for transference purposes.

2. It paves the ground to an Innovative Advanced service, granted by the Clusters to their associates, linking demand & offer of innovation. But how?

- by identifying available solutions (BAT and KET), testing in an Mediterranean network including regional bodies, R&I centres and clusters, agro-food business associations, food companies and farmers and analysing its sustainability and potential for adoption.

RESULTS: 23 pilot tests (5 enterprises of Meat Sector, 10 of Horticultural Sector and 8 Dairy Sector), 5 Open Innovation Labs, Sustainability Analysis, Market Analysis and Feasibility Study for launching the new Reinwaste service and Potential of adoption of best available pilot solutions of the 3 sectors.

3. It contributes to the EU Waste framework (Directive 2008/98/EC on waste and Circular Economy Action Plan pursuing a zero waste economy by 2030). But how?

- by promoting waste prevention in line with the Waste Framework Directive 2008/98/EC, following the waste hierarchy, involving regional authorities to the introduction of inorganic waste reduction objective into regional strategies, and giving policy contributions at European level. Also, many solutions tested in the pilot tests are based on preventing waste.

RESULTS: 3 Regional Action Plans, Meeting with DG-ENV and 3 Regional meetings with S3 managers.

METHOD

The work package 3 represented the core and the main challenges of the project. The aim was to foster the effective technology transfer, by a collaborative & open innovation approach, among agrofood clusters, R&D centers and agriculture and agrofood companies from Emilia-Romagna region (IT), Andalusia region (ES) and PACA region (FR).

The final goal was to design and introduce innovative and R&D-based solutions to remanufacture the food supply chain thanks to waste prevention through eco-design and through testing innovative components and materials to reduce the inorganic waste, both on the agricultural and food transformation phases and the introduction of strategies for a smart inorganic waste management.

The main target groups were:
1. Pool of companies to test the collaborative & open innovation approach to minimize inorganic waste
2. Pool of experts to support companies to uptake innovative managerial and technological solution to minimize inorganic waste

REINWASTE project established the involvement of a pool of companies to cooperate with the project partners in testing the benefit of the collaborative & open innovation approach to redefine some productive patterns in the logic of nearly-zero inorganic waste.
The consultancy offered to companies, both in the phase 1 (30 companies selected and trained to the newest approaches to reduce inorganic waste) and phase 2 (10 companies selected and receiving a full technology audit focused on their own production structure) has been granted by a team of high specialized experts.

In phase 1, the appointed experts engaged roughly 30 companies within a collaborative & open innovation to collect data about the current processes in use, verify the type and size of inorganic waste produced and disclose the companies' requirement to reduce waste, reduce disposal costs and gain in competitiveness. All the companies considered, thus, have benefited of a light assessment to take the preliminary steps to reorganize their own productive processes with a lower inorganic waste production. The results of this preliminary phase were used to verify the readiness of the farmers and industry system to reduce inorganic waste and to address a more focused service for the subsequent phase.

In phase 2, the appointed experts provided with a peer-reviewed report to 10 promising companies (chosen according to some technical criteria and on their own innovation propensity) to develop innovative and R&D-based solutions to remanufacture the food supply chain in a logic of nearly-zero inorganic waste. The outcome of this phase 2 were a business and a feasibility plan per each company that will let the same companies to uptake solutions and reorganize their own agricultural and industrial productive protocols with less inorganic waste.

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RESULTS HORTICULTURE VALUE CHAIN

CURRENT WASTE SITUATION OF THE HORTICULTURAL VALUE CHAIN

CHALLENGES & CRITICAL POINTS

PRODUCTION SECTOR

Inorganic waste poses the following challenges:

- Legal Framework: general lack of awareness. Low implementation.
- Usefulness: there are different materials to perform the same function.
- Cost: The use of an input or the choice of an alternative is highly dependent on this variable.
- Manufacturing: it is difficult to develop made-to-measure production (optimization of use). Mixture of materials (optimization in the separation).
- Implementation: increase or reduction of workforce needed.
- Seasonal variation: production of waste in certain periods of the year.
- Collection: separation and conditioning (selective collection). Presence of dirt and remains.
- Reuse: repeated use up to the end of the lifespan.

The critical points in the management are due to:

- Lack of residues records in the farm register.
- Omission of the shipment application by the waste producer.
- Omission of the waybill by the waste transporters.
- Limited collaboration and cooperation between all the actors of the value chain.
- Lack of an accessible statistical database on the quantification of inorganic waste.
- Lack of a register along the value chain that will allow to know the real waste flow.
- Lack of a waste management system based on its return with the involvement of the facilities that sell plant protection products and inputs.
- Low waste control on public and private certification systems (Official certifications systems for Agri-Food Quality, the former, and Good Agricultural practices: UNE, GlobalGAP).

INDUSTRY SECTOR

Critical points of industrial horticulture sector packaging:

- Continuous changes of the regulatory framework (plastic taxes, etc.)
- Assessment of food safety standards on food contact materials
- Investment and funds need
- Packaging materials existing. Materials / combinations of materials. The polluting products that generate acidic compounds during the extrusion process cause problems in the recycling of PET. There is a range of contaminating substances, including PVC, resin acids present in label adhesives and EVA liner coatings, which can act as acid sources. PVC contamination is a potentially serious problem, because its similar appearance and superimposed densities could hinder the separation of both polymers. Generally, these elements include the closures, the closing coverings, the labels, the sleeves and the security seals.

-**Barriers / Coatings.** Multilayer elements and coatings that are not made of PET are not always compatible with current selection and recycling technologies and could reduce the recovery of PET bottles.

-**Colour.** PET without colour, not pigmented, is not only the highest value and the one with the highest recycling rates, but also has the widest variety of final markets. The use of opacifiers significantly reduces the value of recycled PET.

-**Closures / Closing cladding.** EVA closure coatings are only acceptable in combination with plastics. Conventional silicone seals are not compatible with PET or easily separable.

-Closures made of PS or thermosetting plastics are not desirable, so they should be avoided. The use of aluminium closures should be avoided, as they are more difficult to separate from the bottles.

-**Labels.** Polyethylene and polypropylene are the preferred materials for labels. Metal sheet labels, with lacquer or other covers, are polluting materials.

-Currently, all forms of printing and direct decoration contaminate PET in conventional recycling systems and alter the coloration of the base material.

-**Other elements.** Stabilizing bases, handles, elements for the transport and other accessories, if they are used, should not be stuck to the container or they should be able to be separated in a hot aqueous detergent or aqueous solution.

Challenges of industrial horticulture sector to reduce inorganic waste:

- **To find alternatives to the conventional use of plastic trays:** incorporate recycled material such as recycled PET(rPET) in the packaging while putting into the market a 100% recyclable PET packaging; 100% biodegradable packaging by using biodegradable plastics such as PLA; cardboard tray
- **To apply a logistic optimization:** change dimensions of the packaging (primary packaging); rethink the whole packaging so it results in a more sustainable packaging tray that fits into a secondary packaging that should be adapted to the new way
- **To rethink actual packaging:** compostable plastic flowpack to have a whole biodegradable packaging solution; cardboard tray with lid, to get rid of the plastic flowpack; bands to substitute the whole package so an almost zero waste solution is achieved
- **To find Investment** to replace actual packaging for the new one and in new machinery to implement changes in packaging allowing reducing or avoiding it
- **The need of Training** on sustainability issues in companies

AMOUNT & TYPE OF WASTE PRODUCED

PRODUCTION SECTOR

The information relating to the production of inorganic waste in rural areas is atomized or non-existent. In general, about the composition of this waste, the plastic used as protection material represents approximately 6 % of the total waste produced in intensive agriculture and the remaining 94% correspond to organic residues. The estimation for 35,000 hectares dedicated to horticultural production in greenhouses shows that more than 90,000 tons of waste and a volume of 187,050 m3 are produced every year. The maintenance of the cover structure and the plastic for disinfection are the productive functions with a higher importance regarding the weight (43.22% and 23.21%, respectively). In terms of volume, the highest waste contributing functions are the maintenance of greenhouses and transplanting (26.62% and 21.77%, respectively) (Table 1).

Table 1: Estimation of the wastes composition produced in 35,000 has of intensive farming

FUNCTION	WEIGHT		VOLUME	
	(Tm)	(%)	(m3)	(%)
Greenhouses	39,214.87	43.22	49,798.19	26.62
Substrates	1,219.17	1.34	1,598.33	0.85
Water storage	575.67	0.63	729.53	0.39
Disinfection	21,061.26	23.21	24,065.64	12.87
Shading	9.80	0.01	10.48	0.01
Transplanting	697.75	0.77	40,714.11	21.77
Tunnels	2,259.25	2.49	2,428.52	1.30
Padding	4,900.13	5.40	5,064.98	2.71
Supporting system	6,447.66	7.11	4,890.78	2.61
Irrigation	4,966.50	5.47	20,760.13	11.10
Plant protection	4,033.75	4.45	17,333.23	9.27
Pollination	2,469.26	2.72	26.04	0.01
Harvesting	2,883.20	3.18	19,629.66	10.49
Total	**90,738.27**	**100**	**187,049.61**	**100**

In addition, the following table shows the materials used to carry out the above-mentioned tasks and, the main residues produced correspond to the metals from the structures of the greenhouses (40.69%) and the low-density plastics (LD) used in covers (37.51%) (Table 2). It is important to highlight that 5.30% of the weight produced correspond to polypropylene (raffia and supporting elements) which pose big difficulties in the management of organic waste.

Table 2: Estimation of the residual materials produced in 35,000 has of intensive farming

MATERIAL	WEIGHT		VOLUME	
	(Tm)	(%)	(m3)	(%)
HD polyethylene	8,669.06	9.55	36,599.19	19.57
LD Polyethylene	34,034.46	37.51	55,249.20	29.54
Metal	36,921.41	40.69	27,967.62	14.95
EVA	700.00	0.77	760.87	0.41
Polypropylene	4,812.72	5.30	21,199.90	11.33
Polystyrene	190.60	0.21	40,159.42	21.47
PVC	140.36	0.15	112.28	0.06
Mixed©	437.50	0.48	1,871.66	1.00
Mixed	2,916.56	3.21	427.66	0.23
Wood	283.74	0.31	231.48	0.12
Latex(1)	58.24	0.06	647.11	0.35
Concrete	287.58	0.32	169.17	0.09
Rockwool	767.67	0.85	1,096.67	0.59
Coconut fibre	451.50	0.50	501.67	0.27
Sand	66.86	0.07	55.72	0.03
Total	**90,738.27**	**100**	**187,049.61**	**100**

(1) Gloves used in harvesting. © Plastics and other elements that can be found in irrigation systems.

INDUSTRY SECTOR

In the frame of REINWASTE project works to reduce inorganic waste focusses on horticulture industries commercializing fresh fruit and vegetables. The most common packaging materials used in these companies are:

- Plastics: due to its versatility, it can adopt many different forms and acquire the most diverse designs to adapt to the peculiarities of the product to be packaged. Currently, health authorities regulate the type of substances for the manufacture of plastic materials that are intended to contain food. The European Food Safety Authority (EFSA) is responsible for carrying out periodic evaluations that entail the modification of the legislation to be applied; with the fundamental objective of ensuring the safety for the health of consumers.
- Synthetic plastics: produced mainly from synthetic polymers such as polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET), polystyrene (PS) and polyvinyl (PVC). They are characterized by their low production cost and good mechanical and barrier properties (depending on the type of plastic). Nowadays, they replace in some cases other materials such as glass, metal, or paper / cardboard.
- Biodegradable plastics: biopolymers based on hydroxybutyrate or hydroxy valerate, which are produced in the nature during biosynthesis. Biodegradable means that they decompose under the enzymatic action of microorganisms: bacteria and fungi. They are not recyclable. There are other types of biodegradable plastics that are mixtures of synthetic polymers with starch (potato, rice, and corn) or cellulose. In these cases, only the natural components are decomposed into oxygen and water (in conditions aerobic) or water and methane (under anaerobic conditions), while the synthetic component only breaks into small portions and dissipate into the soil.
- Cardboard: light and resistant material that is manufactured from wood pulp. It is a resource that can be 100% recyclable. It is widely used for the storage, presentation, and shipment of food. Some examples of cardboard uses: take-out boxes, fruit and vegetable boxes, oven trays, corrugated cardboard packaging, liquid containers, dried fruit tubs, tubes for salt and other condiments, food boxes frozen, packaging for transport and food distribution, etc.

SWOT ANALYSIS OF THE HORTICULTURAL VALUE CHAIN

PRODUCTION SECTOR

STRENGTHS & OPPORTUNITIES

- Presence of authorized agents close to production horticultural area
- Willingness to improve inorganic waste management by horticultural producers
- Important technological improvement of biodegradable strings
- Existence of biodegradable string subsidies in horticultural greenhouses
- Product differentiation linked to quality attributes of waste management “zero waste” and higher added value obtaining and competitive advantage (opportunity market)
- Associations in the agricultural sector that favors economy of scale in waste management

WEAKNESSES & THREATS

- Heavy dependence on production system inputs, which generates a high amount of wastes
- Numerous small size greenhouses with difficulties to assume their own waste management (time, costs, paperwork)
- Inorganic waste typology and heterogeneity complicates their management
- High running costs for certain kind of inorganic wastes
- Bad image of the greenhouse sector by some countries, which affects negatively the exportations
- High investments required to implement innovative technologies
- Limited availability of alternative materials at an affordable price

INDUSTRY SECTOR

STRENGTHS

- Small changes (e.g. Logistics) can bring economic benefits.
- There are alternatives of material and packaging and the market that do not imply an additional cost.
- The use of more sustainable packaging materials will cause a positive social impact.

WEAKNESSES

- Lack of a responsible for the environment or similar that takes care about the sustainability measures that need to be implemented to advance towards zero inorganic residues.
- Biased views on the problem of packaging waste beyond its management.

OPPORTUNITIES

- Use of organic waste to generate valuable products (e. g. packaging materials).
- New recyded, biobased and biodegradable materials.
- Packaging ecodesign (e. g. weight reduction).
- Logistic optimization.

THREATS

- Little profit margin per product.
- Adjusted margin on the cost that the packaging materials can assume
- Hight market competition (*i. e.* low margin).
- Uncertainty about the regulation (legislative framework) that is going to apply to this type of product (packaging) and its waste management.

MAIN INNOVATIVE AND SUSTAINABLE INORGANIC WASTE SOLUTIONS PRESENTED FOR THE HORTICULTURE VALUE CHAIN

HORTICULTURE PRODUCTION SECTOR BAT&KET FINDINGS

In the tables below the BAT and KET findings during the research that highlight the necessity to more research on these topics.

Table 3: BAT&KET steered to zero inorganic waste in horticultural productions sector

	BAT	CLASSIFICATION	DESCRIPTION	TYPE	TRL *	SOURCE
1	Biodegradable raffia made of jute fibre	Waste prevention/ Recovery/ Innovative material	Use of a biodegradable string made of jute fibre in addition to other natural materials.	New material	9	Raffia supplier: ROYAL BRINKMAN S.L. http://www.royalbrinkman.es/
2	Cellulose-rayon biodegradable string	Waste prevention/ Recovery / Innovative material	Use of 100% compostable string made of a mixture of cellulose-rayon	New material	9	Innovative solutions supplier for horticultural sector: AGRINATURE INDALICA S.A. http://www.agri-nature.com/
3	Natural Compostable String	Waste prevention/ Recovery / Innovative material	Use of natural and compostable string is made from recycled cotton yarns in addition to agronutrients.	New material	8	Royal Fils S.L.L. (Valencia, Spain) http://www.royalfils.es/?page_id=14 R&D Institute: Textil Research Institute AITEX (Valencia, Spain) http://www.aitex.es/
4	Synthetic Second Generation fuel	Energy recovery	Synthetic fuel produced from the energetic recovery of non-hazardous difficult-to manage waste.	New material	7	Energy recovery company: HINTES OIL EUROPA S.L.
5	Biodegradable mulching plastic film	Waste prevention/ Recovery / Innovative material Energy recovery	In-soil biodegradable mulching film. it is not necessary to collect it or to eliminate the mulching at the end of the crop, because it could be integrated into the soil where it is biodegraded.	New material	9	Plastic mulching film and plant staking elements supplier: Mater-bi https://www.novamont.com/eng/mater-bi
6	Biodegradable raffia made of jute fibre	Waste prevention/ Recovery/ Innovative material	Use of a biodegradable string made of jute fibre in addition to other natural materials.	New material	9	Raffia supplier: ROYAL BRINKMAN S.L. http://www.royalbrinkman.es/
7	Cellulose-rayon biodegradable string	Waste prevention/ Recovery / Innovative material	Use of 100% compostable string made of a mixture of cellulose-rayon	New material	9	Innovative solutions supplier for horticultural sector: AGRINATURE INDALICA S.A. http://www.agri-nature.com/
8	Natural Compostable String	Waste prevention/ Recovery / Innovative material	Use of natural and compostable string is made from recycled cotton yarns in addition to agronutrients.	New material	8	Royal Fils S.L.L. (Valencia, Spain) http://www.royalfils.es/?page_id=14 R&D Institute: Textil Research Institute AITEX (Valencia, Spain) http://www.aitex.es/
9	Synthetic Second Generation fuel	Energy recovery	Synthetic fuel produced from the energetic recovery of non-hazardous difficult-to manage waste.	New material	7	Energy recovery company: HINTES OIL EUROPA S.L.
10	Black biodegradable mulching plastic	Waste prevention/ Recovery / Innovative material Energy recovery	In-soil biodegradable black plastic film made of biobased and renewable raw materials together with a black smoke pigment for optimum opacity.	New material	9	Plastic mulching film supplier: SOTRAFA S.L. www.sotrafa.com
11	Long lasting plastic cover	Innovative material/ waste reduction	Alternative material: thermal film made of EVA / EBA, and metallocene polymers. Cover with duration 3 years, which can be extended up to 4-5 years in case of avoiding the use of chemical phytosanitary products.	New material	9	Plastic mulching film supplier: SOTRAFA S.L. www.sotrafa.com
12	Inorganic waste management improvement in horticultural greenhouses	Other	Inorganic waste management monitoring in the horticultural greenhouses sector for its optimization.	Strategy	1	Innovative solutions consultancy for agricultural sector: ECOGESTIONA SCA - https://es.linkedin.com/pub/dir/Manuel/Torres+Nieto

* Technological maturity level

BAT	CLASSIFICATION	DESCRIPTION	TYPE	TRL *	SOURCE
13 Replacement of mulching plastic cover by straw layer	Waste prevention	Testing of different washing, spreading and drying methods for solarization and mulching plastics in greenhouses before being recycled in treatment plants.	Strategy	1	Farmers association-UNICA GROUP
14 Biodegradable raffia made of jute fibre	Waste prevention/ Recovery/ Innovative material	Use of a biodegradable string made of jute fibre in addition to other natural materials.	New material	9	Raffia supplier: ROYAL BRINKMAN S.L. http://www.royalbrinkman.es/
15 Cellulose-rayon biodegradable string	Waste prevention/ Recovery / Innovative material	Use of 100% compostable string made of a mixture of cellulose-rayon	New material	9	Innovative solutions supplier for horticultural sector: AGRINATURE INDALICA S.A. http://www.agri-nature.com/
16 Natural Compostable String	Waste prevention/ Recovery / Innovative material	Use of natural and compostable string is made from recycled cotton yarns in addition to agronutrients.	New material	8	Royal Fils S.L.L. (Valencia, Spain) http://www.royalfils.es R&D Institute: Textil Research Institute AITEX (Valencia, Spain) http://www.aitex.es/
17 Synthetic Second Generation fuel	Energy recovery	Synthetic fuel produced from the energetic recovery of non-hazardous difficult-to manage waste.	New material	7	Energy recovery company: HINTES OIL EUROPA S.L.
18 Strategic solution for using cleaning methods of solarization and mulching plastics	Reuse	Use of a machine to recover agricultural films for the purpose of recycling. It improves conditions for the collection and recovery of used farm film, significantly reducing the rate of contamination by using cleaning techniques closer to the place of use.	Techno-logy	9	Global Plastics Alliance is responsible for Marine Litter Solutions, a collaboration of plastics producers & manufacturers worldwide. RAFU project (https://www.marinelittersolutions.com/projects/project-rafu-recycling-of-used-agriculture-films/) «Simonneau (Company that has built the machine in France). Escribano Maqreplac.

HORTICULTURE INDUSTRY SECTOR BAT&KET FINDINGS

Pursuing the REINWASTE goal of zero inorganic waste, the pilots in the Horticulture Industrial Sector are focused on 4 actions to reduce and prevent packaging waste:

- Weight reduction: Lightening of the container, increase of primary packaging units for each grouping container. Increase in the amount of product contained without modifying the characteristics of the packaging.

- Reduction of Environmental Impact: Reduce the presence of heavy metals in packaging, Reduce or eliminate printed surfaces of packaging. Substitution of materials that generate a lower environmental impact, use of packaging with certificate of sustainable management of natural resources, and use of packaging from renewable sources.

- Redesign: Use of larger capacity packaging, Reduce the volume of the product to use less quantity of packaging, lightening of the packaging by design change, optimization of palletization mosaic and modification of the design of the packaging to facilitate a better use of the product.

- Re-use: Replacing single-use packaging with reusable ones, Second use: Use of used packaging or waste of the productive processes for the packaging of products, Commercialize the product in rechargeable packaging, minimizing the amount of packaging necessary for recharging, Preparation for reuse: Increase the shelf life of reusable packaging by improving their physical-chemical properties and / or repair techniques or replacement of parts, Improve the characteristics of reusable containers to extend their useful life.

The expected impact of the outlined actions to be carried out in the agro-food stage, will affect the whole supply chain in different aspects, basically a reduction of the logistic costs and a lower consumption of plastics (thinner packaging, substitution with biodegradable and compostable materials and avoiding the use of packaging).
The logistic changes affect as well to the transport companies as to the retailers and wholesalers.
In the case of the packaging changes, retailers, wholesalers, and consumers are affected, so that their point of view must be been considered by the industry.

The main Best Available Technologies and Practices found for the horticultural sector are summarized below issued from the 5 cases studied in the frame of REINWASTE project in industrial horticulture sector in Andalusia.

- Replacing the current set of PET trays + PP flow pack with 100% cardboard trays.
- Logistics optimization (modification/ optimization of dimensions/weight of secondary packaging).
- Use of loop-type grouping elements that allows dispensing with the use of packaging that allows avoiding both the flow pack and the tray.
- Design of the primary packaging, so that it reverts to a reduction in cardboard waste and favours logistical optimization.
- Lighter PP alternative or, preferably, the search for a rPET alternative

THE EXPERIENCE OF PROVEN SOLUTIONS TESTED IN HORTICULTURAL COMPANIES

PRODUCTION PILOT ACTIONS

TECHNICAL DESCRIPTION

Pilot 1: Use of alternative materials for plastic staking elements

The pilot action aimed at evaluating the use of twines produced with sustainable materials as alternatives to the plastic polypropylene twine currently used in farms. For each alternative, tests have been carried out on 20 tomato plants pruned at 2 feet, with a stem height of 2.5 m, which represents a total consumption of 5 m of twine per plant and 100 linear meters (l.m.) of twine.

- ALTERNATIVE n, USE OF CONVENTIONAL TWINE:

Use of staking elements made from polypropylenes which, at the end of use, are removed together with vegetable waste, to continue the recovery process.

- ALTERNATIVE 1, USE OF 100% BIODEGRADABLE TWINE:

Use of non-plastic staking elements made from biopolymers which, at the end of use, are removed along with the plant waste to be composted. This raffia to be tested is composed of a mixture of vegetable fibres and a biopolymer.

- ALTERNATIVE 2, USE OF 100% COMPOSTABLE TWINE:

Use of non-plastic staking elements made from natural fibres which, at the end of use, are removed along with the plant waste to be composted. This raffia to be tested is composed of 100% of natural origin based on jute fiber.

Pilot 2: Waste traceability management systems

The objective of this pilot action is to test a documentary traceability system for waste management, from the farm to the waste management plant to study the feasibility and impact of the implementation in the short and medium term.
The alternatives to test are the following:

- ALTERNATIVE n, CONVENTIONAL DOCUMENTARY CONTROL SYSTEM.

To accomplish the regulatory obligation, a MANAGEMENT CONTRACT (MC) must be fulfilled between the operator and the recipient before any shipment of waste.

- ALTERNATIVE 1, PHYSICAL DOCUMENTARY CONTROL SYSTEM.

To comply with the regulatory obligation, there must be an **IDENTIFICATION DOCUMENT[1] (ID)**, before any shipment of waste and will have the purpose of maintaining traceability during the transfer, certifying to the operator that the waste has reached its destination and has been accepted by the recipient, and will constitute the chronological file established by law.

- ALTERNATIVE 2, COMPREHENSIVE DOCUMENT REGISTRATION SYSTEM.

To achieve an optimal organization of the inorganic waste management circuits, it will control all the usual waste management documents by registering them in the **FARM REGISTER[2] (EC)**.

Pilot 3: Use of alternative materials for plastic mulching films

Three types of mulches were used for the pilot tests, being installed as 37 m long and 1.60 m wide 23 rows:

- Conventional mulching film made of low-density polyethylene (LDPE). Black, micro-perforated and 200 gauge thick (7 rows).
- Compostable mulching film Ecovio® (BASF). Black, micro-perforated and 200 gauge thick. It complies with the EN - 13432 standard and is certified with the OK biodegradable SOIL and OK COMPOST seals from TÜV - AUSTRIA (8 rows).
- In-soil biodegradable mulching Biomulch. Black, micro-perforated and 200 gauge thick, non-commercial plastic, it needs the addition of a microorganisms inoculum for in situ biodegrading (8 rows).

Pilot 4: Energy recovery of difficult-to-manage waste

The management of waste derived from plastic materials used directly on the soil, such as mulching, disinfection, solarization, maximum transparency film plastics and thermal blankets involves great difficulties for horticultural farmers. The high degree of degradation and dirt content associated with these wastes means that in most cases their treatment is not economically profitable for management companies, considering this waste as not recoverable. This is the reason why producers are charged for their management or management companies do not even accept them. Among the available thermal treatment technologies, gasification is considered the most appropriate option for energy recovery for difficult-to-manage waste. A second life is given to these materials through this process, thus allowing them to be used as an energy source.

[1] The document that identifies and accompanies the waste during its shipment.
[2] It is a record of all plant protection treatments carried out on the farm.

Pilot 5: Comparison of different associative waste management levels

This pilot test involved carrying out a theoretical study on the establishment of a waste management system in a cooperative that represents the sector. For this purpose, several alternatives were proposed and compared among each other with an increasing level of complexity:

- ALTERNATIVE n:
Conventional practice. The company does not participate in the management of the waste of its associates.

- ALTERNATIVE 1:
The Company establishes agreements with authorized waste transport companies.

- ALTERNATIVE 2:
The Company establishes collaboration agreements with authorized waste management companies.

- ALTERNATIVE 3:
The Company coordinates the waste management process and establishes agreements with authorized management companies.

- ALTERNATIVE 4:
The Company becomes a waste manager.

- ALTERNATIVE 5:
The Company becomes the final recycler.

FEASIBILITY ANALYSIS

Pilot 1: Use of alternative materials for plastic staking elements

The level of integration of the identified solutions, as well as the recovery level of the materials, assessed in the following table:

Table 4: Level of integration of the identified solutions and recovery level of the materials

ALTERNATIVE	LEVEL	MATERIAL	RECOVERY
n	High	Plastic	Not degradable
1	Medium	Biopolymer	Biodegradable
2	Medium	Natural fibre	Compostable

In both alternatives, a technological improvement is expected in comparison to the conventional one, guaranteeing the maximum reduction in the use of plastic for tomato crops staking. Although the tested alternatives are commercial, these are not strongly implemented due to the distrust of producers to switch to more sustainable twine, which is the reason that they are considered a «medium level".

Pilot 2: Waste traceability management systems

In both alternatives an organizational improvement is expected in comparison to the conventional one. The integration degree of the alternatives is shown in the following table:

Table 5: Integration degree of the alternatives

ALTERNATIVE	LEVEL	CONTRACT
n	High	Without contract
1	Low	Contract with waste manager
2	Medium	Contract with advisor

Feasibility is ensured since all participating agents, with different roles, are involved. Therefore, the producer derives his/her responsibility to the professional staff, ensuring that his/her waste is correctly managed.

Pilot 3: Use of alternative materials for plastic mulching films

The degree of integration of the alternatives identified within the activities performed by the company is considered as high. The tests conducted during the pilot project show that both alternatives are feasible from a technical point of view. Both the compostable mulch (alternative 1), and the mulch biodegradable in soil (alternative 2), maintained a good state of preservation during the almost 8 months of the growing cycle despite presenting small tears or perforations. In view of the above, it is understood that alternative materials meet the expectations as substitutes for conventional materials.

Pilot 4: Energy recovery of difficult-to-manage waste

From a technical point of view, the feasibility of energy recovery from difficult-to-manage waste from greenhouse horticulture is a priori out of doubt because of the chemical characteristics of the raw material to be gasified. However, between 15,000 and 20,000 t/year of difficult-to-manage waste are estimated as necessary to guarantee the feasibility of the installation of a gasification plant in the surroundings of the company, since the production of a single cooperative is insufficient. Therefore, the only way this alternative was feasible would be to extend this solution to other horticultural plants in the area and even incorporate the treatment of vegetable waste (approximately 299,700 t in the region of Níjar). On the other hand, the location of the plant should be close to the cooperatives logistics centers in order to commercialize the thermal or electrical energy produced. Therefore, it would be necessary to have enough space for the gasification installation, the storage area and the logistics management of waste.

Pilot 5: Comparison of different associative waste management levels

Table 6: Technical feasibility of the different alternatives tested

ALTERNATIVE	TECHNICAL FEASIBILITY
1	High
2	High
3	Medium
4	Low
5	Unfeasible

According to the study performed, alternative 5 should be dismissed since it is not feasible. However, alternatives 1 and 2 could be easily implemented and further levels of complexity could be progressively be achieved.

Pilot 1: Use of alternative materials for plastic staking elements

Table 7: Cost evaluation of the alternatives for pilot 1

	ALTERNATIVE 1	ALTERNATIVE 2
Twine purchase cost, €/ha year	559.20	622.22
Grant amount line 1 (Individual producer), €/ha year	419.29	419.29
Grant amount line 2 (Producer Organization), €/ha year	369.07	410.67
Overrun vs conventional twine, €/ ha year	**-450.31**	**-513.33**

The total cost of purchasing alternative twines amounts between 559.20 and 622.22 €/ha and the subsidy for an individual producer is 419.29 €/ha, compared to the producers who are part of an Organization of Producers of Fruits and Vegetables, in which the grant of 66% of the invoice amount represents between 369.07 and 410.67 €/ha. In that way, without considering the grants, there is an overrun about 450.31 and 513.33 €/ha. Considering the 2 possible grants, the overrun would represent 139.91 to 190.13 €/ha for alternative 1 and 202.93 to 211.55 €/ha for alternative 2.

Pilot 2: Waste traceability management systems

Table 8: Cost evaluation of the alternatives for pilot 2

	ALTERNATIVE 1	ALTERNATIVE 2
Waste agent contract (supported by producer), €/ha year	150.0	150.0
Farm adviser contract (supported by producer), €/ha year	150.0	150.0
Farm register, €/ha year	-	91.0
Overrun vs conventional alternative, €/ ha year	**300.0**	**391.0**

Pilot 3: Use of alternative materials for plastic mulching films

Since BIOMULCH (alternative 2) is a material that is in the experimentation phase and is not currently marketed, only the cost analysis corresponding to ECOVIO (alt.1) has been carried out.

Table 9: Cost evaluation of the alternatives for pilot 3

	ALTERNATIVE 1	ALTERNATIVE N	OVERCOST
Plastic film required, €/ha year	480.0	480.0	**0**
Managing cost, €/t	0	70.0	**-70.0**
Plastic average cost, €/kg	4.2	1.77	**2.43**
Plastic average cost, €/ ha year	2,016	849.6	**1,166.4**
Managing cost, €/ ha year	0	33,6	**-33.6**
Eligible through operational funds,	-504	0	**-504.0**
TOTAL, €/ ha year	**1,512.0**	**883.2**	**628.8**

Pilot 4: Energy recovery of difficult-to-manage waste

Table 10: Cost evaluation of the alternatives for pilot 4

	ALTERNATIVE 1	ALTERNATIVE N	OVERCOST
Managing cost, €/t	45	70	**-25**
TOTAL, €/ ha year	**45**	**70**	**-25**

Managing cost estimated made by Greene, the gasification company. Waste transport has not been included since it will depend on the distance from the gasification plant to the farms and subjected to market fluctuations. Regardless of transport, gasification could be a cheaper option than current management option (alternative n).

Pilot 5: Comparison of different associative waste management levels

Table 11: Cost evaluation of the alternatives for pilot 5

EXTRA COST OF THE DIFFERENT ALTERNATIVES (€/YEAR)
Alternative n (current):
• Long-term extra costs due to environmental degradation.
• Long-term extra costs because of the sector's discrediting by the end customer, which may lead to a decrease in exports.
• Administrative penalties
Alternative 1: 2,910 (€/ha and year).
Alternative 2: 2,910 (€/ha and year).
Alternative 3: 12,690 (€/ha and year).
Alternative 4: 22,690 (€/ha and year).

Pilot 1: Use of alternative materials for plastic staking elements

Table 12: Environmental impact assessment for alternatives of pilot 1

	Impact Description (Alternatives 1 & 2)	Assessment
QUALITATIVE LIST OF THE ENVIRONMENTAL IMPACTS AND EXTERNALITIES	Water pollution	(+) Low
	Soil contamination	(+) High
	Impact on the flora	(+) High
	Impact on the fauna	(+) High
ENVIRONMENTAL EXTRA-COSTS BASED ON THE IMPACTS AND EXTERNALITIES IDENTIFIED	The use of BIO-ACCESSORIES as staking elements, have a positive environmental impact as they can be transformed together with the plant waste into compost, thus reintroducing nutrients to the soil and improving its physico-chemical properties.	

Pilot 2: Waste traceability management systems

Table 13: Environmental impact assessment for alternatives of pilot 2

	Impact Description (Alternatives 1 & 2)	Assessment
QUALITATIVE LIST OF THE ENVIRONMENTAL IMPACTS AND EXTERNALITIES	Water pollution	(+) High
	Soil contamination	(+) High
	Impact on the flora	(+) High
	Impact on the fauna	(+) High
ENVIRONMENTAL EXTRA-COSTS BASED ON THE IMPACTS AND EXTERNALITIES IDENTIFIED	The implementation of the alternative proposed can improve traceability compared to the initial situation and this has a positive impact on related impacts.	

Pilot 3: Use of alternative materials for plastic mulching films

Table 14: Environmental impact assessment for alternatives of pilot 3

	Impact Description (Alternatives 1 & 2)	Assessment
QUALITATIVE LIST OF THE ENVIRONMENTAL IMPACTS AND EXTERNALITIES	Impact on fluvial dynamics.	(+)
	Visual and landscape impact.	(+)
	Impact on the flora.	(+)
	Impact on the fauna.	(+)
	Impact on marine and coastal environment	(+)
ENVIRONMENTAL EXTRA-COSTS BASED ON THE IMPACTS AND EXTERNALITIES IDENTIFIED	Decrease in the long-term cost derived from a deterioration of the environment would happen if alternative n (current) was maintained.	

Pilot 4: Energy recovery of difficult-to-manage waste

Table 15: Environmental impact assessment for alternatives of pilot 4

	Impact Description	Assessment
QUALITATIVE LIST OF THE ENVIRONMENTAL IMPACTS AND EXTERNALITIES	Impact on fluvial dynamics.	(+)
	Visual and landscape impact.	(+)
	Impact on the flora.	(+)
	Impact on the fauna.	(+)
	Impact on marine and coastal environment	(+)
ENVIRONMENTAL EXTRA-COSTS BASED ON THE IMPACTS AND EXTERNALITIES IDENTIFIED	The proper management of difficult-to manage-waste would result in a positive environmental impact	

Pilot 5: Comparison of different associative waste management levels

Table 16: Environmental impact assessment for alternatives of pilot 5

	Impact Description (Alternative 1 & 2)	Assessment
QUALITATIVE LIST OF THE ENVIRONMENTAL IMPACTS AND EXTERNALITIES	Impact on fluvial dynamics.	(+)
	Visual and landscape impact.	(+)
	Impact on the flora.	(+)
	Impact on the fauna.	(+)
	Impact on marine and coastal environment	(+)
	Impact Description (Alternative 3 and 4)	**Assessment**
	Impact on fluvial dynamics.	(+)
	Visual and landscape impact	(+)
	Impact on the flora.	(+)
	Impact on the fauna.	(+)
	Impact on marine and coastal environment	(+)
	Other impacts for alternatives 3 and 4: Emissions to the air of particles associated with the processes of handling and discharging plastic waste, storage and transit of vehicles at times coinciding with the presence of wind in certain directions. Specific and diffuse impact, associated to periods of great waste generation, compatible with the implementation of corrective measures	(-)

SOCIAL ANALYSIS

Pilot 1: Use of alternative materials for plastic staking elements

Table 17: Social analysis of alternatives of pilot 1

	Impact Description (all the alternatives)	Assessment
QUALITATIVE LIST OF THE SOCIAL IMPACTS AND EXTERNALITIES	New self-management activities	(+) Medium
	Development of small infrastructures	(+) Medium
	It creates jobs.	(+) Medium
ENVIRONMENTAL EXTRA-COSTS BASED ON THE IMPACTS AND EXTERNALITIES IDENTIFIED	The application of the alternative can improve employability as a consequence of creating a new professional activity related to the self-management of plant waste directly at the farms by self-consuming biomass.	

Pilot 2: Waste traceability management systems

Table 18: Social analysis of alternatives of pilot 2

	Impact Description (all the alternatives)	Assessment
QUALITATIVE LIST OF THE SOCIAL IMPACTS AND EXTERNALITIES	New professional activities.	(+) Medium
	It creates jobs.	(+) Medium
ENVIRONMENTAL EXTRA-COSTS BASED ON THE IMPACTS AND EXTERNALITIES IDENTIFIED	The implementation of the alternative proposed can improve the creation of jobs compared to the initial situation and this has a positive impact on related impacts.	

Social analysis is analogue for pilots 3, 4 and 5 and it can be summarised as follows:

Table 19: Social analysis of alternatives of pilot 3, 4 and 5

	Impact Description (all the alternatives)	Assessment
QUALITATIVE LIST OF THE SOCIAL IMPACTS AND EXTERNALITIES	Improving the quality of life of the population from a hygienic and sanitary point of view.	(+)
	It creates jobs.	(+)
ENVIRONMENTAL EXTRA-COSTS BASED ON THE IMPACTS AND EXTERNALITIES IDENTIFIED	Positive social impact produced by improving the quality of life of the population and creating new jobs.	

TECHNICAL DESCRIPTION

Pilot 1: Fresh tomatoes packaging

The company has selected a cardboard box to replace a plastic trays flow packed in plastic film. The simulations on logistics pointed the need to change also the secondary packaging. The company is currently evaluating machinability.

This new packaging enable :
- A better recyclability, and plastic removal of the packaging
- A cost reduction related to the materials
- A maintenance of the shelf life

Initial situation

New packaging

Pilot 2: Fresh tomatoes packaging

In the Initial situation there were 10 trays per box. A software optimization and a new design of the trays enable to have 12 trays per box.

This new packaging enable :
- A reduction of the use of boxes : 7000 per year
- An optimisation of the logistic, the new design enable to have 576 trays on each pallet, 56 more trays than the previous one

The company is now evaluating the option to use trays fabricated from rPET.

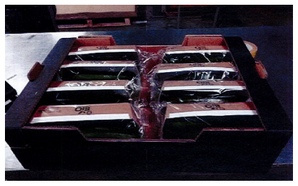
Initial situation

New packaging

Pilot 3: Fresh pepper packaging

The company has acquired a machine to apply bands over their products (such as zucchinis).

This packaging dramatically reduce the amount of waste produced compare to the previous one, a cardboard tray flow packed in a PE film. Another advantage is palletization more efficient.



Initial situation

New packaging

Pilot 4: Premium tomatoes packaging

The company wanted an attractive packaging. The proposed solution has a fancy Look and is made of 100% from post-consumer rPET.
The logistic has also been optimize with 15 pot/box vs the previous 12 pots/box)

This new packing enable:
- Reduction of material, the boxes are more simple, so the amount of cardboard used by the company is much lower
- No investment is required and the shelf life is not affected
- The new pot is both recyclable and made from recycled post-consumer material

Initial situation

Proposed options packaging

Pilot 5: Peeled pineapple packaging

The company wanted to develop/design a new thermoformed instead of the injected PP pot (and IML labelling) they were using. The new pot could use rPET as material. A whole innovation project is required for this. Thanks to the thermoforming, the company will be able to produce this new pots in-site, which represent a huge reduction of the transportation of empty packages and avoid packaging residues coming from the shipping.

The new packaging enable :
- A significant reduction in material cost : from 0.116€ / unit to 0.095€/ unit. This is explain also by a lower price of the PET compare to PET. Taking into account the amount of pots employed by the company every year, the annual economy associated to the pots is approximatively 135 000€.
- An investment is required but thanks to the savings on the unit cost, the investment should be amortized between 1 year for a simple change of the material and 3 years if the decide to invest in a thermoforming machine.

FEASIBILITY ANALYSIS

Pilot 1:

It is considered a good example to try to implement the use of trays made from recycled material (rPET) or recyclable material (cardboard). The critical point in the generation of waste is given by the PET trays and the use of flow pack. It is a 25-micron thick macro-perforated PP film.
The innovative solution aimed at reducing inorganic waste, replacing the current set of PET trays + PP flow pack with 100% cardboard trays.

Pilot 2:

Is a company with a lot of room for improvement. In this case, it´s considered an interesting company to work on **logistics optimization (modification/optimization of dimensions/weight of secondary packaging).**

Pilot 3:

It is considered that the most feasible innovation to be implemented and that would have a direct impact on the reduction of waste is trying to find a suitable packaging solution for courgettes and that allows to avoid plastic flow pack. Two possible solutions were raised with the company: - A tray alternative that was 100% cardboard; - **Use of loop-type grouping elements that allows dispensing with the use of packaging that allows avoiding both the flow pack and the tray**. Given the attractiveness of being able to completely avoid packaging, **the company invest in an in a machine that allowed this type of packaging progressing towards zero waste.**

Pilot 4:

is using a very specific primary packaging shaped as a cup with a lid. The proposed pilot actions consist in eco-design, combined with a logistic optimization (modification/optimization of dimensions/weight of secondary packaging).
We work on the **design of the primary packaging, so that it reverts to a reduction in cardboard waste and favours logistical optimization.**

Pilot 5:

is a company that could work in the eco-design of their primary packaging, because they are using an apparently strong injected PP cups for their product. At the outset, the company was asked to find a **lighter PP alternative or, preferably, the search for a rPET alternative**. With a simple change of supplier and without changing the packaging concept, the consumption of plastic per year could be reduced by 22.8%.

SUSTAINABILITY ANALYSIS IN THE HORTICULTURE VALUE CHAIN

PRODUCTION

The objective of the sustainability analysis was to evaluate the impacts associated with the innovative solutions compared with the traditional ones by quantifying and integrating indicators at the 3 dimensions of sustainability (economic dimension, social and environmental) and at the global level by integrating these 3 dimensions.
For that we used the AHP (Analytical Hierarchy Process) methodology and the evaluation through a survey of 9 experts in the sector.

Priorities of the alternatives in the dimensions of sustainability
Adding the behavior of the alternatives in the different indicators according to the three dimensions of sustainability, it is obtained that alternative 3 'Collaboration between cooperative and managers' stands out in the economic and environmental dimension, while alternative 4 'Cooperative manages inorganic waste' stands out in the social dimension. In any case, the performance differences between these two alternatives are not very great. The rest of the alternatives always fall behind, their order being the same in the three dimensions of sustainability: alternative 2 'Cooperative agreements with management plants', alternative 1 'Cooperative agreements with transport company' and alternative 0 'Cooperative not involved in waste management'.

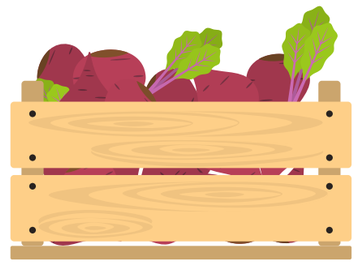
Priorities of the alternatives at global level
On a global level, the performance of alternatives 3 'Collaboration between cooperative and managers' and 4 'Cooperative manages inorganic waste' is very similar, being slightly higher than that of 3, and is superior to that of the rest of the alternatives. In particular, the worst overall performance of alternative 0 'Cooperative not involved in waste management' is evident.

Conclusions: Sustainability analysis of horticulture greenhouses production (Spain)
The results obtained show that for all the pilots studied there are alternatives that perform better from an economic, social, and environmental point of view, and therefore at a global level, than the alternatives currently used in a conventional way. For all pilots, the conventional alternative is the worst globally.

The following table summarizes for each pilot the best overall alternative to conventional practice:

Table 20: Conventional versus best global alternatives for each pilot

PILOT	CONVENTIONAL ALTERNATIVE	BEST ALTERNATIVE
Alternatives to the conventional use of plastic stakes	Conventional plastic stakes	100% compostable stakes
Documentary traceability systems	Conventional documentary control system	Telematic documentary control system
Thin plastic films for soil mulching	Conventional plastic film	Biodegradable plastic film
Energy valorisation of difficult-to-manage waste	Traditional waste management channels	Treatment in gasification plants
Establishment of a waste management model at associative level	Cooperative not involved in waste management	Collaboration between cooperative and managers



INDUSTRY

3 experts in horticulture industry in Spain were surveyed. The indicators evaluated by the experts in all the pilots/practices analyzed are:

Economic dimension/indicators
They refer to the economic aspects of sustainability, relative to farmers/industries economic (market) benefits and costs. They are:
- Overall profitability for farmers/industries: It refers to incomes minus variable costs. Income and costs are the totals of the economic activity developed by the farmer/industry, not just those associated with the technique being tested. It measures how the practices implemented can affect the overall profitability obtained.
- Strategic positioning and competitiveness in the market: It refers to the fact that early adoption of innovations can improve the company's position in the medium and long term.
- Intrinsic product quality: Refers to the quality attributes found within the products obtained by the farmer/industry. It refers to sensory and organoleptic issues, etc.
- Diversification of economic activities related to waste management in the region: This refers to the presence in the region under study of diversified economic activities related to waste management.

Social dimension/indicators
They refer to the social aspects of sustainability. They are social (non-market) benefits and costs. They are:
- Direct and indirect employment: Jobs generated in the farm/industry and in parallel sectors.
- Intergenerational continuity of agrifood activities: Level of guarantee of continuity of economic activity over time due to the continuation of human capital.
- Health of consumers and public health: Guarantee of good hygienic and health conditions of the products obtained by the farmers/industry.
- Health conditions of workers: Guarantee of good hygienic and health conditions for the farmers/workers.

Environmental dimension/indicators
They refer to the environmental aspects of sustainability. They are environmental (non-market) benefits and costs. They are:
- Biodiversity of flora and fauna: Amount and variety of presence of different living beings present in the environment.
- Quality of groundwater and surface water: Low contamination of groundwater and surface water mainly due to the application of inputs in the production process.
- Soil fertility/quality and control of soil erosion: It is important that the soil is not lost and that its agronomic quality is the best possible.
- Climate change abatement: Contribution to the fight against climate change as they are processes that emit less CO_2.
- Landscape quality: It refers to aesthetic quality of the landscape in the region.

The results obtained show that for all the pilots studied there are alternatives that perform better globally than the alternatives currently used in a conventional way. For all pilots, the conventional alternative is the worst globally. Differences are especially evident in the environmental and economic dimensions.

The following Table summarizes for each pilot the best overall alternative to conventional practice:

Table 21: Conventional versus best global alternatives for each pilot

PILOT	CONVENTIONAL ALTERNATIVE	BEST ALTERNATIVE
Alternatives to the conventional use of plastic trays	Conventional plastic materials	Carton-based trays
Logistics optimization	Conventional plastic tray	Rethink whole packaging - more sustainable solution
Rethinking packaging towards zero inorganic waste	Conventional packaging: cardboard tray + plastic flowpack	Bands – no packaging
Sustainable packaging for gourmet products	Fancy pot and lid	Redesign gourmet packaging
Redesign and change of materials	Conventional robust PP pot	Redesign - rPET pot

ADOPTION ANALYSIS OF INNOVATIONS IN THE HORTICULTURAL VALUE CHAIN

THE ADOPTION OF INNOVATING SOLUTIONS IN THE HORTICULTURAL PRODUCTION SECTOR

LIMITING FACTORS

It is important to highlight that all the limiting factors that have been proposed in the survey are all considered to be of medium-high importance, since all the average punctuation obtained have been greater than 5.00 (See the following table) according to the scale from 1 to 9.

Table 22: Limiting factors in the adoption of the alternatives for the reduction of inorganic waste

LIMITING FACTORS	AVERAGE (RELATIVE IMPORTANCE FROM 0: LEES LIMITING TO 9: MOST LIMITING)
Lack of knowledge from farmers about the innovative alternatives available in the market	5.33
Lack of guarantee and responsibilities from the manufacturers of the innovations respecting to their technical features	5.33
Management cost for certain kind of inorganic wastes	5.83
Lack of education and information background of producers respecting to waste management	6.17
High investments required for the implementation of innovative technologies	6.17
Numerous small size greenhouses with difficulties to assume their own waste management	6.53
Lack of some inorganic waste management traceability systems	7.00
Lack of research and innovation areas for minimizing waste at source	7.17
Lack of specific managers for certain inorganic wastes	7.50
Lack of proper technical characteristics with compostable and biodegradable raffia string	7.50
High cost and limited availability of alternatives materials at an affordable price	7.67
Lack of environmentally friendly alternatives of thin plastics	7.67

Source: Own elaboration from the survey carried out within the framework of the REINWASTE project (2020).

PROMOTING FACTORS

The results obtained in relation to the factors that promote the adoption of the alternative measures for a better management of inorganic waste and its relatives importance on an average on a rating scale from 0 (not important) to 9 (very important) are shown below (Table 23):

Table 23: Promoting factors in the adoption of the alternatives for inorganic waste reduction

PROMOTING FACTORS	AVERAGE (FROM 0 TO 9)
Increasing demand and willingness to pay more for sustainable products that reduce waste by consumers	4.50
The use of the alternatives to reduce the inorganic waste has positive effects on public health	4.83
Product differentiation linked to quality attributes of waste management “zero waste” and higher added value obtaining and competitive advantage (opportunity market)	5.50
Existence of public subsidies for some innovative alternatives	5.67
Current research and innovation trends focused on valorization of waste, bio economy and circular economy	6.50
Presence of authorized agents close to production area	6.50
Technological innovation addressed in most of the companies to improve their efficiency using production resources	6.83
Willingness to improve inorganic waste management by producers and their associations	7.17
Associationism that favors the scale economy and willingness to encourage collaboration among companies to promote joint waste management investments and favor scale economy to reduce costs	7.17
Higher social awareness in the agri-food value chain regarding to waste’s generation	7.17
Technological improvement of biodegradable strings and mulching	7.83

Source: Own elaboration from the survey carried out within the framework of the REINWASTE project (2020).

STRATEGIES TO ENCOURAGE THE ADOPTION OF TESTED ALTERNATIVES

To promote farmers adoption of the alternatives tested within the framework of the REINWASTE project in horticultural sector, some recommendations, and strategies, based on expert knowledges can be grouped into the following five blocks: (i) information and education, (ii) quality certifications, (iii) subsidies, and legislation, (iv) waste managers and collection points, and (v) various technical strategies (See the following table).

Table 24: Strategies suggested by the experts for an improvement in waste management

1. Information and education:
- Information transfer and awareness campaigns to the sector
- Conducting demonstration pilots
- Promote results transfer through communication campaigns in social networks, videos on YouTube
- Agreements between research and production entities to find innovative R&D solutions
- Communication and transfer actions by technicians to disseminate solutions for the horticultural sector

2. Quality certifications:
- Promote quality certificates related to zero waste
- Incorporating biodegradable materials in organic farming and integrated production

3. Subsidies and legislation:
- Develop a regulatory framework that includes all types of inorganic waste in a differentiated manner, guaranteeing their correct management through a system of extended responsibility
- Intensify or increase control of uncontrolled dumping
- Use of public funding to clean up areas affected by spills
- Promote administrative incentives and find out why the incentives that currently exist do not work properly
- Include waste management fees in the operational programs of fruit and vegetable producer organizations

4. Waste managers, collection points:
- Promote the existence of specific managers for each type of waste
- Improve the waste points network (low cost and at short distances from production areas).
- Promote appropriate separation of waste with reasonable appreciation

5. Various technical strategies:
- Improving waste management logistics.

Source: Own elaboration from the survey carried out within the framework of the REINWASTE project (2020).

THE ADOPTION OF INNOVATING SOLUTIONS IN THE INDUSTRY SECTOR

The information used to analyze the potential for adoption in the horticulture industry sector was obtained from a survey of experts in packaging materials and processes of food industry. The results of this study are therefore based on the 'expertise' and 'background' that the experts have on the sector and on the innovative solutions that potentially reduce or minimize waste, as well as on a review of their works related. The survey carried out, is structured in the following questions:

- The degree of concern and knowledge of producers/businesses about the problem of inorganic waste in general.
- The degree of knowledge of the innovative solutions available in the market to reduce inorganic waste in each step of the horticulture industry value chain.
- The level of knowledge of the five pilots proposed for the sector considered and their corresponding alternative solutions in the framework of the REINWASTE project.
- The potential for adoption of these tested pilots with alternative solutions for the horticulture industry sector.
- The limiting factors for the adoption of these alternatives (socio-economic, environmental, and technical) by the sector.
- The promoting factors that encourage and favour the adoption of these alternatives by the sector (socio-economic, environmental, and technical).
- The strategies that can be developed to promote and encourage the adoption of the alternative solutions tested with the pilots for the horticulture industry sector.

In order to quantify expert opinion on certain issues (importance, interest, level of agreement, etc.), the same scale has always been used, ranging from 1 (not important/not interesting, totally in disagreement, etc.) to 9 (very important, very interesting, very much in agreement, etc.). For the analysis of the data obtained, the information has been categorized as 'low' when the score is between 1 and 4, 'medium' when it is between 4 and 6 and 'high' for those scores over 6. Likewise, this work presents only a qualitative-descriptive analysis of the most important results of the different questions. The descriptive analysis is supported by arithmetic means and information generated by the surveys.

LIMITING FACTORS

In the following table, different factors that limit adoption of alternatives proposed to reduce inorganic waste in horticulture sector are considered, following methodology of the experts surveys.

Table 25: Limiting factors in the adoption of the alternatives in the horticultural industry

LIMITING FACTORS	AVERAGE (FROM 0 TO 9)
Lack of knowledge from the supplier of the "new materials"	5
Low degree of technical update from the people involved in the Quality/Materials Dept.	6
Continuous changes of the regulatory framework (plastic taxes, etc.)	7
Assessment of food safety standards on food contact materials	7
Investment and funds	7,5

Source: Own elaboration from the survey carried out within the framework of the REINWASTE project (2020).

Experts considered that aspects related to necessary investment (average of 7,5) and the food safety assessments are limiting factors. Thus, both factors represent, still, a real barrier to the effective introduction of innovation regarding the use of "biobased materials" (i.e., bioplastics and compostable materials) which could highly contribute to improve the circularity and to reduce the generation of the packaging waste volumes at plant level. Another stage of limitations, on the same level, is represented by the variations occurred to the regulatory framework the less-retained limiting factors are represented by the lack of knowledge from the suppliers of "new materials" and the low degree of technical update from the people involved in the Quality dept.

PROMOTING FACTORS

The results obtained in relation to the factors that promote the adoption of the alternative measures for a better management of inorganic waste are shown below.

Table 26: Promoting factors in the adoption of the alternatives for the reduction of inorganic waste

PROMOTING FACTORS	AVERAGE (FROM 0 TO 9)
Marketing leverage	8
Consumer acceptance in terms of impact on sustainability	9
Improvement of CSR company strategy	7
Reduction of packaging waste volumes	7

Source: Own elaboration from the survey carried out within the framework of the REINWASTE project (2020).

Respecting to the factors that promote the adoption of innovation, the horticulture sector fees that the most important one is the consumer acceptance in terms of impact on sustainability, which received an average of 9. It is quite normal because at company level, when introducing an innovation, the perception of any changes by the consumers is considered largely relevant.

Other factors which are perceived rather important are both the marketing leverage (8) and the improvement of the company Corporate Social Responsibility (CSR) strategy (average 7) and they are clearly connected to the consumer acceptance topic. The food companies (not only horticulture) are very keen about how to valorise their engagement on the sustainability topic.

STRATEGIES TO ENCOURAGE THE ADOPTION OF TESTED ALTERNATIVES

According to the knowledge and feedback collected by the experts who participated in this short survey, the following strategies are recommended for the horticulture industry sector in order to promote the adoption of the alternatives tested within the framework of the REINWASTE project:

- Better involvement of plastic producers/processors and suppliers of packaging
- Extensive dialogue with regional / national waste treatment facilities operators
- Better use of funding schemes existing at national/regional to finance the necessary investments at plant level

REINWASTE INNOVATIVE SOLUTIONS SERVICE

PROPOSAL OF A SERVICE FOR THE HORTICULTURAL PRODUCTION SECTOR

GENERAL DESCRIPTION, TARGETED GROUPS, AND SCOPE OF THE SERVICE

The new REINWASTE service is based on the industrial ecology principle maintaining that collective benefit (social optimum) is greater than the sum of individual benefits (private optimum). It will consist of an online platform channelling the supply and demand of innovative solutions concerning waste management in horticultural value chain.

This platform aims to be a support tool for farmers and associations and will show solutions (supply) to the problems (demand) derived from waste management, in an attractive format. The service's objective is to prevent waste generation by putting in contact different agents of the value chain that may find synergies among each other. Farmers or farmers' associations (cooperatives or other types of agricultural associations) are the main target for this service. However, users different than waste producers or managers could register. Sometimes companies from other sectors could be interested in acquiring or releasing a particular material. The platform will be open and of voluntary use, meaning any person/company will be able to search for materials or solutions for free by checking the webpage. However, only registered users will be able to contact the supplier/ demander of interest and get further information. In any case, the possible agreements and deals reached because of using the service are out of the scope.

POTENTIAL USERS AND THEIR INTERESTS ON THE SERVICES

The table below shows the degree of influence of certain specific agents in the demand from the perspective of farmers, since they will be the main users of the service. Waste management companies or auxiliary industry suppliers will be, a priori, very willing to implement any measure that can contribute to spread knowledge about the possibilities their respective companies offer and therefore their capacity to change the demand is lower.

Table 27: Degree of influence of certain specific agents in the demand from the perspective of farmers

AGENT INFLUENCING THE DEMAND	DEGREE OF INFLUENCE IN CHANGES OF THE DEMAND (SHORT RUN)	EFFECT ON SERVICE DEMAND
Technical innovations	Poor	Neutral
Environmental regulations	High	Positive
Final consumers requirements	Medium	Positive
Market/ sector regulations	High	Positive

SERVICE FEASIBILITY

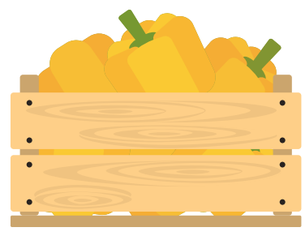
Considering the service would be non-profit it should be ideally run by a Public Administration Office since it would be the best way to guarantee the neutrality among the supply and demand of solutions. In addition, if waste exchange were finally included, it would be performed according to legal regulations. Lastly, although the service does not mean any cost for the users, it does involve a cost for launching and maintenance.

A priori, the implementation of REINWASTE new service would involve the following costs:

Table 28: Induced cost for the implementation of REINWASTE new service

COST ITEM	FIRST YEAR (€/YEAR)	SECOND YEAR AND SUCCESSIVE (€/YEAR)
Platform creation	3000	-
Mobile application creation	7000	-
Data protection management	500	500
Server renting	100	100
Domain opening	20	-
Platform Maintenance	1200	1200
TOTAL	**11,820**	**1800**

On the other hand, the market analysis is favourable, and the implementation of the service is a priori technically feasible. For these reasons, it is possible to conclude that the potential service for innovative solutions sharing and exchange, born in the context of REINWASTE project, is FEASIBLE. However, further analyses including a detailed study of the sector is required. Lastly, the feasibility of the service is conditioned to the fact that Regional Administration agrees to be responsible for it.



PROPOSAL OF A SERVICE FOR THE HORTICULTURAL INDUSTRY SECTOR

GENERAL DESCRIPTION, TARGETED GROUPS AND SCOPE OF THE SERVICE

The new REINWASTE service will consist of an online platform channeling the supply and demand of innovative solutions concerning waste management in horticultural value chain.
This platform aims to be a support tool for farmers, industries and associations and will show solutions (supply) to the problems (demand) derived from waste management, in an attractive format. The service's objective is to prevent waste generation by putting in contact different agents of the value chain that may find synergies among each other. Additionally, although the exchange of innovative solutions will be the core of the service, waste exchange is aligned with circular economy principles, so it is worth it to include this possibility for interested waste producers or managers.
The platform will be open and of voluntary use, meaning any person/company will be able to search for materials or solutions for free by checking the webpage. However, only registered users will be able to contact the supplier/ demander of interest and get further information. In any case, the possible agreements and deals reached as a consequence of using the service are out of the scope.
The demand will be divided into two categories, one for materials and one for solutions. The supply of solutions and materials will be divided, too. On the other hand, as an added value, the platform can include some information related to regulations and legal issues as well as recent scientific publications regarding waste management for the value chain. In addition, the news affecting the sector/value chain can also be included.
The service is conceived as non-profit, meaning that its strict benefit will be environmental and social. However, knowledge about innovative solutions/waste exchange may bring savings or incomes for industries and other actors of the agricultural sector. On the other hand, the lower waste is generated, the lower contamination risk of the production areas so the consequences, are economical as well as environmental and social (sustainability approach).
Lastly, it will start as a pilot service working only at regional level and for a particular value chain. Subsequently, if synergies among sectors were found, the service could be extended to other value chains in the same region. REINWASTE solutions platform model could even spread at national level. In parallel, connections between different regions and even among countries are expected to come up.

POTENTIAL USERS AND THEIR INTERESTS ON THE SERVICES

Industries, and associations (cooperatives or other Types of agricultural associations) are the main target for this service. However, different than waste producers or managers could register. Sometimes companies from other sectors could be interested in acquiring or releasing a particular material. Besides, research centres, Authorities, Administration Offices, industries, and associations, waste transport companies, etc. could also be interested in registering. In any case, they would need to indicate the type of waste for which they offer or request solutions or material exchange.

SERVICE FEASIBILITY

Responsibility of creating the platform will be shared by the partners as each will develop a different service according to its value chain.
The users of the platform have been indicated in the previous section and are expected to be mainly horticulture industries, waste management companies and horticultural auxiliary industry suppliers. Considering the use will be voluntary, users will be obliged to keep the terms of use of the platform, basically involving the responsible use of the service, providing true information regarding waste management/production and updating the information whenever needed. In addition, only registered users will be able to make contact with the supplier/ demander of interest and get further information. Therefore, users have the right to maintain their privacy for the general public, ordinary citizens will not be able to register since a company tax identification card will be compulsory to provide when registering. Registrations will not be effective until this information has been contrasted and verified (i.e. an entity that cannot legally justify its productive activity will not be able to register).
Regarding other registration inputs, new users will need to provide user name and password, personal data such as name, surname, telephone and e-mail and professional data such as company name, location and company's main activity, and as mentioned, tax identification card. In addition, a brief description of the company's activity should be included. Moreover, they will need to indicate whether they register as suppliers or demanders and if they offer/request solutions or materials, so that the system can assign them the right category.
All those data will be mandatory but there will also be some optional fields regarding the type of waste of interest (both for solutions and material), for example, vegetable origin, wood, plastic, metal, etc. Users can optionally decide if they want to receive an alert (by means of e-mail communication) whenever there is a new item of interest in the supply or demand. In addition, if the service became popular among users, it could be associated to a mobile application, that would be more practical to use but would require a higher investment, as it will be further tackled.
A tailored design of the website and codification of the solutions is essential for the potential service to succeed. A different code number will be assigned to every solution or material to be exchanged. Then, it will be automatically classified as supply or demand.
The demand will be divided into two categories, one for materials and one for solutions. The supply of solutions and materials will be divided, too. In addition, a colour code only for solutions could be used to indicate the degree of implementation in the market, for example: 1) Green colour for solutions fully implemented. 2) Yellow colour for solutions in testing phase. 3) Red coloured for untested solutions published in bibliography or websites. Furthermore, an alert shall be programmed so that when an offer and a demand agree in type of waste (both for solutions and/or materials), a symbiosis message shows up and an e-mail is sent to both parties.
On the other hand, as mentioned, the platform can include regulations and legal issues as well as recent scientific publications or related news. Lastly, search and contact buttons would also be provided.
A specialized web design agency would oversee the creation of the interface, setting and handling alerts and making the service more operative. As mentioned, if the feasibility of the service was high, a supplementary mobile application could be developed as well. Nevertheless, the possibility to include a link in REINWASTE project website for the platform access is currently under consideration.
Finally, concerning permissions, apart from the expected when opening a new webpage (domain contracting cost, server renting, etc.), personal data protection needs to be properly managed by a specialized legal agent.

RECOMMENDATIONS FOR THE HORTICULTURAL VALUE CHAIN

PRODUCTION SECTOR

- The sustainable solution proposed on biodegradable and compostable twines in horticultural greenhouses are well qualified as staking elements and allow the self-management of the plant waste of the crop through composting in areas near the place where they are produced or in their own farms. So, farmers would save transport costs and waste management.

- With the physical documentary control system, a correct traceability is acquired, and administrations are helped with their control, surveillance, and inspection functions, but extra costs must be supported by producers, shippers, and waste managers. On the other hand, the second alternative, a comprehensive document registration system, is more feasible than the first one, because a better control and monitoring of waste is achieved, through the farm register, a tool with which the producer is more familiar. In the ideal case, a combination of both alternatives would be the most efficient solution.

- The use of compostable plastic is highly recommendable since it is possible to use it both for short and long cycle crops (approximately 8 months) at the same time it offers a good management alternative since it can be easily composted with vegetable waste. In addition, waste could even return to the production process as compost or soil conditioner, with the associated social and environmental advantages that composting involves.

- Energy recovery of difficult-to-manage waste (thin plastics such as mulching, solarisation or thermal blankets) through gasification is technically feasible due to the characteristics of the waste (high low heating value (LHV) and high volatile carbon content make it an excellent raw material). This practice could guarantee proper management, avoiding negative environmental impacts, providing a positive image of the sector to the end customer, ensuring the documentary traceability of waste management, and creating jobs. However, the only way this alternative was feasible would be to extend this solution to other horticultural plants in the area so that enough waste was available for being energetically recovered.

- The non-involvement of the companies (cooperatives) in the management of the inorganic waste produced by its associates at farm level can result in situations of waste dumping in the environment which would cause several direct environmental impacts, such as visual and landscape impacts. On the contrary, reaching agreements between the cooperatives and transport or waste management companies could be very positive for the sector. Once easier to implement alternatives have been adopted, further levels of complexity could be progressively applied.

INDUSTRY SECTOR

During the testing activities carried out in the horticulture industry companies it was clear that the packaging waste topic was considered an issue.

Thus, it was difficult to quantify amounts of waste because its management is usually subcontracted and the company pays a fixed cost for the service, irrespective of the amounts.

With respect to the measures proposed, all of them could bring benefits in terms of sustainability of the food chain. In particular:

- Use of rPET
- Investment in machinery to replace plastic packaging by bands
- Eco design in primary and secondary packaging

However, any change in packaging systems needs feasibility assessment to assure food safety. Innovative sustainable materials are available, the cost is expected to decrease in the next few years.

Plastic should continue to be used, though in a wiser manner (i.e., optimization of packaging materials in view of the best end-of-life and eco-design. R-PET represents an opportunity for plastic waste reduction since it allows perfect circularity of plastic (return to the same use).

RESULTS DAIRY VALUE CHAIN

CURRENT WASTE SITUATION OF THE DAIRY VALUE CHAIN

CHALLENGES & CRITICAL POINTS IN THE DAIRY VALUE CHAIN

PRODUCTION SECTOR

The test phase carried out in the dairy livestock sector was developed from some premises. The first is that in general inorganic waste in agriculture is produced in reduced quantities compared to other sectors and areas (see paragraph Amount & type of waste in production sector); the second is that in the dairy sector, due to the type of production (milk) and the Region in which the trial was conducted (Emilia-Romagna), which allocates 90% of milk production in Parmigiano Reggiano, the management of inorganic waste has not yet represented a problem for farmers and waste plant managers.
These premises are also the basis of the fact that in the research phase of innovative solutions to reduce inorganic waste, no innovative solutions of literature and projects already existing, specific for the dairy farming sector, were found.
Despite this, the experimentation conducted confirmed some situations and highlighted some new elements to guide the sector towards a reduction of plastic (round bale net and silage film) that is the most type of inorganic waste produced by dairy livestock section.
Moreover, the research has also shown that for the dairy sector there aren't innovations that make it possible to replace plastic materials with biodegradable materials or the few research and experiments carried out, such as those on plastic silage covering films, do not yet have a mature technology to be applicable to such use.
In addition, a substantial difficulty has emerged in significantly reducing the use of plastics at least with the technologies currently available as alternative materials are not available now with the same performance.
There are also difficulties to recycle the plastic waste from round bales nets or plastic covering films for silage, due to the residual material (e.g. hay, straw, earth) which does not allow recycling due to the difficulties in cleaning the waste.

INDUSTRY SECTOR

Emilia-Romagna region is a leader in Europe with regards for agriculture, farming and food industry related activities. As for the dairy industrial sector, ER is the region with the largest number of companies (381 units) mainly devoted to the production of Parmigiano Reggiano cheese.
In this region approximately half of the total 23 dairy cooperatives existing in Italy are operating. This corporate form (characterized by small and very small companies) represents about 63% of the total of local units in Emilia-Romagna.
The sector is highly fragmented: 381 operators produce 148 thousand tons. With a focus on cheese production 80% of production is made up of hard cheeses, followed by the 17% of fresh cheeses while semi-hard and soft cheeses are very low.
The agrifood sector is included in the first strategic priority of the S3, as one of the pillars of the regional economy, representing 16.7% of the regional employees and contributing significantly to the overall export. It starts from an already advanced level, but there are significant margins for improvement which are all relevant for Reinwaste objectives.

CHALLENGES

1. **Regulatory Framework.** Based on the national regulation, the use of packaging materials accounts for a significant cost item.
2. **Heterogeneity.** Food industry is characterized by a wide differentiation of materials for specific application, this makes management a challenge.
3. **Cost.** Some pilot actions imply higher cost of investment.
4. **Performance verification of alternatives.** The finding of alternatives to current materials and the reduction of materials use need to be verified based on the actual effectiveness.
5. **Waste made of Plastics + food.** The food industry quality systems imply the batch online sampling for the verification of compliance.
6. **Retailers and consumers** increasingly demand for smaller or even single-serve packages

CRITICAL POINTS

1. **Technical limitations** of packaging lines for shifting to alternative materials.
2. **Limited collaboration and cooperation between all the actors** of the value chain.
3. **Low involvement and awareness** on the plastic waste streams and management (often subcontracted to third parties)
4. **Waste management costs considered as a fixed cost, such as administrative costs.**

AMOUNT & TYPE OF WASTE

PRODUCTION SECTOR

Starting from data and statistics on amount/volume and type of waste produced, it emerges that the impact in 2016 of the agricultural sectors, that includes agriculture, forestry, hunting and fishing, is 0.2% of the total waste produced.
In 2016 the production of special waste in the Emilia-Romagna region is over 13.6 million tons, 10.1% of the national total. The production of agricultural waste accounts for 1%.

Table 1 shows the main inorganic waste produced by dairy livestock sector.

NON-HAZARDOUS WASTE	HAZARDOUS WASTE
Packaging without hazardous residuals (Detergents, Desinfectants, etc.)	Packaging with hazardous residuals (Detergents, Disinfectants, etc.)
Plastic material: silage films, round bale nets	Infectious risk materials (needles, syringes, etc.) and expired veterinary drugs
Iron and steel and demolition materials	Exhausted oils and diesel filters
Plastic irrigation pipes	Waste Electrical and Electronic Equipment
Waste tyres	Asbestos

From the experimentation phase carried out it appears that the main sources of non-organic wastes in farms are plastic materials: silage films and round bales nets (Fig. 1).

The management of agricultural waste consists of a series of common obligations to all Italian companies relating to the “temporary storage” and the traceability documents of the waste produced up to the destination. For a lot of waste streams such as packaging, vegetable oils and fats, polyethylene goods, exhausted oils, etc. there are environmental consortia to promote the recycling and recovery of such wastes.

Moreover, in the agricultural sector, there are the «organized collection circuits». They are Agreements/ Conventions between the supply chain that produces and manages agricultural waste and in some cases with the territorial administration. The aim of these agreements is to track and organize the delivery of agricultural waste for the purpose of recovery. At present, the management of agricultural waste is not perceived as a critical issue for companies, due to the small amount of waste produced annually.

Figure 1 shows the results of the test phase on 5 enterprises.

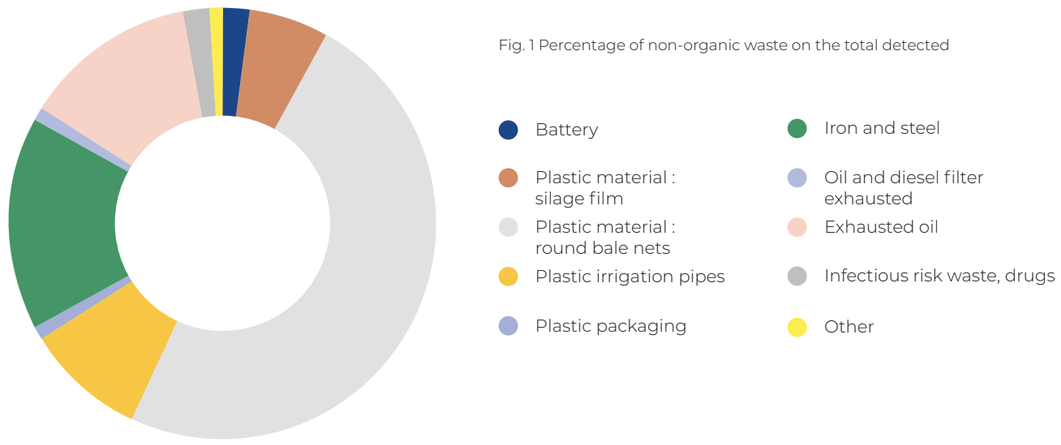


Fig. 1 Percentage of non-organic waste on the total detected

INDUSTRY SECTOR

With regard to the food industry dairy sector most of the waste generated by a dairy firm is inorganic: primarily packaging waste from both raw and secondary materials as well as the final product. Other wastes related to the maintenance activities, cleaning or laboratory and repair work are also produced. The recycling and treatment of waste generated in a dairy firm begins with separation, which avoids their being discarded with liquid waste and mixing together that would prevent adequate treatment of each type of waste.
The main inventory of waste in the dairy industry could be summarised as follows:

Table 2: Waste inventory in the dairy industry

GROUP		WASTE	PLACE OF GENERATION	CUSTOMARY USES
Organic wastes		Rejected product (raw material, semi-finished product, final product)	Process	Recycling (animal feed)
Similar to domestic waste		Bits of food, paper	Offices	Composting or storage at a dumping site
Packaging and packing	Empty	Removable film, wooden pallets heavy paper bags, Plastic, glass, cardboard, paper packaging	Reception	Reuse or recycling
	Full	Plastic, glass, cardboard, paper packaging	Packaging Storage Returns	Dumpling or separation of the packaging from the product and separate management
Waste from maintenance operations		Electric cables, scrap iron	Workshops Maintenance areas	Recycling or storage at dumps
Hazardous waste		Used	Laboratory Storage Workshop Cleaning areas	Transport, treatment and elimination or storage at hazardous dump sites

Table 3: Waste in the Dairy industry

PRODUCTIVE PROCESS	LEVEL OF GENERATION	MOST SIGNIFICANT OPERATIONS	OBSERVATIONS	PPO
Milk	Hight	Filtering/Clarification Skimming/Homogenization Packaging	Used filters and sludge from filtering organic material. Waste from packages and packaging	25
Cream and butter	Hight	Packaging	Waste from packages and packaging	25
Yogurt	Hight	Packaging	Waste from packages and packaging	25
Cheese	Low	-	Mainly from secondary operations	25
Secondary operations	Medium	Cleaning and disinfection Maintenance of installations Laboratories	Waste from packaging from cleaning and desinfection. Waste from maintenance operations. Laboratory wastes	24-26-32

SWOT ANALYSIS OF THE DAIRY VALUE CHAIN

PRODUCTION SECTOR

Table 4: Swot Analysis of the dairy value chain, production sector

STRENGTHS

- Consolidated experience in the dairy sector
- The possibility of testing innovations on a sample of companies with different dimensional and production characteristics.

WEAKNESSES

- Difficulties for companies to find information on available innovations and resistance to applying them for costs
- Completeness of data due to the limited availability of companies

OPPORTUNITIES

- Public administrations' sensitivity to supporting agricultural enterprises in waste management
- In the Region selected, the dairy sector represents a widespread, organized, consolidated and innovation-oriented supply chain
- Activation of synergies between the companies involved in the project and the stakeholder

THREATS

- Rapid technological evolution to make obsolete the innovation tested
- Introduction of prohibitions and regulatory restrictions related to the context in which innovation is placed
- Small number of innovations already available for the reduction of waste produced by the dairy sector

INDUSTRY SECTOR

Table 5: Swot Analysis of the dairy value chain, industry sector

STRENGTHS

- Small changes (e.g. Logistics) can bring economic benefits.
- There are alternatives of materials and packaging in the market that do not imply an additional cost.
- The use of more sustainable packaging materials will cause a positive social impact.

WEAKNESSES

- Lack of responsible for the environment or similar that takes care about the sustainability measures that need to be implemented to advance towards zero inorganic residues.
- Biased view on the problem of packaging waste beyond its management

OPPORTUNITIES

- Use of organic waste to generate valuable products (e.g. packaging materials).
- New recycled, biobased and biodegradable materials.
- Packaging ecodesign (E.g. weight reduction).
- Logistic optimization.

THREATS

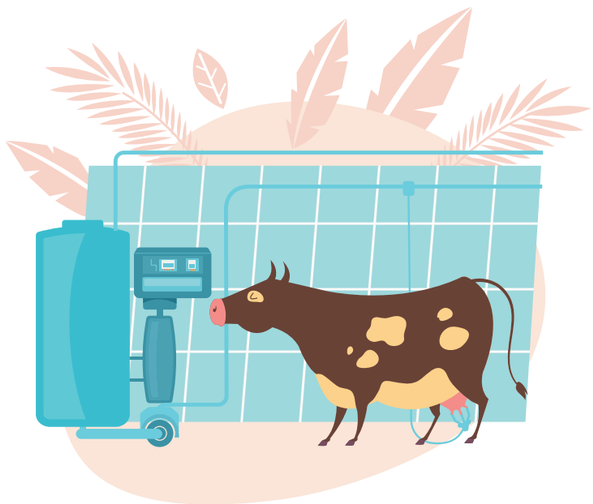
- Little profit margin per product
- Adjusted margin on the cost that the packaging materials can assume.
- Hight market competition (i.e. low margin).
- Uncertainty about the regulation (legislative framework) that is going to apply to this type of products (packaging) and its waste management.

MAIN INNOVATIVE AND SUSTAINABLE INORGANIC WASTE SOLUTIONS FOR THE DAIRY VALUE CHAIN

The test phase carried out in the dairy livestock concerning the reduction of inorganic waste, the strategies available are less organized and much more dependent on technological innovation and eco-design strategies related to the industrial sector. Positive known examples relating to the dairy sector are:

- Replace, where possible, the current procurement procedures (for examples products used for cleaning and disinfection) with return-refill schemes to reduce the quantity of packaging waste.
- Change, where possible, the current business model to reducing the use of plastics (for examples in dairy sector the use of a feed different from silage).
- Implement industrial symbiosis initiatives to create biodegradable products from agricultural waste.

In the table after the BAT and KET findings during the research that highlight the necessity to more research on these topics.



DAIRY PRODUCTION SECTOR BAT&KET FINDINGS

Table 6: BAT&KET steered to zero inorganic waste in Dairy Production Sector

	TITLE	CLASSIFICATION	DESCRIPTION	TYPE	SOURCE
1	Recycling dirty farm plastics	Recycling	The project aims to develop a logistics system, also a three-stage process for on-site removal of earth and rocks from the film, involving a dry airflow technology. The group planned to develop two technologies, intended to reduce costs and make agricultural plastics film recycling economically and environmentally sustainable.	Technology and software tool	«START» Project ID: ID 218335 Funded under:FP7-SME *https://cordis.europa.eu/result/rcn/157208_en.html* *http://start.uk-matri.org*
2	BIO-BOARD -Say cheese: the whey forward in renewable plastics	Eco design	The EU-funded BIO-BOARD (Development of sustainable protein-based paper and paperboard coating systems to increase the recyclability of food and beverage packaging materials) project set out to develop sustainable, protein-based paper a nd paperboard coating systems.	Innovative material	BIO-BOARD Project ID: 315313 Funded under: FP7-SME *http://cordis.europa.eu/projects/rcn/105658_en-.html* *Project web site: http://bioboard.eu/*
3	BioConSepT-Turning plants and waste into renewable plastic and chemical	New material	The project treated cellulose as well as oil and fat residues using (bio) conversion processes to produce intermediate compounds that can be used to produce bio-based plastics and other added value chemicals.	Innovative material	BioConSepT Project ID: 289194 Funded under: FP7-KBBE Project website: *http://www.bioconsept.eu/* Project details:*http://cordis.europa.eu/project/rcn/101861_en.html*
4	RHEA-Weed terminators	New technology and software tool	The RHEA (Robot fleets for highly effective agriculture and forestry management) project aimed to develop systems to reduce pesticides. The auto bots roam around, locating weeds with various cameras, killing the unwanted plants using targeted poison plus physical methods.	Waste prevention	RHEA Project ID: 245986 Funded under: FP7-NMP *https://cordis.europa.eu/result/rcn/164052_en.html* *http://www.rhea-project.eu*
5	BARIGAZZI F.LLI S.R.L. E ECOBLOKS / WOOD PACKAGING / 2015	Strategy	Barigazzi S.R.L. produces wooden pallets. For the production of different pallet lines, the company decided to replace the solid wood blocks with blocks supplied by the company Ecobloks, a manufacturer of pallet blocks, recycled wood blocks.	Eco design	Barigazzi srl - CONAI Successful case : *http://www.conai.org/prevenzione/pensare-al-futuro/casi-di-successo/imballaggio-in-legno/*

	TITLE	CLASSIFICATION	DESCRIPTION	TYPE	SOURCE
6	PARMAREGGIO / PARMIGIANO REGGIANO PACKED/ 2015	Strategy	Parmareggio has devised a new design of secondary packaging in corrugated cardboard with a view to reducing environmental impact. The new design allows a 61% logistics optimization and a 6% reduction in the weight of the secondary packaging per piece.	Eco design	PARMAREGGIO-SUCCESSFUL CASE CONAI: *http://www.conai.org/prevenzione/pensare-al-futuro/casi-di-successo/parmigiano-reggiano-confezionato/*
7	POLI BOX ITALIANA SRL / BUCKET 5 LT / 2016	Strategy	Poli-box Italiana Srl, a manufacturer and distributor of transport packaging, has redesigned the plastic 5-liter bucket with a view to lower environmental impact. In fact, the bucket, today composed of 50% recycled material, has been made mono-material and therefore more easily recyclable.	Eco design	polibox italiana srl - successful case CONAI: *http://www.conai.org/prevenzione/pensare-al-futuro/casi-di-successo/secchio-da-5-lt/*
8	CASCINA PULITA SRL - TOWARDS THE ZERO	Strategy	Cascina pulita srl is a leader Italian company in the collection, recovery and disposal of agricultural waste. Cascina Pulita has always been able to recover and recycle all products coming from agricultural processing, except for containers containing dangerous substances: empty containers of crop protection products, treated seed bags, agrochemicals containing dangerous substances. With the «Zero waste» project, Cascina Pulita has the important goal of achieving zero impact. For this reason, in 2013, the Clean Wash system was built at the Borgaro site. A project of excellence that involved the purchase of a special building, used as a washing container: an operation that allows the complete elimination of waste in agricultural activity. In this way, the waste becomes RECYCLABLE, absolutely inert and no longer harmful to the environment. A case of absolute excellence, first in Italy.	Recycling	cascina pulita srl *http://www.cascina-pulita.it/drain/verso_lo_zero*

	TITLE	CLASSIFICATION	DESCRIPTION	TYPE	SOURCE
9	FRACTALS-Innovative FIWARE-based apps for more productive farming	Ict Device	The EU-funded FRACTALS project set out to encourage the development of innovative technologies focused on increasing agricultural productivity.	Waste prevention	FRACTALS Project ID: 632874 Funded under: FP7-ICT WEBSITE:*https://www.fractals-fp7.com/index.php/stories-from-our-teams* *https://cordis.europa.eu/result/rcn/202828_en.html*
10	LIFE M3P - Material Match Making Platform for promoting the use of industrial waste in local networks	SOFTWARE TOOL, ICT DEVICE	The LIFE M3P project aims to promote and develop industrial symbiosis by connecting SMEs or clusters of SMEs to foster alternative uses of their wastes in line with the EU Circular Economy Package and the Resource Efficiency Roadmap.	Waste prevention	M3P, LIFE PROGRAMME, *http://www.lifem3p.eu/en/, LIFE15 ENV/IT/000697*

DAIRY INDUSTRY SECTOR BAT&KET FINDINGS

Table 7: BAT&KET steered to zero inorganic waste in Dairy industry Sector

TITLE	CLASSIFICATION	DESCRIPTION	TYPE	TRL*	SOURCE
PHBOTTLE - BIODEGRADABLE PACKAGING	Recycling	First prototype of active bio-packaging from sugars of wastewater juice.	NEW MATERIAL	6	EU R&D project
Recycling recycled PET	Recycling	New technology which converts PET waste back into virgin grade material for use in food packaging.	TECHNOLOGY	4	R&D solution provider

THE EXPERIENCE OF PROVEN SOLUTIONS TESTED IN DAIRY COMPANIES

PRODUCTION PILOT ACTIONS

The waste characterization phase, where was involved 15 companies, highlighted that most of the inorganic waste produced by the dairy livestock sector are nets for round bales and films for silage which together represent 49% of the inorganic waste produced.
The real phase of identifying the solutions and simulating the best environmental, social and economic performance compared to the solutions traditionally used has therefore concentrated on these two types of waste.
At the same time, however, the experimentation has also highlighted that even small interventions or changes in the methods of production, supply and maintenance can contribute to the reduction of inorganic waste. It was also found that the innovative solutions currently available to reduce the production of the various types of inorganic waste have focused on process modifications, such as the use of:

- Larger containers for detergents with the possibility of refill the containers.
- Eco-design solutions, such as reducing the thickness of the silage film or packaging.
- Good practices, such as the use of LED lighting systems to reduce consumption energy, reducing the maintenance of the lighting system and the production of hazardous waste (mercury, argon).

Table below shows the main recommendations provided to the sample companies regarding the reduction of non-organic waste.

Table 8: Recommendations for reducing non-organic waste

To protect round bale nets and plastic silage films became waste; to avoid wind, rain and further contamination of soil and water, to keep the material dry and clean. This also decreases disposal / recovery costs.
To use larger containers for detergents with the possibility of refill the containers.
To adopt LED lighting systems in order to reduce the electrical consumption, the maintenance and the production of hazardous waste.
To use plant protection products contained in biodegradable packaging.
To use plastic silage films with reduced thickness, maintaining the same resistance index.
To use agronomics and productive best practices to reduce drugs, antibiotics, plant protection products, etc. to minimize the waste packaging.

Containers to protect round bale nets and plastic silage films became waste

Containers to protect round bale nets and plastic silage films became waste

TECHNICAL DESCRIPTION

The research identified the following alternatives to the use of traditionally used bale nets and silage film. It was identified two pilot tests:

PILOT 1

THE ALTERNATIVE SOLUTIONS FOR CONVENTIONAL ROUND BALE NETS (HIGH DENSITY POLYETHYLENE): MESH NET CASING USED FOR PACKING CYLINDRICAL BALES

ALTERNATIVE 1
Use of round bale net with a 5 % lower weight
Mesh net casing with reduced thickness used for packing cylindrical bales

ALTERNATIVE 2
Polypropylene twine
Thin rope casing made of polypropylene used for the packaging of bales

ALTERNATIVE 3
SISAL twine
Thin rope Sisal wrapper used for packing bales. Sisal (vegetable textile fiber derived from the leaves of Agave sisalana)

ALTERNATIVE 4
Use of the Big Baler
High density pressing for the packaging of large prismatic bales

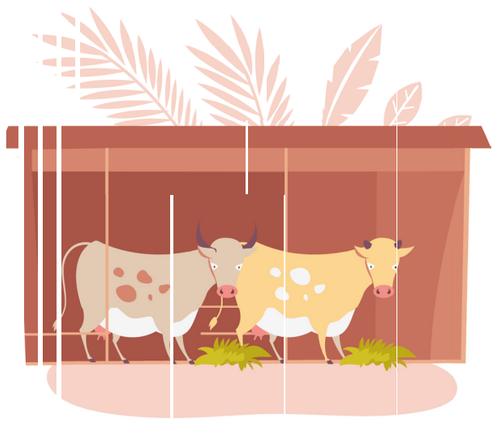
ALTERNATIVE 5
Use of the two-stage haymaking process of loose hay
Haymaking technique which involves a first pre-drying phase in the field and a second phase in which the product is brought loose in the barn to complete drying.

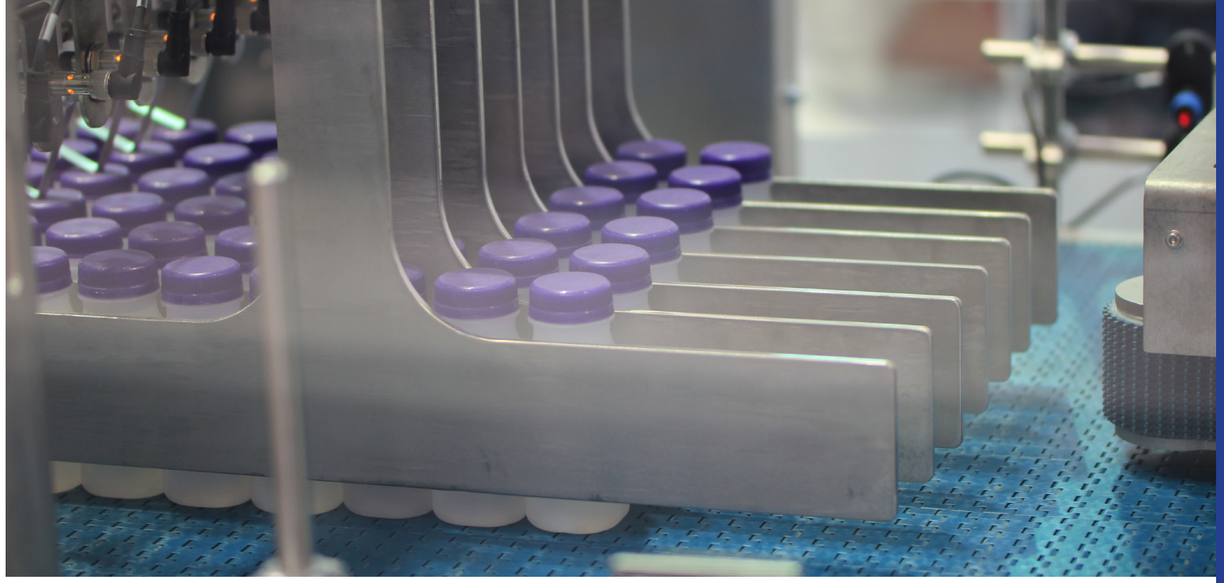
PILOT 2

ALTERNATIVE SOLUTION FOR CONVENTIONAL USE OF PLASTIC SILAGE FILM.
Plastic films for covering and protecting silage in order to guarantee their shelf life.

ALTERNATIVE 1
Use silage film of less thickness with 50% lower weight
Plastic films for covering and protecting silage in reduced thickness trenches with the use of smaller quantities of plastic materials.

ALTERNATIVE 2
Use of haylage round bales
Silage technique that involves the complete wrapping of the bales by plastic films.





FEASIBILITY ANALYSIS: OUTCOMES SUMMARY OF THE FULFILLED FEASIBILITY SCHEME

The experimentation on the 5 farms expected the comparison between the alternative found for each pilot to verify the following KPI related to:

- Cost of investment and use (euro/t of dry matter).
- Environmental sustainability through the calculation of the equivalent CO2 (KgCO2 eq/t of dry matter).
- Social sustainability as the work hours (h/t dry matter).
- Production of plastic waste (Kg plastic waste/t dry matter).

The data shows in the table below, were related to the ton of dry matter intended as raw material and contains average values, obtained taking into account the real farms characteristics. For this reason, they cannot be considered universally valid in all situations. In different contest the numerous variables that influence these processes may show different data.

Table 9: Cost, environmental and social sustainability and plastic waste production for the tested alternatives in pilots 1 and 2

PILOT 1	€/t dry matter	Kg CO2eq/t dry matter	h/t dry matter	Kg inorganic waste/t dry matter
Round bale net with a 5 % lower weight	16.10	7.56	8.95	0.54
Polypropylene twine	15.23	7.85	7.92	0.30
SISAL twine	18.23	9.98	7.92	0.00
Big Baler	17.15	4.59	25.45	0.48
Two-stage haymaking process of loose hay	21.69	17.96	8.00	0.00
PILOT 2	€/t dry matter	Kg CO2eq/t dry matter	h/t dry matter	Kg inorganic waste/t dry matter
Silage film of less thickness with 50% lower weight	13.70	4.47	65.98	0.32
Haylage round bales	39.33	18.40	6.40	3.64

BUSINESS & FINANCIAL PLAN

PILOT 1

As shown in the first column of the previous table for pilot 1 the situation is the following: the improved performance for pilot 1 (alternatives to the use of nets for traditional round bales) concerning the cost of use and investment was found to be the use of polyethylene twine with a KPI of 15.23, followed by the net for the round bale net with a thickness of less than 5% .
The worst performance was two-stage haymaking process of loose hay with a value of 21.69 due to energy use, followed by the Sisal twine which confirms the higher cost still associated with biodegradable alternatives (18.23) and by the Big baler solution which has a high-cost investment of machinery/ infrastructure (17.15).

PILOT 2

As shown in the first column of the previous table for pilot 2 (alternatives to the use of silage film) the situation is the following.

The less expensive alternative is the plastic film with reduced thickness (13.7 against 39.33) with about a third of the costs compared to the other solution (haylage round bales).

ENVIRONMENTAL ANALYSIS

PILOT 1

As shown in the second column of the previous table for pilot 1 the situation is the following.

The data show that the most environmentally sustainable solution in terms of CO2 eq is the Big baler (4.59) while worse performances are recorded for two-stage haymaking process of loose hay (17.96), again due to the high energy consumption. It should be noted that the solutions of the round bale nets with less thickness, polypropylene twine and SISAL twine stand on comparable values (between 7.5-10) as evidence that from an environmental point of view they are equivalent.

PILOT 2

As shown in the second column of the previous table for pilot 2 the better performance of CO2 eq is related to silage film of less thickness with 50% lower weight (13.70) respect the other one (39.33).

SOCIAL ANALYSIS

As shown in the third column of the previous table for pilot 1 Polypropilene twine (7.92), Sisal twine (7.92), two-stage haymaking process of loose hay (8), round bale net with a 5 % lower weight (8.95), have the comparable results in terms of time to perform these kinds of agricultural activities. The worst solution is the use of Big Baler.
For pilot 2 the best solution is silage film of less thickness with 50% lower weight (0.32).

INDUSTRY PILOT ACTIONS

PILOT #1. LIGHTWEIGHTING OF PLASTIC FILMS FOR CHEESE PACKAGING

SCOPE:

to reduce the amount of unnecessary packaging materials used, this will lower the amounts of wastes inhouse and the amount of plastic materials put on the market

RATIONALE:

packaging lightweighting is a strategy for optimization through the adoption of thinner and/or lighter packaging materials. Lightweighting reduces the use of resources and the generation of wastes and represents the easiest way to tackle the issue of packaging waste reduction. Packaging primary role is to protect food products and maintain their quality, hence packaging optimization implies the use of as minimum materials as necessary to guarantee its protective functions. Packaging minimization should be taken for granted, Since lightweighting also carries a reduction of costs for the producer, however, many commercial cases prove that significant improvements are still possible and that the use of unnecessary amounts of materials is, in fact, an underestimated issue (Licciardello, 2017; Licciardello & Piergiovanni, 2020).

TARGET COMPANIES.

The action is addressed to any food company, irrespective of production volumes and company dimension.

TECHNICAL FEASIBILITY.

The optimization of packaging systems implies the verification of performances (mechanical, barrier) by comparative shelf life testing, whose aim is to prove that the alternative system guarantees the same shelf life standards as the conventional system. The shift to thinner packaging may be facilitated by the possibility to maintain the same material supplier and to adapt packaging lines by modification of some process parameters, hence this action can be promptly implemented.

FINANCIAL ASPECTS.

The action allows to maintain materials suppliers and packaging lines, without extra costs other than for the initial evaluation and comparative shelf life tests. Cost savings will result from the use of less material per mass unit of food and lower environmental contribution. Lightweighting will allow to increase in-house stock for packaging materials. The reduction of the amount of plastic packaging can be claimed on the packaging label and become an effective marketing lever.

ENVIRONMENTAL SUSTAINABILITY.

If shelf life standards are guaranteed, packaging lightweighting results in neat sustainability improvement, reduction (up to 20%) of wastes generated by the value chain.

FINAL REMARKS.

Lightweighting could be achieved by reducing thicknesses for the same material and/or adopting composite structures with higher performances: however, sustainability-driven packaging reduction should be addressed under an end-of-life perspective, preferring mono-materials instead of composite multilayer materials (wherever possible), which bring higher performances but are less recyclable.

Further references

Licciardello F. & Piergiovanni L. (2020). Packaging and food sustainability. In: The Interaction of Food Industry and Environment. Charis Galanakis. Academic Press. Chapter 6, pp. 191-222 (ISBN: 9780128164495).
Licciardello F. (2017). Packaging, blessing in disguise. Review on its diverse contribution to food sustainability. Trends in Food Science and Technology, 65, 32-39. DOI: 10.1016/j.tifs.2017.05.003.

PILOT #2. REPLACEMENT OF CONVENTIONAL PACKAGING WITH COMPOSTABLE MATERIALS

SCOPE:

to substitute a conventional type of packaging, which is not recycled, with a new one possible to be addressed to industrial composting.

To date, in the actual waste management system in Italy, plastic trays are not recycled, irrespective of the nature of the material. This is especially due to the fact that such packages combine different materials for gas barrier purpose. Currently, CONAI is assessing the feasibility of recycling PET trays, but other materials widely used for fresh products applications, such as PP and PS, have no alternative scenario other than collection through the plastic waste stream and incineration. PS, in particular, in the expanded form (XPS) is widely used for meat and dairy products. Both the conventional PET, PP and PS trays, and the The use of synthetic plastic has posed serious ecological problems due to their non-degradability and to the depletion of fossil resources. Bioplastics have recently been proposed as alternatives, at least for certain applications, to fossil-based, non-biodegradable, plasticsexpanded PS ones, might be substituted by compostable bioplastics for specific applications.
According to the European Bioplastics Organization (EUBP, 2018), "bioplastic" is the word to be used to indicate plastics which are either "biodegradable" or "bio-based" (i.e., obtained from renewable resources), or having both these features, i.e. plastics which are bio-based and biodegradable together. Table 10 lists current commercial bioplastics and their classification based on source and biodegradability.

Table 10: Synopsis of commercial bioplastics and classification based on source and biodegradability. Adapted from Licciardello & Piergiovanni, 2020.

ACRONYM	FULL NAME	SOURCE		BIODEGRADABILITY
		RENEWABLE	FOSSIL	
PVOH, PVA	Polyvinyl alcohol		CS	+
PCL, PLC	Polycaprolactone		CS	+
PBS	Polybutylene succinate		CS	+
PBAT	Polybutylene adipate terephthalate		CS	+
Bio-PP	Bio-polypropylene	CS		-
Bio-PE	Bio-polyethylene	CS		-
Bio-PET	Bio-polyethylene terephthalate	CS		-
PLA	Polylactic acid, Polylactide	CS		+
PHAs	Polyhydroxyalkanoates	SMO		+
TPS	Thermo-plastic starches	CS		+
Cellophane	Regenerated cellulose	CS		+
Chitosan	Chitosan	DFB		+

DFB: directly from biomass; CS: chemically synthesized; SMO: synthesized by microorganisms

The substitution with biobased, compostable materials could reduce the amount of non-recyclable plastic wastes generated by the value chain and allow to valorize the waste, usually dirty with food residues, through industrial composting.

TARGET COMPANIES.

dairy companies producing portioned cheese, soft cheese and also yogurts. Action needs investments in materials selection (package main body and top film), packaging lines settings, specific moulds (thermoforming) etc. The action might imply the change of packaging supplier.

TECHNICAL FEASIBILITY.

Biosourced and compostable bioplastics suitable for production of trays and yogurt pots are already available in the market: polylactic acid (PLA) can be effectively extruded in sheets which can be then thermoformed to obtain trays with variable geometries and depth, while for polyhydroxybutyrate co-valerate (PHBV) thermoforming remains an actual challenge and needs effort for optimizing formulation and conditions.
PLA is more versatile and can be processed through injection moulding, thermoforming and blow-molding. PHBV can be effectively injection-molded, while thermoforming is an actual challenge: selection of specific polymer grade, formulation and processing conditions are necessary for producing thermoformed cups and pots. Due to the novelty of the application, sealing films and adhesives should be assessed, taking into account that the feature of compostability/biodegradability should be offered by all packaging components. The adoption of alternative materials should finally be validated in terms of shelf life: comparative shelf life studies might assess the suitability of the new packages to guarantee shelf life standards comparable with conventional packaging solutions.

FINANCIAL ASPECTS.

The cost of bioplastics is 3-5 times higher than conventional plastics. To date, the choice of biodegradable/biosourced plastics brings no advantage in terms of Environmental Contribution: indeed, the actual CONAI contribution concerns bioplastics as conventional plastics, due to the lack of consolidated collection-recycling systems, and include packaging made of bioplastics within the category of materials charged with the highest level of environmental contribution. Of course, the situation is expected to change in the near future, with the development of recycling lines and composting processes specific for bioplastics.
On the other hand, the choice of alternative biobased and compostable packaging materials may attract consumers, thus representing a tool for increasing competitiveness.

ENVIRONMENTAL SUSTAINABILITY.

Scientific evidence has demonstrated that bioplastics obtained from renewable materials and which are also biodegradable/compostable, carry environmental benefits, however the most suitable end-of-life should be evaluated through specific LCA studies. Indeed, composting is not always the best strategy, while recycling seems the most efficient way (Hottle et al., 2017).

FINAL REMARKS.

Actual **end-of-life** depends on national and regional facilities. To date, bioplastics are considered as non-recyclable plastics in terms of Environmental contribution (CONAI), but important changes in the end-of-life management and regulation are expected soon, including the implementation of specific waste treatment routes (recycling and/or composting) and the differentiation of the national environmental contribution for bioplastics. At the same time, the materials cost is expected to decrease in the next few years, this will, in turn, contribute to reach a "critical mass" of product which is necessary for the implementation of specific waste management systems.

Further references

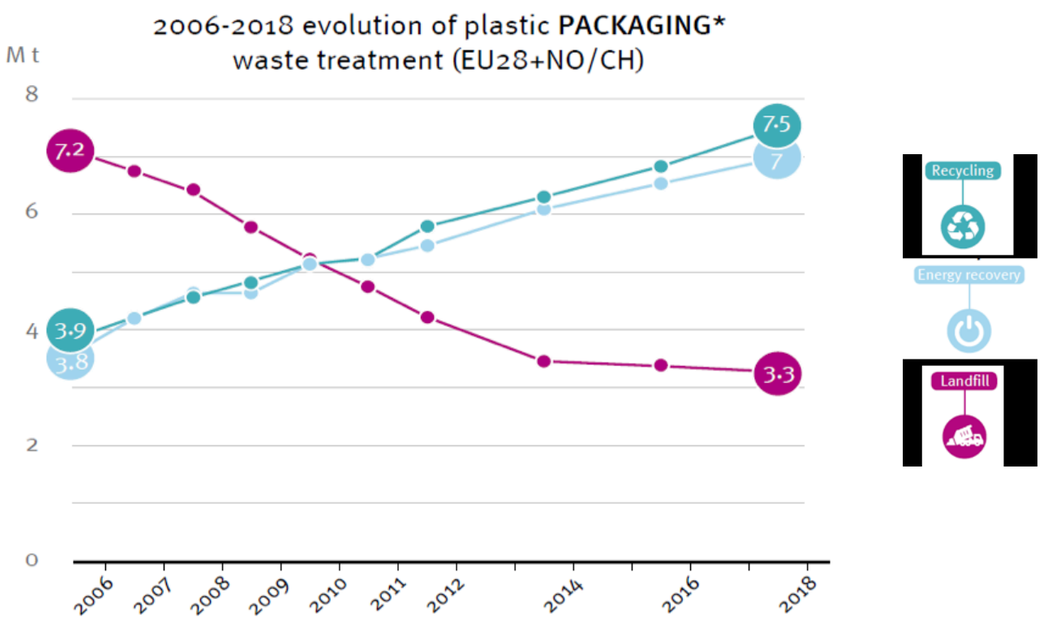
EUBP, European Bioplastics. (2018). Bioplastics, facts and figures. Retrieved from https://www.european-bioplastics.org/
Hottle, T. A., Bilec, M. M., & Landis, A. E. (2017). Biopolymer production and end of life comparisons using life cycle assessment. Resources, Conservation and Recycling, 122(July), 295–306. https://doi.org/10.1016/j.resconrec.2017.03.002
Licciardello F. & Piergiovanni L. (2020). Packaging and food sustainability. In: The Interaction of Food Industry and Environment. Charis Galanakis. Academic Press. Chapter 6, pp. 191-222 (ISBN: 9780128164495).

PILOT #3. REPLACEMENT OF COMPOSITE MATERIALS WITH MONOMATERIALS

SCOPE:
"design for recycling", to substitute a conventional type of packaging with a recyclable one.

RATIONALE:
The optimization of end-of-waste is one of the main targets of the packaging sector and of institutions. Plastic is a resource, prior to being an environmental issue, hence its valorization should be attempted where an improvement can be foreseen. This is the case of recyclability of plastic packages. The recycling of plastic post-consumer packaging waste has significantly improved in EU in the last years, showing an increase by 92% in the timeframe 2006-2018 (Figure 2), however, recycling represents the actual end-of-waste for only 42% of the collected plastic packaging waste, while 39,5% ends up in energy recovery plants and still 18,5% in landfill (Plastics Europe, 2019). These data testify the potential room for improvement, by making recyclable plastic waste fractions which, to date, follow routes different from recycling. Such improvement can be achieved primarily through the simplification of packaging materials, whose complexity is the main barrier to recyclability, and through improvements at the selection plants and recycling plants level.

Figure 2. Reproduced from: Plastics - the Facts 2019. An analysis of European plastics production, demand and waste data. https://www.plasticseurope.org/download_file/force/3183/419



TARGET COMPANIES.
any. Packaging for dairy is mostly composite, for gas barrier purposes. Action needs investments in materials selection, packaging lines settings, gas barrier and sealability verification, etc.

TECHNICAL FEASIBILITY.
Both PET and polyolefins (PE and PP) have the potential to be recycled in Italy. PET bottles are effectively recycled, and some recycling plants also valorize PE and PP films. However, trays are not recycled, even if currently the National Consortium for Packaging (CONAI) has undertaken a verification of PET trays recyclability. Recyclability is usually limited by the combination of different materials, which cannot be discriminated and/or separated at the waste-management plants. The use of mono-PET trays, for example, could offer sufficient performances for dairy products. Moreover, a small amount of barrier layer (i.e. EVOH, up to 5%) is tolerated and may not compromise recyclability (Ceflex, 2020), while conferring better performances for specific applications. Since dairy products are very susceptible to oxidation and microbial spoilage, gas barrier of the material is an important issue, and should be evaluated in terms of O2 barrier and maintenance of modified atmosphere. Furthermore, the usual combination of PE with PET allows an easy seal but represents a limit to recyclability, hence sealability of mono-PET packaging should be assessed.

FINANCIAL ASPECTS.
Monomaterial packages are cheaper than composites and, as for packaging lightweighting, the adoption of simplified packaging brings economic advantages with the possibility to significantly reduce production costs. Moreover, the use of monomaterial packaging may soon be encouraged also by the National Environmental Contribution, with a possible "jump" of mono-PET trays from C contribution level (546,00 €/ton) to B1 (208,00 €/ton). Furthermore, the choice of simpler and more recyclable packaging solutions may be valorized by food companies through marketing strategies, thus representing a tool for increasing competitiveness. Finally, the use of mono-PET packaging offers specific economic advantages: indeed, PET represents the only material allowed to return to the same use after recycling: it is the case of R-PET. The use of R-PET, which is foreseen to be allowed in the near future in Italy, allows companies to skip the already planned national plastic tax which is not due for the use of recycled plastic materials.

ENVIRONMENTAL SUSTAINABILITY.
From the environmental point of view, the adoption of monomaterial packaging and the contribution to increase recyclability of packaging systems will bring environmental benefits through the reduction of non-recyclable plastic waste ending up in landfill and energy recovery plants, and by making plastic packaging always more circular. To these regards, recycled PET (R-PET) from post-consumer packaging can be used to make new packaging, thus allowing to reduce recourse to virgin raw materials and to reduce the amounts of plastic wastes. In Italy, the amount of R-PET which can be used for making food packaging is limited, requiring at least 50% virgin material. However, a recent law (DL n. 104/2020) has removed such limitation for PET bottles, starting from 2021, thus allowing the production of 100% R-PET bottles with significant environmental advantages. It is expected that a similar approach will also cover other PET packages soon. R-PET represents an opportunity for plastic waste reduction, since it allows perfect circularity of plastic (i.e., the return to the same use). Finally, the adoption of PET as monomaterial brings another environmental advantage, which comes from the possibility to obtain PET partially from renewable resources (bio-PET): this material is high-performing and recyclable, as well as conventional PET, and represents another sustainability strategy towards the reduction of fossil sources exploitation.

FINAL REMARKS.
The use of monomaterials should be encouraged in food packaging since they can offer barrier performances compatible with the shelf life of many products. Such performances may be increased with the addition of barrier materials, such as EVOH, up to 5%. Mono-PET, among all, offers the best potential since it can be recycled to return to the same use. Monomaterial packaging should be evaluated through comparative shelf life tests with conventional composite or laminated solutions. A significant increase of monomaterial packaging can allow the valorization of the plastic waste stream fraction which is not recyclable to date.

Further references

Plastics Europe, 2019. Plastics - the Facts 2019. An analysis of European plastics production, demand and waste data. https://www.plasticseurope.org/download_file/force/3183/419
DL n. 104/2020. Decreto Legge 14 agosto 2020, n. 104, recante: «Misure urgenti per il sostegno e ilrilancio dell'economia
Ceflex, 2020. Designing for a Circular Economy Guidelines, retrieved from https://guidelines.ceflex.eu/resources/

PILOT #4. ADOPTION OF NON-DESTRUCTIVE TECHNOLOGIES FOR THE CONTROL ON PACKAGED PRODUCTS

SCOPE:

Shift from a destructive batch sampling approach to a non-destructive monitoring of packages

RATIONALE:

Many dairy products are commonly packed in modified atmosphere, which usually include variable mixtures of CO2 and N2, with the aim of minimizing O2 levels: indeed, O2 is responsible for the growth of aerobic spoilage microorganisms (bacteria and moulds) and for some biochemical alterations resulting in sensory and nutritional changes. Current monitoring of gas levels in modified atmosphere-packaged products consists of O2 and CO2 destructive measurement by needle sampling of headspace. This conventional procedure relies on the use of portable gas-readers, which sample a known volume of headspace through a needle; once the needle has perforated the package, they are sacrificed, generating a mixed waste (packaging + food) with complex disposal management. This destructive approach allows a limited number of controls; moreover, it is not possible to monitor the gas composition in the same package during time, which would be useful, for instance, to evaluate the gas barrier behaviour of a packaging system.

TARGET COMPANIES.

Big companies with high turnover and high availability for investment. Action needs investments for acquisition of new equipment and inline setting

TECHNICAL FEASIBILITY.

Innovative non-destructive measurement of headspace gas is commercially available and is based on IR laser spectroscopy (Figure 3). Non-destructive measurement of headspace gas can be performed on transparent and semi-transparent materials, not on metalized ones; for this reason, the technology couples well with action #3 being in line with the actual trend to shift from complex and metalized materials to simplified monomaterial packaging, with higher recyclabilty.

Figure 3. Schematization of IR laser spectroscopy-based non-destructive systems for gas measurement.

Non-destructive measurement of gases can be implemented in-line or can be performed off-line. In the first case, it can be completely automatized and allow the monitoring of 100% production, increasing quality standards of the production lines. In-line systems can also include leak detection systems with automatic rejection of non-compliant packages. In the second case it needs manual intervention. In any case, the innovation will save packaging and food, preventing samples from turning into a waste.

FINANCIAL ASPECTS.

The implementation of non-destructive gas measurement systems may contribute to increase the quality level of production, by guaranteeing higher standards and minimizing incidence of non-compliance, since it allows the control of 100% production, differently from conventional destructive systems, which can be performed only on a small number of packages, usually sampled at regular intervals during production. The needed investment makes this action suitable for dairy companies with higher turnover, however, pay-back of the investment is expected to be rapid thanks to costs saving at the quality control level (especially if automatized and coupled with data management systems), higher compliance to standard and minimization of claims, which will end in improved brand reputation and increased competitiveness.

ENVIRONMENTAL SUSTAINABILITY.

The generation of packaging waste at the quality control level represents an avoidable environmental impact which can, nowadays, be avoided with the adoption of non-destructive control on production. Not only the packages sacrificed for quality control contribute to the amount of plastic waste generated by the industry, but this waste is actually a mixed waste, made of food and plastic together, which need to be separated before disposing. The wasted food often represents a higher environmental impact that the packaging itself (Wikström et al., 2018), and it is well known that certain food types (i.e., animal and dairy) are characterized by higher production impacts, as a consequence, their wastage results in higher resources consumption and higher emissions compared with the wastage of lower-impact foods (vegetables, beverages). For instance, Venkat (2011) estimated that beef accounted for the largest impact contribution of wasted food (16% of the total emissions), even though the amount of waste for this product was less than 2% (by weight) of total waste. The minimization of sacrificed products, therefore, meets the need for limiting plastic waste production and food waste generation at the production level.

FINAL REMARKS.

Non-destructive packaging control undoubtedly represents one of the frontiers for the modern food industry: this technology is consolidated on the market and is available at two levels, for offline and online sample evaluation. Both configurations allow saving packages and food. Moreover, the latter configuration brings further advantages, such as the possibility to control 100% production and to increase quality standards.

Further references

Venkat, K. 2011. The climate change and economic impacts of food waste in the United States. Journal on Food System Dynamics, 2(4), 431-446. https://doi.org/10.18461/ijfsd.v2i4.247.

Wikström, F., Verghese, K., Auras, R., Olsson, A., Williams, H., Wever, R., Grönman, K., Pettersen, M.K., Møller, H., & Soukka, R. (2018). Packaging strategies that save food: A research agenda for 2030. Journal of Industrial Ecology, 23: 532-540. doi:10.1111/jiec.12769.

SUSTAINABILITY ANALYSIS DAIRY VALUE CHAIN

PRODUCTION

As shown in the third column of the previous table for pilot 1 the alternative solutions that do not produce plastic waste are SISAL twine and two-stage haymaking process of loose hay, Whereas the three other solutions do from 0.3 to 0.54 kg inorganic waste / t dry matter.For pilot 2 the solution that produces less plastic waste is silage film of less thickness with 50% lower weight.

INDUSTRY

For all the pilots studied there are not many alternatives to the conventional ones. However, they always perform better globally than the alternatives currently used in a conventional way. Differences are particularly evident in the environmental and economic dimensions, while they are not very high in the social dimension.

The following Table summarizes for each pilot the best overall alternative to conventional practice:

Table 12: Conventional versus best global alternatives for each pilot

PILOT	CONVENTIONAL ALTERNATIVE	BEST ALTERNATIVE
Alternatives solutions to avoid over-packaging issue	Conventional packages are not always optimized with regards for material thickness	Light-weighting of plastic films for cheese packaging
Replacement of plastic with compostable materials obtained from renewable sources	Conventional type of packaging (trays and pots), which are not recycled	Replacement of conventional packaging for yogurt with compostable pots
Alternative solutions to improve the recyclability of packaging	Non-recyclable multi-layer and composite materials	Replacement of composite materials with mono-materials
Integration of inspections on packaging lines of products packed in modified atmosphere	Destructive analyses (by needle sampling) of headspace gas on random samples	Adoption of non-destructive on-line control on packaged products based on infra-red spectroscopy

ADOPTION ANALYSIS OF INNOVATIONS IN THE DAIRY VALUE CHAIN

THE ADOPTION OF INNOVATING SOLUTIONS IN THE DAIRY PRODUCTION SECTOR

LIMITING FACTORS

The most limiting factor that it is highlighted is related to the fact of the alternatives cannot be considered universally valid for all farms in the livestock sector and that there are not solutions currently available that can replace the traditionally ones.

For these reasons it is necessary to strengthen research in identifying solutions for the reduction of plastics in the dairy sector that are applicable to companies with different characteristics and that can have a significant impact in management of non-organic waste.

PROMOTING FACTORS

The sector has, with respect to the available alternatives, a medium/low interest on it for both the pilots. The reason for this is related to the fact that for the dairy sector there are no innovations that make it possible to replace plastic materials with biodegradable materials or the few research and experiments carried out, such as those on plastic silage covering films, do not yet have a mature technology for be applicable to such use.

In addition, a substantial difficulty has emerged in significantly reducing the use of plastics at least with the technologies currently available as alternative materials are not available now with the same performance.

There are also difficulties to recycle the waste from round bales nets or plastic covering films for silage, due to the residual material (e.g., hay, straw, earth) which does not allow recycling due to the difficulties in cleaning the waste.

From this emerge the need of promote research on the use of biodegradable materials or, at least, greater innovation in eco-design to reduce the use of plastic materials or to facilitate the removal of residual material to allow for recycling and to assess the need to strengthen the infrastructures for the recycling of materials present in the area

STRATEGIES TO ENCOURAGE THE ADOPTION OF TESTED ALTERNATIVES

The strategies that are recommended for the dairy primary sector to promote the adoption of the alternatives tested are the following:

- Incentive at European or National level on machinery and equipment to reduce/better recovery agricultural waste.
- Information issue for examples, organizing an “innovation day” to improve communication between the agricultural company and the companies that manage agricultural waste to identify good practices that will improve the management of temporary storage on the farm, increasing the amount of waste to be used for recovery operations and show in detail all the innovations in this field. The information should concentrate to increase accountability towards environmental issues.

THE ADOPTION OF INNOVATING SOLUTIONS IN THE DAIRY INDUSTRY SECTOR

Through this question, the potential for adoption by the dairy industrial sector is evaluated through expert knowledge based on the different alternatives tested in the REINWASTE project and commented in the previous section. The results are presented in Table 13.

Table 13: Potential adoption of the alternatives tested in the REINWASTE pilots

DEGREE OF POTENTIAL IMPLEMENTATION OF THE FOLLOWING ALTERNATIVES OF INNOVATION	AVERAGE (FROM 0 TO 9)
1. Alternatives solutions to avoid over-packaging issue	
1.1. Light-weighting of plastic films for cheese packaging	8,2
2. Replacement of plastic with compostable materials obtained from renewable sources	
2.1. Replacement of trays with compostable ones	7
2.2. Replacement of conventional packaging for yogurt with compostable pots	5,2
3. Alternative solutions to improve the recyclability of packaging	
3.1. Replacement of composite materials with mono-materials	7
4. Integration of inspections on packaging lines in a protective atmosphere	
4.1. Adoption of non-destructive infra-red online control on packaged products	8

Source: Own elaboration from the survey carried out within the framework of the REINWASTE project (2020).

In the potential for adoption that the sector has with respect to the available alternatives both the use of light-weighting of plastic films for cheese packaging and the adoption of non-destructive infra-red online control on packaged products showed a very good potential for adoption at plant level (average 8). Probably the reason is why both options have ensured full market uptake for the proposed solutions. The potential for adoption recorded by both the replacement of trays with compostable ones and the replacement of composite materials with mono-materials is rather good (average 7). These solutions, indeed, have been tested concretely by the dairy companies even if research is still ongoing (especially for the use of compostable trays). However, the feeling is that dairy industry companies are ready to adopt in a near future the above-mentioned solutions.
With reference to the potential for adoption of the replacement of conventional packaging for yogurt with compostable pots it should also be noted that the sector has a medium predisposition to adopt this specific innovation (average 5,2). It is therefore clear that the sector has a great need for innovative alternatives for this type of plastic waste but now the thermoforming for PHBV (polyhydroxyalkanoate) is an actual challenge.

LIMITING FACTORS

To start, it is important to highlight that all the limiting factors that have been proposed in the survey are all considered to be of medium-high importance, since all the average punctuation obtained have been greater than 5.00 (Table 14) according to the scale from 1 to 9 considered.

Table 14: Limiting factors in the adoption of the alternatives for the reduction of inorganic waste

LIMITING FACTORS	AVERAGE (FROM 0 TO 9)
Lack of knowledge from the supplier of the "new materials"	6,2
Low degree of technical update from the people involved in the Quality/Materials Dept.	6,4
Continuous changes of the regulatory framework (plastic taxes, deposit scheme, EPR fees...)	7
Assessment of food safety standards on food contact materials	7,8
Volatility of raw materials prices	6,8
Shelf-life assessment	8,6

Source: Own elaboration from the survey carried out within the framework of the REINWASTE project (2020).

Experts considered that aspects related to the shelf-life (average of 8,6) and the food safety assessments are limiting factors of a huge importance. Thus, both factors represent, still, a real barrier to the effective introduction of innovation regarding in particular the use of "biobased materials" (i.e. bioplastics and compostable materials) which could highly contribute to improve the circularity and to reduce the generation of the packaging waste volumes at plant level. Another stage of limitations, on the same level, is represented by the variations occurred to the regulatory framework (national basis) and the volatility of raw materials (average 7 and 6,8 respectively). This is important because these limitations are related to "external" factors outside the plant. The less-retained limiting factors are represented by the lack of knowledge from the suppliers of "new materials" and the low degree of technical update from the people involved in the Quality dept. Both factors got the lower rate (average 6,2 and 6,4 respectively).

PROMOTING FACTORS

The results obtained in relation to the factors that promote the adoption of the alternative measures for a better management of inorganic waste are shown below (Table 15).

Table 15: Promoting factors in the adoption of the alternatives for the reduction of inorganic

PROMOTING FACTORS	AVERAGE (FROM 0 TO 9)
Marketing leverage	7,2
Consumer acceptance in terms of impact on sustainability	9
Improvement of CSR company strategy	6,8
Possible decrease of Environmental fee to be paid to national collection consortium system (CONAI, Corepla etc)	7,4
Reduction of packaging waste volumes	6,2
Others (please indicate):	

Source: Own elaboration from the survey carried out within the framework of the REINWASTE project (2020).

Respecting to the factors that promote the adoption of innovation, the sector perceives that the most important one is the consumer acceptance in terms of impact on sustainability, which received an average of 9. It is quite normal because at company level, when introducing an innovation, the perception of any changes by the consumers is considered largely relevant.
Based on the Italian regulatory framework the second-ranked factors is represented by the possibility to get reduction of the Environmental Fee which is paid by the company to the collection consortium system (CONAI, Corepla etc). For example, the light-weighting or even the use of monomaterials innovations go under this direction (average 7,4).
Other factors which are perceived rather important are both the marketing leverage (7,2) and the improvement of the company Corporate Social Responsibility (CSR) strategy (average 6,8) and they are clearly connected to the consumer acceptance topic. The food companies (not only dairy) are very keen about how to valorise their engagement on the sustainability topic.
The factor considered with a lower rate of importance is the reduction of packaging waste volume (average 6,2) if considered itself. There is the need to link this aspect to the other above-mentioned factors to have a full view at company level.

STRATEGIES TO ENCOURAGE THE ADOPTION OF TESTED ALTERNATIVES

According to the knowledge and feedback collected by the experts who participated in this short survey, the following strategies are recommended for the dairy industry sector in order to promote the adoption of the alternatives tested within the framework of the REINWASTE project:

- Better involvement of plastic producers/processors and suppliers of packaging
- Extensive dialogue with regional / national waste treatment facilities operators
- Better use of funding schemes existing at national/regional to finance the necessary investments at plant level

REINWASTE INNOVATIVE SOLUTIONS SERVICE

PROPOSAL OF A SERVICE FOR THE DAIRY PRODUCTION SECTOR

GENERAL DESCRIPTION, TARGETED GROUPS AND SCOPE OF THE SERVICE

The service that it is described below is referred to a service implemented within companies associations with the aim to support, firstly, companies associated.
For this reason, the promotion of the service is delegated to the official website of the association, through a page dedicated to the reduction of non-organic waste in agriculture., including a self-assessment check list and a decision diagram, aimed at assessing the state-of-the-art of the farm and its propensity to reduce non-organic waste, as well as facilitating its own path to implement existing innovative solutions.

Based on the interest found, companies will be provided with a first check-up and a «light assessment». The light assessment will provide some general recommendations that will be made on the sectors concerned as much as possible. The service can be implemented by:

- An analysis of economic operators related to the management of existing waste at the territorial level,
- The verification of the “Program Agreements” or Framework Conventions carried out by the Unions/ Federations in order to realize the “organized collection circuits”.

This analysis will enable the triggering of virtuous and shared routes, such as information material on the waste produced and their management, the preparation of good practices for cleaning plastic material and a better classification of waste according to their recyclability and depending on the destination plants of waste.
This will improve the awareness of agricultural enterprises in the proper management of waste and increase the amount of recycled agricultural waste. This could also be added to an awareness of the public administration to recognize the technical and organizational efforts in terms of waste carried out.

POTENTIAL USERS AND THEIR INTERESTS ON THE SERVICES

The Reinwaste analysis showed that waste management for agricultural sector and in particular for dairy farms, even in relation to the smallest quantities produced annually, is not perceived as a critical point in business management. That said, the new environmental policies, especially in relation to plastics management will have an impact on the company's needs to find new solutions to waste disposal and the use of the proposed service.

However, the trial showed a general interest on the issue and the willingness to implement the company's innovation also in terms of plastic waste. In consideration of the fact that nets for round bales and plastic films for silage are two containment materials used for raw materials that serve to feed livestock, the tested alternatives can be successfully applied as well as in dairy cattle farms also in the farms of:

- beef cattle.
- sheep and goats.
- equine.
- buffaloes.
- all those types of herbivorous animal farms (eg camels, llamas, alpacas, etc.).

At present, the uncertainties caused by the COVID-19 health emergency in relation to the present and future instability of the economic framework make it more difficult for companies to implement such innovation systems to reduce inorganic waste production.

SERVICE FEASIBILITY

The access point and promotion of the service will take place through the official web site of the companies' association through a dedicated page. The technical specifications are as follows:

Service development Responsibilities
Responsibility for the development of the service is the responsibility of companies' association.

Responsibilities of the users. Obligations and rights.
Users interested in the service must first complete the self-assessment check list together with their contact information to be transmitted to companies' association.

Service design and costs
A web page will be activated on the official website of companies' association dedicated to the theme of reducing non-organic waste in agriculture in connection with the Reinwaste project. A dedicated e-mail address will be active for information and, eventually, to request the service. The costs for the creation of the web page and its updates are related to human resources, databases and the costs of implementing and maintaining the official web site.

Permissions
The web page is open to the use of all users. It is necessary to be associated with companies' association for the service. For non-associated farms, the service is for payment.

Inputs required to power the service

- Reinwaste Materials
- Environmental and waste regulations
- Innovation tested in the Trial of the Reinwaste Project
- Best Practices of the Circular Economy Stakeholder Platform (www.icesp.it)

Platform upgrade and maintenance
Updates and maintenance will be related to the companies' association web site.

Content update and strict surveillance
The update of the contents will be carried out by the technical staff of companies' association.

Cost Summary:
1 senior resource and 2 juniors, partially dedicated
Updating of Confagricoltura web page for service activation and maintenance
Subscription to the Environmental Regulatory Database

PROPOSAL OF A SERVICE FOR THE DAIRY INDUSTRY SECTOR

GENERAL DESCRIPTION, TARGETED GROUPS AND SCOPE OF THE SERVICE

After the project duration in the case of Federalimentare the most tangible outputs and results collected by REINWASTE will be set up in a permanent repository on "sustainable management of packaging and packaging waste" service.
The main scope of the service will be the design of a web-based permanent observatory including regulatory and R&D updates on this topic.

POTENTIAL USERS AND THEIR INTERESTS ON THE SERVICES

This service will be addressed to all the Italian food and drink companies, especially those coming from dairy industry sector. However this information would be also interesting for the food stakeholders (public and private) dealing with the subject of packaging waste management and its correlation to better standards of sustainability and circular economy.

SERVICE FEASIBILITY

The permanent observatory on sustainable management of packaging and packaging waste will be edited by Federalimentare Servizi and added within the several services already offered to the food companies' members.
Thus, personnel working in the EU project area will continue to take care of the periodical update of content to upload useful documentation.

RECOMMENDATIONS FOR THE DAIRY VALUE CHAIN

PRODUCTION SECTOR

The Reinwaste project, through the experimental phase and the comparison between farmers, the world of research and companies that manage agricultural waste, within the Open Innovation Lab (Reggio Emilia 30 September 2019) and the workshop in Cremona at the Fiere Internazionali zootecniche of 23 October 2019, has highlighted some specific issues on plastic waste.

From the direct confrontation it emerged the need to activate institutional tables between the competent administration, the association representatives of the companies producing the products used in the farms (for example round bales nets and silage film), the association representatives of the farms and the managers of the collection and waste treatment, to:

- Improve communication between the agricultural company and the companies that manage agricultural waste, to identify good practices that will improve the management of temporary storage on the farm, increasing the amount of waste to be used for recovery operations.

- Verify what incentives can be put in place to support agricultural enterprises that implement good waste management practices.

- Define the feasible solutions for each of the subjects in this supply chain, useful for improving the recovery process of these types of waste.

- Assess the need to strengthen the infrastructures for the recycling of materials present in the area.

- Promote research on the use of biodegradable materials or, at least, greater innovation in eco-design to reduce the use of plastic materials or to facilitate the removal of residual material to allow for recycling.

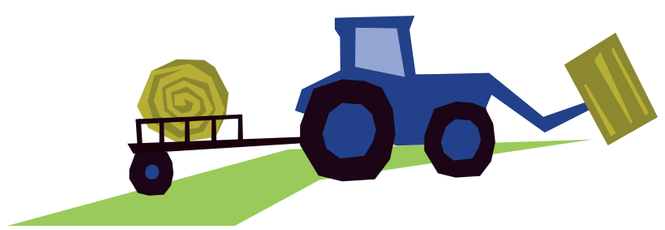
However, the need to have a diversification of the applicable solutions for reducing the use of plastics and inorganic materials in the primary sector of the dairy sector seems clear, given the differences in size, level of innovation and production system aimed at obtaining of a product often linked to different production regulations with respect to the PDO (Protected Designation of Origin) circuit to which it belongs that characterizes the companies in the sector.

Lastly, it is useful to underline, although not subject to experimentation, that in the agricultural field it can be useful to encourage the replacement of goods and roofs containing asbestos. The experimentation phase has highlighted the solutions available that can be implemented to improve the management of inorganic waste in the agricultural sector.

In the table below a summary of the needs of the dairy and livestock sector.

Table 16: Needs / Measures to improve the management of non-organic waste in the agricultural sector

Encourage agricultural businesses that use a service instead of product packaging (To use larger containers for detergents with the possibility of refill the containers)
Encourage the production but also the use of agricultural products that are designed to be reused, repaired or easily recoverable, maintaining the same properties and characteristics of current products
Encourage good practices aimed at cleaning soil material, debris, plant residues and water to facilitate the recovery of plastic material both for plastic waste from round bales nets and for silage film
Encourage technologies aimed at cleaning soil material, debris, plant residues and water to facilitate the recovery of plastic material coming from round bales nets and for silage film
Encourage the research for alternative materials capable of replacing or making the round bales nets and for silage film more recoverable
Encourage the replacement of asbestos-containing goods and roofing on farms



INDUSTRIAL SECTOR

With regards for the industrial dairy sector, most of the waste generated by dairy companies is inorganic: primarily packaging waste from both raw and secondary materials as well as the final product. The recycling and treatment of waste generated in a dairy firm begins with separation, which avoids their being discarded with liquid waste and mixing together that would prevent adequate treatment of each type of waste.

During the testing activities carried out in the dairy industry companies it was clear that the packaging waste topic was considered an issue. However, during the audit it was remarked that the related costs were considered as fixed items (similar to the administrative expenses). Thus it was difficult to quantify amounts of waste, because its management is usually subcontracted and the company pays a fixed cost for the service, irrespective of the amounts.

With respect to the measures proposed, all of them could bring benefits in terms of sustainability of the food chain. In particular:

- Lowering plastic use by packaging **light weighting** allows reducing **fossil sources exploitation** and **waste streams**.

- **LCA studies on bioplastic** packaging report environmental advantages compared to conventional systems.

- The use of monomaterials **improves recyclability** levels. Environmental Contribution takes into account the potential environmental impact of packaging and fixes a fee which is inversely related to recyclability.

- The adoption of non-destructive control systems prevents waste generation at the quality control level.

However any change in packaging systems needs feasibility assessment through comparative shelf life studies because **food safeguard comes first**. Innovative sustainable materials are available, the cost is expected to decrease in the next few years, as well as the waste management systems (specific composting and recycling) are expected to be implemented when the critical mass is reached. Plastic should continue to be used, though in a wiser manner (i.e. optimization of packaging materials in view of the best end-of-life –and **eco-design. R-PET** represents an opportunity for plastic waste reduction, since it allows perfect circularity of plastic (return to the same use).

RESULTS MEAT VALUE CHAIN

CURRENT WASTE SITUATION OF THE MEAT VALUE CHAIN

CHALLENGES & CRITICAL POINTS IN THE MEAT VALUE CHAIN

PRODUCTION SECTOR

The main challenges are to consolidate the achievements in terms of management of the three most important agricultural waste streams we can find in meet sector : empty packaging (which has contained plant protection products, fertilizers, seeds or hygiene products), used plastics (films, string and nets) and hazardous waste (non-usable plant protection products, personal chemical protective equipment and plant protection effluents).
Public authorities have defined six ways to improve the main agricultural waste streams. The first concerns the implementation of actions to improve the rate of collection of agricultural waste, particularly in the territories or for production chains with lower performance. That's why the government and ADIVALOR also set themselves the objective of «establishing a dialogue on the regulations, regulatory changes and measures put in place by the Ministry impacting the activity of ADIVALOR». Strengthening the training, information and awareness of the agricultural world, as well as the creation of environmental indicators on the collection and recovery of agricultural waste is the subject of the following two ways. Finally, the last two concern the reduction of the environmental impacts of agricultural waste and the search for specific actions for waste without a solution for collection or recovery.

INDUSTRY SECTOR

The Meat value chain is facing several challenges in terms of inorganic waste minimization. Many of these challenges are linked to packaging, and to a common need to banish non-recyclable plastic-based packaging. This need has several vectors:

- **A shifting political will:**
the French national context forces the Meat value chain to adapt: indeed, since January 21th 2020, the French deputies have been debating the bill against waste and for circular economy. As it stands, the text imposes the end of single-use plastic packaging by 2040, following European guidelines. It has thus become necessary for heavily plastic-reliant sectors to change their ways.

- **Evolution of the consumers' demand:**
the meat value chain is confronted with a need to evolve to answer its consumer's changing needs. The French consumers are demanding more sustainable packaging in the products they buy, and the sustainability of the packaging has become in the recent years an important purchasing argument. A study quoted by All4pack stipulates that one French consumer in five says he is very much in favor of using refillable packaging and eight out of ten consumers are in favor or very much in favor of buying sustainable packaging[1].

- **Technical challenges:**
however, it is not simple to entirely banish plastic from the sector, as it is reliable in terms of quality, security and price – furthermore, the machines used by the companies are calibrated to use plastic, and this is thus the most used packaging material in the catering sector.

- **A growing development of sustainable packaging:**
the enterprises of the Meat sector have already began to work on sustainable packaging and on the reduction of inorganic waste, but they are confronted to various challenges: Fleury Michon, a French company producing catering products, has replaced its plastic trays with French poplar trays (wood), and the plastic films covering the whole have been replaced with Flowpack films. However, the Flowpack trays are five times more expensive than a polymer-based film, and the wood used to create plastic trays is not recyclable. Another French Catering company, Daunat, is reducing its unnecessary packaging, including plastic, cardboard and film overpacks, lightening the packs, favoring recyclable raw materials etc., but is dependent on the technological developments of suppliers and delayed in its efforts by a complex ecosystem which involves local authorities for collection and recycling. Thus, many efforts are made in the French meat sector to minimize inorganic wastes, especially in packaging. However, the transition has proven to be complicated, as the sector heavily relies on plastic, plastic which many of its smaller companies have difficulties to replace: the price of alternative materials is far higher than plastic, the technologies not adapted, or the ecosystem itself forbids the recycling of some innovative materials.

[1] *https://www.all4pack.fr/Temps-forts/resumes-conferences/eco-conception-recyclage/Quels-challenges-doit-on-relever-pour-le-sustainable-packaging*

AMOUNT & TYPE OF WASTE PRODUCED IN THE MEAT VALUE CHAIN

PRODUCTION SECTOR

In France for more than 20 years, the agricultural profession has been organizing to collect, recover or recycle its waste. There are two sectors in particular.

The first one is for professional streams: these are the agriculture-specific elimination streams (UNPP, PPVT, DASRI). These channels have existed for some years. The most important part of these inorganic wastes is collected through ADIVALOR device:

- Empty Packaging of Phytosanitary Products (PPVT),
- Non-Usable Phytosanitary Products (UNPP),
- Empty Packaging of Fertilizer Products (EVPF),
- Used agricultural plastics (PAU), like silage film and plastic ballast bags
- Empty Packaging of Hygiene Products used in Meet Farming (EVPHEL),
- Empty Seed Packaging (EVS),
- Twine and Used Net (FIFU),
- Hail nets (FP).

The second sector is organized around specialized sectors: These are national waste disposal channels that are not specific to agriculture. For example, the recovery of oil, batteries and more recently tires.
We can also find plastic irrigation pipes, ferrous materials (parts of agricultural machinery, car catches, etc.) in meat farms. Meat farmers use medicated foods and all feeds packaging, veterinary medicines packaging, and could have expired veterinary drugs. Other medical waste such as for example needles, syringes, latex gloves, masks can be collected through a specific device.

INDUSTRY SECTOR

A study[2] conducted by FICT (French Industrial Federation for Delicatessen and meat-based products) and ECOEMBALLAGES describes the challenges and opportunities faced by FICT's meat companies in terms of inorganic waste minimization. It highlights the many efforts and initiatives launched by the sector to improve its waste minimization and remind that the main inorganic wastes created by the interrogated companies are created mainly by plastic trays and films, plastic jars and cans. It underlines that the types of packaging in the meat-catering sector are distributed as such: 29% plastic films, 20% plastic trays, 8% plastic operculum and 34% of other packaging types. Plastic, in the sector, represent 2/3 of the material used.
Another older study by CELENE, the French Meat industry association, shows that the meat sector produces an average of 10 kg of inorganic waste per ton of carcass (toc). As the sector produces 3.7 million toc of beef animals and 2 million toc of poultry annually, the annual production of inorganic waste for the meat production sector is around 57 000 tons.

[2] *https://www.all4pack.fr/Temps-forts/resumes-conferences/eco-conception-recyclage/Quels-challenges-doit-on-relever-pour-le-sustainable-packaging*

SWOT ANALYSIS OF THE MEAT VALUE CHAIN

PRODUCTION SECTOR

Table 1: SWOT Analysis of the meat value chain, production sector

STRENGTHS

- Existence of **ADIVALOR**, a national organization unique in Europe that is in charge of collecting and recycling waste in agriculture in France
- **Good waste traceability** for the agriculture sector with ADIVALOR which enables to quantify the waste collected and recycled each year and analyze progress
- **System financed by producers and marketers** through an eco-contribution in accordance with the European principle of shared responsibility

WEAKNESSES

- **Dependence of the agricultural sector to plastic material** which leads to heavy production and use of waste for this domain
- **Waste collect through ADIVALOR is not homogeneous** between French region and varies between 30% and 90% between regions
- **Lack of environmental friendly alternatives**
- **High cost** to develop **bio-based plastic**
- **Impossibility to use compostable alternatives** for the meat sector in agriculture as solid materials are necessary

OPPORTUNITIES

- **Higher awareness among farmers** of the agricultural world, of the need for a more sustainable agriculture
- **Consumers also more aware and concerned about plastic** pollution and ready to pay more for sustainable products
- Several **research projects and innovation trends on bio-economy** and valorisation of end of life waste Biomaterials being developed and tested in the agrofood industry
- Use the already existing system and **improve the recycling rate to 100%** everywhere in France
- **Transfer this knowledge at European level**

THREATS

- Focus and research is still mainly on recycling rather than preventing and reduce production at the source
- Recycling is important but plastic product cannot be recycled indefinitely
- Implementation of innovative technologies require high investments
- Strong lobbying at European level to defend interests from plastic industries

INDUSTRY SECTOR

Table 2: SWOT Analysis of the meat value chain, industry sector

STRENGTHS

- Company's **motivation** about the topic
- Some companies are majors that have an influence over suppliers
- Easy data sharing

WEAKNESSES

- Soiled inorganic waste
- Multi-layer plastic container
- **Strict process criteria** (microwavable, cooking temperature...)
- High level of functional requirements for packaging (food contact, mechanical resistance, tightness, gas barrier...)
- Recycling chain of consumption packaging depending of many actors

OPPORTUNITIES

- **EGALIM** law in France
- Single use directive
- A lot of research and innovation on new materials
- **Consumers' expectations** and needs

THREATS

- **Banishment of single use plastics** (2021)
- Material costs
- Contamination of plastic materials by exudates
- Effective recyclability of plastics in relation to existing sorting processes
- Impact of new packaging on the shelf time of the products

MAIN INNOVATIVE AND SUSTAINABLE INORGANIC WASTE SOLUTIONS PRESENTED FOR THE MEAT VALUE CHAIN.

In the tables below the BAT and KET findings during the research that highlight the necessity to do more research on these topics.

MEAT PRODUCTION SECTOR BAT&KET FINDINGS

For the agricultural meat sector in PACA, a few BATs were identified in France and in Europe manly regarding the improvement of the recycling process as not many technologies have been yet developed and proved successful for the fabrication and application of bio-based plastics in the meat sector in agriculture.

Table 3: BAT&KET steered to zero inorganic waste in Meat Production Sector

	TITLE	CLASSIFICATION	DESCRIPTION	TYPE	TRL*	SOURCE
1	Establishment of a waste collection and recycling national organization for agriculture waste	Recycling	ADIVALOR establishes and finances the recycling of plastic waste from agriculture.	Strategy	9	National Device ADIVALOR
2	Recycling of High Density Polyethylene waste	Recycling	ADIVALOR collects and recycles empty phytosanitary packaging.	Strategy	9	National Device ADIVALOR
3	Recycling of Polyethylene waste	Recycling	ADIVALOR collects and recycles waste made from polyethylene (used plastics films for agriculture).	Strategy	9	National Device ADIVALOR
4	Recycling of Polypropylene waste	Recycling	ADIVALOR collects and recycles waste made from polypropylene (round bales strings, Big Bags for fertilizer and grains)	Strategy	9	National Device ADIVALOR
5	Greenbag for the preservation of cattle food	Innovative material	Manufacture of a large bag made from multiples extrusions et diverse layers.	New material	10	Private R&D solution provider
6	Eco-designed plastic film for fodder protection	Innovative material	Plastic film Régéfilm is made from more than 75% of recycled matter (new multilayer technology).	New material	10	Private R&D solution provider
7	Low energy consumption recycling of strings and nets for agriculture	Recycling	RecyOuest is a green economy start up that recycles filament thermoplastics contaminated (round bales nets, strings) with a new dry cleaning technology	Technology	10	Private R&D solution provider

* Technological maturity level

THE EXPERIENCE OF PROVEN SOLUTIONS TESTED IN MEAT COMPANIES

MEAT INDUSTRY SECTOR BAT&KET FINDINGS

Table 4: BAT&KET steered to zero inorganic waste in Meat Industry Sector

	TITLE	CLASSIFICATION	DESCRIPTION	TYPE	TRL*	SOURCE
1	Monomaterials thermoforming	Innovative material	Trays made of single-material (PET for example) or separable materials made up entirely or partly of recycled material. It is important, however, to validate the single-material solution in terms of conservation to ensure the desired lifetime.	Technology, new material	*TRL 9*	Private R&D solution provider
2	Granting society with Low environmental impact innovative PACKaging	Innovative material	GLOPACK proposes a cutting-edge strategy addressing the technical and societal barriers to spread in our social system, innovative eco-efficient packaging able to reduce food environmental footprint. It aims to support users and consumers' access to innovative packaging solutions enabling the reduction and circular management of agro-food, including packaging waste.	Technology, new material	The aim of Glopack is to bring PHA from TRL 3 to TRL 6	GLOPACK (Granting society with Low environmental impact innovative Packaging), H2020 programme
3	ERANOVA	Innovative material	ERANOVA is a French biotech company that develops soft plastic made from seaweed and whose innovations respond to the environmental and sustainable development challenges facing society and the packaging industry	New material	*TRL 6 (estimated)*	Private R&D solution provider

* Technological maturity level

PRODUCTION PILOT ACTIONS

Pilot 1 : Extension of scope and frequency of collection through ADIVALOR device

- *Technical description*

In France, the ADIVALOR organisation is in charge of collecting and recycling waste from agricultural streams. It was created in 2001 by the actors of the agricultural world. It collects different types of waste (plastic, paper) from all agricultural sectors including meat, horticulture and dairy.

- *Feasibility analysis*

Although, the ADIVALOR process could achieve even higher recycling rates with some improvement solutions. Indeed, according the ADIVALOR activity report from 2018, collect rates are increasing and the collect rate for nets and strings is around 39%, which proves the efficiency of the system but also that still too many plastic waste are not recycled. It is possible to increase the rate through more mobilization from farmers.

- *Business & financial plan*

The cost of each specific container is 35€ Excl. T. A functional equipment is composed by 4 containers for a total cost of 140 € Excl. T. Each farmer can buy it but sometimes, suppliers can offer them during promotional operations. For high schools, an operation financed by a Territorial Community can be organized.

- *Environmental analysis*

ADIVALOR tracks waste and publishes a report each year with key numbers regarding the quantity of waste collected and recycled and acknowledges the improvements compared to the previous year. For this, each time they collect waste from farmers, the farmers sign at attestation of collect. The objective is to increase the collecting rate until 90% at minimum.

- *Social analysis*

In terms of waste management, the last ten years have been marked by the development, in regulatory terms, of the concept of «extended producer responsibility»: the «polluter pays» principle applies to the holder of the waste but also to the distributors, manufacturers and importers of the product at the origin of the waste. In France all farmers can contribute to ADIVALOR collecting actions and demonstrate their engagement in inorganic waste management. Moreover, they contribute actively to circular economy through plastic recycling device.

Pilot 2 : Strengthening communication with farmers

- *Technical description*

ADIVALOR and farmer's organizations communicate through different supports to mobilize farmers for waste collecting actions (videos, leaflets, meetings, phone calls, posters etc.).
YouTube and internet websites are used to present videos explaining the preparatory phases for each type of waste so that waste are ready for recycling when collected. The objective is to develop communication tools.

- *Feasibility analysis*

Different ways can be used to reinforce messages. For general messages about collection periods, social networks (Facebook, Tweeter, websites, newsletter) are used to complement the posters, flyers and leaflets that are placed in the warehouses of agricultural suppliers where farmers come for supplies. Information is also disseminated by email and SMS to farmers.

- *Business & financial plan*

The cost of using digital tools (social networks, websites, emails and newsletter) is included in the general operating costs of the organizations. The cost of posters, brochures and leaflets specific to each collection operation depends on the quantity and technological quality of the documents produced (case by case study).

- *Environmental analysis*

A better communication from ADIVALOR and all organisms associated in collecting and recycling device help to improve the quantity of plastic collected.

- *Social analysis*

Different kinds of returns have been expected :
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- Emphasize the awareness-raising aspect on plastic waste through communication

- Increase farmer's mobilization in multiplying communication support (for example set up meeting to discuss between farmers and share ideas and challenges. Those meetings could be organized by chambers of agriculture)

- Encourage mobilization of local public authority and harmonization at regional level

One of the most important problem detected during pilots experiments for meat sector is the difficulties observed in farms in mountains. Climate and geographic conditions (snow, topography,...) is a limit to optimize collecting periods. Except this particular situation, farmers are receptive to new way of communication as social medias. Most of farmers used more and more digital technologies and social medias to improve their practices.

Pilot 3 : Use of specific containers to sort plastics and improve the process

- *Technical description*

The objective is to use new specific containers to sort plastics and improve the process at farm level.

- *Feasibility analysis*

Containers are very easy to install. The farmers or other users, can buy them on internet website from ADIVALOR. But the most easier to get them for farmers, is to contact their suppliers.

- *Business & financial plan*

The cost of each specific container is 35€ Excl. T. A functional equipment is composed by 4 containers for a total cost of 140 € Excl. T. Each farmer can buy it but sometimes, suppliers can offer them during promotional operations. For high schools, an operation financed by a Territorial Community can be organized.

- *Environmental analysis*

The recycling of plastic waste is often distorted due to organic matter, silage or soil remains or, for example, stains on the material. Even if the preparatory phase carried out by farmers includes cleaning, some undesirable products have to be removed. The use of these new containers forces the farmer to be more precise and careful when sorting his plastic waste. The quality is better and recycling is easier.

- *Social analysis*

In addition to actions with farmers, demonstrations can be organised in high school. Students are involved in tests especially in experimental farms in high schools and can test ADIVALOR protocols before joining a farm. It's a very good way to promote waste management with young generations and future farmers.

INDUSTRY PILOT ACTIONS

TECHNICAL DESCRIPTION

In the meat industry, 5 different pilots have been conducted. These pilots relate to:

- Sliced product packaging
  - Thermoforming trays
  - Sealing lines
- Whole ham cooking and packaging bags
- Compote and sauces packaging (Doypack)
- Precooked meals packaging
- On the go dishes (single use cutlery)

The pilots have had an impact on various waste production levels, as shown on Table 5 “products and link to the type of waste impacted in the value chain”. The pilots have impacted the incoming packaging and have minimized the resources taken at the beginning of the cycle, but they also have had an impact on the quantity of packaging used during the product’s production process. Finally, they have also permitted to reduce post-consumption waste through the transformation of the packaging step.

Table 5: products and link to the type of waste impacted in the value chain

VALUE CHAIN WASTE / PRODUCTS	RAW MATERIALS PLASTIC WASTE	PROCESS PLASTIC WASTE	PACKAGING PROCESS PLASTIC WASTE	POST CONSUMPTION PLASTIC WASTE
Sliced product packaging (Thermoforming trays, Sealing lines)			+	+
Whole ham cooking and packaging bags		+	+	
Compote and sauces packaging (Doypack)	+			+
Precooked meals packaging			+	+
On the go dishes (single use cutlery)	+			+

Pilot 1 - Sliced product packaging.

Several alternatives have been analysed to reduce the inorganic waste quantity of sliced product packaging. First, packaging can be conducted using a no skeleton technology that will reduce the quantity of material, and so, of plastic, used. Sealing lines technology can also be used in order to seal mono material such as PP, with for example, under skin technology. In addition, a special attention must be paid to the composition of the material, in order to enable a good optical sorting of the plastic waste. Dark pigments (carbon black type) in the material are not detectable by optical sorting, and components such as blotter, label, and glue can disturb the sorting as well. Thermoforming tray is a very common technology in the meat sector. It enables to have a good shelf –time for the meat products thanks to a modified atmosphere. This packaging is also very efficient from a cost and logistical point of view as the food company receives films rolls and make the packaging on line. But those packaging are composed of many materials, and until now trays and lid were rarely made of recyclable or recycling material. Indeed, to meet the food and preservation standards, the packaging needs to have certain barrier properties (to gas) and food contact abilities.

The solutions which seem to be the most favourable regarding the various quality criteria are those consisting of trays made of single-material or separable materials made up entirely or partly of recycled material. More specifically, the idea is to replace complex materials such as PVC by a material with sorting instruction, for example monoPET, so that the material will be collected and recycled. MonoPET is a mono material that can be thermoformed with the same principle as the one currently used for PVC-PE or other complex materials. The replacement of PVC has a double benefit: environmental and sanitary as this material can induce risks for consumer. It is important, however, to validate the single-material solution in terms of conservation to ensure the desired lifetime.

Pilot 2 - Packaging of precooked meals.

Precooked meals usually require ultra clean trays as they allow the companies to work on sensible products with a lower thermal treatment compared to other preserved food such as can. Ultra clean conditions are required, because there is no thermal treatment after conditioning and until the product’s consumption. It is designed for precooked meals and/or high value products. The idea for this type of packaging is to replace complex material such as PET-PE by a material with sorting instructions, for example monoPP, to ensure that the material will be collected and recycled. This technology upgrade can reduce the waste of packaging of the ready meals industry at post-consumption level. As it is ready-to-eat food, the product portions are small. Thus, the ratio packaging/product is very high and represents an important environmental issue. The use of PP as a single material on the heaviest packaging component is a good solution with regard to the recommendations of COTREP, Centre of experts and resources for plastic packaging recyclability.

- This solution guarantees good sealings unlike the c-PET
- The translucency of the PP offers transparency by contact with the product, which is a criterion expected by the consumer
- This product visibility is not brought by mixed cardboard-plastic solutions which could be an alternative associating material reduction and more marketing

Pilot 3 - Whole ham cooking and packaging bag.

To process ham, the meat is packaged in a first packaging, which possesses specific requirements to resist cooking constraints. After cooking and in order to eliminate the exudates, the ham is unpacked and then packed again in a new film, in which it is pasteurised before the shipping step. The alternative presented here is to use a single packaging that can ensure both functions of cooking packaging and final packaging. To do so, two technologies, still in optimization steps, are currently proposed, using a meat adhesion film and using an in-valve film. These technologies still need to be improved in order to satisfy the quality requirements. Another issue lies on the lack of suppliers for that specific type of double-use packaging.

Using a unique bag for both steps of the process or using a recycled/recyclable material for the bag, are alternatives which do not already exist in the ham industry. In this context where on the one hand the company is very dependent on the technologies offered by the suppliers of machines and materials, and on the other hand there are no well-organized waste recovery channels for this type of packaging (complex and soiled), it seems difficult to envisage an operational alternative. However, this project enables to highlight the needs of the ham industry sector. It is highly recommended, in order to find an efficient solution for the entire ham sector, to set up a shared research and development project at the level of the "ham" sector on the optimization of industrial practices and on technological developments bringing together industrial butchers, technology suppliers, packaging material suppliers, collectors and centres branch techniques. The quantity of films used throughout the sector makes it possible to envisage cooperation not only at national level but also at European level. A study of the deposits of these cooking bags as well as the potential of recyclability of these inorganic wastes has been launched in France to clarify the challenges.

Pilot 4 - Doypack packaging.

Doypack packaging can be a challenge in terms of recyclability as they are composed of multi materials (especially if metal is combined to plastic). Several alternatives have been studied: removing spout and cap decrease the waste quantity, but it also means a loss of use function; removing the aluminium layer still must be validated at sterilization level; incorporating recycled material is a solution still under development that needs to be validated technically and economically.

Pilot 5 - Single use cutlery in on the go dishes.

For a certain number of ready meals or take-out salad, the service is conditioned by the use of disposable cutlery provided with the packaging. However recent regulations at French and European level tend to ban single-use plastic utensils. Several responses can then be provided depending on the company's strategy and its target market:

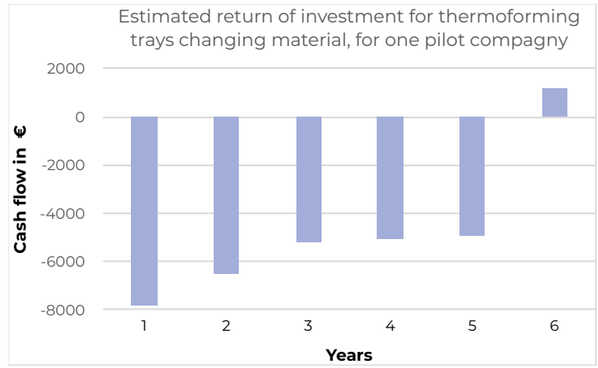
- purely and simply removing single-use plastic cutlery
- replacing them with cutlery made of materials such as wood or even by edible materials
- giving the possibility of using reusable cutlery
- reviewing the concept and the use made by the consumer

BUSINESS & FINANCIAL PLAN

Pilot 1 - Sliced product packaging: thermoforming trays

Nowadays, these alternatives are more expensive, or at least, at the same price than the currently used solutions. However, it is foreseen that their price will decrease. The recycling fee (collected by CITEO in France), should also decrease thanks to the national evolution towards recycling packaging. But as of now, without passing on increases in the sale price of the product or increase in productivity, the return to breakeven would only be done in year 6, as shown in figure 1.
The solutions which seem to be the most favourable regarding the various quality criteria are those consisting of trays made of single-material or separable materials made up entirely or partly of recycled material. More specifically, the idea is to replace complex materials such as PVC by a material with sorting instruction, for example monoPET, so that the material will be collected and recycled. MonoPET is a mono material that can be thermoformed with the same principle as the one currently used for PVC-PE or other complex materials. The replacement of PVC has a double benefit: environmental and sanitary as this material can induce risks for consumer. It is important, however, to validate the single-material solution in terms of conservation to ensure the desired lifetime.

Figure 1: Cost evaluation for one pilot company.



Pilot 2 & 3: packaging of precooked meals and whole ham cooking and packaging bags

There are no estimated costs or estimated return of investment available for these two pilots.

Pilot 4 & 5 – Doypack packaging and single use cutlery

Another example of inorganic waste reduction inducing financial economics: Removing the caps of pouches packaging would save nearly 40,000 euros per year by assuming the purchase of the necessary sealing caps. To this economy, will be added a significant drop in the CITEO fee. The savings made would thus quickly amortize an investment estimated at 100,000 €/year, necessary to update the equipment required for sealing as a replacement for the cap. In the same trend, removal of cutlery with ready-to-eat meal induces plastic and cost reductions.

ENVIRONMENTAL ANALYSIS

Most of the alternatives analysed throughout this project induce the same environmental gain: using fewer raw materials to create packaging and hawing less plastic waste. Using a recyclable material will decrease the waste at post consumption level and enable to decrease the raw material consumption for new material to be made. Using recycled material is, in the same way, decreasing the use of raw material. Using less packaging, for ham production especially, will also decreasing the raw material use.

For the specific companies that have participated in the REINWASTE project, it is also a waste saving, as showed in Table 6.

Table 6: Expected inorganic waste savings for alternatives tested in the pilot companies

N° PILOT	TYPE OF ALTERNATIVES	EXPECTED INORGANIC WASTE SAVINGS	SOURCE OF WASTE SAVING
Pilot 1	Thermoforming trays	**30 %**	Waste will be recyclable
Pilot 2	Ultra clean trays	**30 %**	Waste will be recyclable
Pilot 3	Whole ham cooking packaging bag	**50 %**	Less waste induce
Pilot 4	Removal cap	**25 %**	Less raw material used
Pilot 5	Cutlery	**35 %**	Less raw material used

In table 6, the amount estimated relate to the companies involved in the project, and depend on the volume of production, the specific technology used currently and the alternative chosen.

SUSTAINABILITY ANALYSIS MEAT VALUE CHAIN

PRODUCTION

The pilot experiment carried out in France in the meat industry focused on one hand on the technological solutions, and on the implementation of organizational solutions in farms on the other hand.

On the technological level, the objective was to study the replacement of conventional materials used for example in round bale nets or hay bale twine (Polyethylene, Polypropylene) by compounds based on recycled plastic.
The results demonstrated the excessive fragility of these alternative solutions. Recycled plastic-based products are not strong enough to replace conventional materials. They do not withstand the pressure of round balers. This analysis was confirmed by the results of the Italian pilot. However, the publication of REINWASTE's results in European seminars has made the needs of the meat sector known to rope manufacturers.

On the organizational level, the main objective was to study how to improve the mobilization of farmers in the ADIVALOR system, and to study the feasibility of setting up more practical sorting and collection systems for farmers.

Strengthening communication by making greater use of social networks and digital media is welcomed by farmers. More and more farmers are using these modes of communication and sharing their know-how on improving farming practices on social networks. Nevertheless, REINWASTE's work has shown that depending on the geographical contexts, farmers could be more reluctant to change: this is particularly noticeable in mountain areas where climate and topography complicate inorganic waste collection operations.
In addition, the economic context, which has been severely disrupted by the COVID 19 pandemic, is having an impact on plastic recycling. The sharp drop in the price of oil is prompting plastic manufacturers to favour oil rather than the more expensive recycled plastic.
Finally, tests of specific small containers in the farms were favourable. Their objective is to facilitate sorting and improve on-farm storage conditions. These devices are easy to install and their price is low. Farmers have no difficulty in using them.

INDUSTRY

The 7 different pilots conducted can be grouped into 4 thematic:

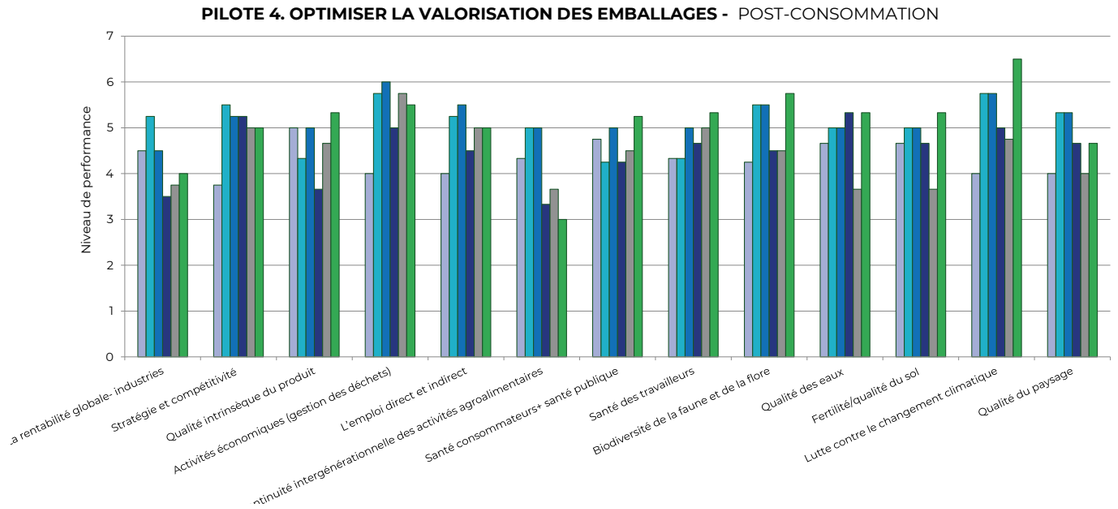
- Reducing Raw materials plastic waste
- Reducing process plastic waste
- Reducing packaging plastic waste
- Optimizing the recovery of post consumption plastic waste

For each pilot, a group of criteria have been determined, such as the profitability, the intrinsic quality, the economic dimension, water quality, but also the social aspects such as worker's health. All criteria have been judged by 5 experts, for each pilot thematic alternative. The average of the 5 scores has been calculated. In the present report is developed the result of the last thematic, regarding the recovery of packaging post consumption, as shown in the graphic below.

For the analysis "Optimizing the recovery of packaging – post consumption", 6 different alternatives have been evaluated:

- **Alternative 0.** Traditional valuation
- **Alternative 1.** Tray and lid made of recyclable monomaterials (PET, PP)
- **Alternative 2.** Tray made of recycled raw material
- **Alternative 3.** Tray made of bio-sourced products (cellulose, other...)
- **Alternative 4.** Tray made of biodegradable compostable expanded bio-sourced products
- **Alternative 5.** Redesign the primary/secondary system: reusable active secondary/reduced primary

Figure 2. Performance level of different criteria regarding alternatives of pilot 4



According to the graphic, no solution is better than the others on all the criteria. Depending on the situation, some criteria will be promoted by the company to choose the most adapted solution.

ADOPTION ANALYSIS OF INNOVATIONS IN THE MEAT VALUE CHAIN

THE ADOPTION OF INNOVATING SOLUTIONS IN THE MEAT PRODUCTION SECTOR

LIMITING FACTORS

From a technical point of view, the main obstacle to the adoption of new types of round bale nets or hay bale twine made from recycled plastic is the lack of strength of the new materials.
On the organizational level, the ADIVALOR system for sorting, collecting and recycling inorganic farm waste has been perfectly operational for about ten years on a national scale. Three factors can still hinder the deployment of collection and recycling operations.
The first is linked to the particular conditions that exist in certain regions in terms of climate (long periods of frost and snow that hinder travel) and topography (mountainous areas where travel is complicated by topography).

The second concerns logistics costs, particularly for the suppliers of farmers (cooperatives, traders, distributors) who offer their services and make their facilities and platforms available without financial compensation. The eco-contribution does not make it possible to finance this part of the system.
The third is linked to the global context. On the one hand, China, which until 2018 agreed to recycle European plastic waste, has decided to close its borders, and on the other hand, the few plants specialized in recycling used plastics in France is disrupting the industry. The economic downturn in oil prices in 2020 following the COVID 19 pandemic has exacerbated this situation.

PROMOTING FACTORS

Plastics manufacturers are aware of the technical difficulties raised by breeders. A rapprochement between manufacturers of plastics for agriculture is underway to study the factors limiting the development of these new technologies and to bypass them.
At the national level, French farmers are very receptive to the management of their inorganic waste. They have been involved since the early 2000s in the collection and recycling of all types of inorganic waste. One way to further promote collection operations is to strengthen direct communication with the farmer. The increasingly frequent use of the media and social networks is a promising avenue.
It is also necessary to test new sorting and collection solutions and to disseminate them to as many farmers as possible when they are operational and relevant.

STRATEGIES TO ENCOURAGE THE ADOPTION OF TESTED ALTERNATIVES

The strengthening of links between farmers, plastics manufacturers and the recycling industry must continue. ADIVALOR and the APE (European Association of Plastic Manufacturers) are structures whose durability must be ensured. At the technological level, work is currently being carried out by these suppliers in the fishing sector to develop products based on compostable materials. The first contacts between the PACA Chambers of Agriculture and the industry should lead to the establishment of specifications specific to the needs of the meat sector in early 2021 in order to create nets and twines adapted and sufficiently resistant based on compostable materials.
The new systems, which are very simple to implement and inexpensive, can easily be disseminated on farms by relying on agricultural development networks and training institutions for future farmers. A large-scale operation is being set up by ADIVALOR with the experimental farms of the country's agricultural high schools. Students will be able to use these new containers and improve the sorting and collection process of plastics on the farms.
More generally, the cost of the collection operations set up by ADIVALOR, agricultural advisory bodies and suppliers is significant. The study of the business model shows that the eco-contribution does not cover all the costs of the collection and recycling chain. It is therefore necessary to mobilize a small part of the public authorities' funds to ensure the sustainability of the system by ensuring a significant leverage effect. This approach is perfectly in line with the S3 strategy in France.

THE ADOPTION OF INNOVATING SOLUTIONS IN THE MEAT INDUSTRY SECTOR

In order to evaluate the potential adoption of the different alternatives, 5 experts have noted different factors and they have defined different strategies to adopt in order to promote the adoption of these alternatives. The results are shown in the tables after.

LIMITING FACTORS

Table 7: Limiting factors in the adoption of the alternatives in the meat industry

LIMITING FACTORS:	AVERAGE (FROM 0 TO 9)
Cost of alternative materials	8,4
Sanitary risks: food contact aptitude	8
Barrier properties: reduced service life	8
Sanitary risks: sealing of packaging	7,8
Incompatibility with microwave cooking/heating	7,8
Reduction of temperature resistance	7,6
Materials availability	6,6
Reduction of mechanical resistance	6,4

The top 3 most limiting factors for the adoption of innovations in the producing meat sector are the cost of the alternative materials (8,4/10), the sanitary risks regarding the food contact aptitude of the material (8,0/10) and the barrier properties that could induce a reduction of the service life (8,0/10).

PROMOTING FACTORS

Table 8: Promoting factors in the adoption of the alternatives in the meat industry

PROMOTING FACTORS:	AVERAGE (FROM 0 TO 9)
Cost reduction	8,8
Respect of law	8,4
Consumer awareness	8,2
Image of a more virtuous product	7
Improvement of company image	6,6
Company commitment in RSE	5,4

The top 3 promoting factors for the adoption of innovation are the cost reduction that could induce a change (8,8/10), but as seen previously, a change can also induce an increase of costs for companies. So, this cost of adoption of an alternative method should be well considered, in short and long term, to determine if it would mean an increase or a decrease for the company. Then, the respect of law (average 8,4/10) and the awareness of consumers (8,2/10) are also important promoting factors. The others are all above 6, except for the company commitment that is medium, with 5,4/10.

STRATEGIES TO ENCOURAGE THE ADOPTION OF TESTED ALTERNATIVES

Strategy to promote the adoption of the tested pilot alternatives

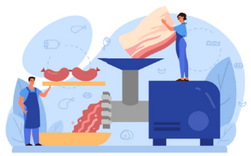
1. Political recommendation: encourage companies to adopt alternative solutions thanks to regional and national technical et financial supports

2. Encourage research and development project about new alternative solutions

3. Regional support for companies who are willing to put alternative solutions in place

4. Raising awareness of consumers

Four strategies to promote the adoption of the tested pilot alternatives have been proposed by the experts. Support for companies that would encourage them to adopt alternative solutions, at a regional or at a national level. Also, encouraging research and development on this topic and the raising awareness of consumers are strategies worth considering.



REINWASTE INNOVATIVE SOLUTIONS SERVICE

PROPOSAL OF A SERVICE FOR THE MEAT PRODUCTION SECTOR

GENERAL DESCRIPTION, TARGETED GROUPS AND SCOPE OF THE SERVICE

The operation of the sorting, collection and recycling chain is based on the principle of shared responsibility between all professionals in the agri-supply industry.
This system requires the voluntary commitment of the different actors of the agricultural profession. It has proven its effectiveness in France.

POTENTIAL USERS AND THEIR INTERESTS ON THE SERVICES

Marketers, industrialists or importers contribute to the financing of the various collection and recovery programs through a specific eco-contribution.
Professional users, mainly farmers, sort, prepare and bring in their waste on the dates and at the locations set by their collection operators.
Collection operators collect used plastics from farmers.
Used plastics are recycled in specialized plants.

SERVICE FEASIBILITY

To contribute to the development of a sustainable agriculture, respectful of the environment, the professionals of agro-supply, industrialists, distributors and farmers, have created ADIVALOR, a private, non-profit eco-organization, whose mission is to organize the collection and recovery of agricultural inputs at the end of their life.
Its missions are :

- operational organization of the recovery and treatment of Used Agricultural Plastics (UAP),
- technical support to operators of used agricultural plastics collection,
- animation of the network of service providers in recovery and recycling,
- development of a research and development program aimed at improving the recovery and processing of used agricultural plastics,
- dissemination of information and communication on the operational aspects of the sector.

Some key figures :

- approximately 70 agricultural plastics manufacturers involved (7.5 M€ in turnover)
- Global sales: 83,400 tons of which animal production: 66,900 tons (silage, wrapping, net, net round bales, livestock building)
- PAU volumes collected by ADIVALOR: 61,390 tons (including staining) of which animal production: 40,260 tons.
- Overall collection rate: 60%.

PROPOSAL OF A SERVICE FOR THE MEAT INDUSTRY SECTOR

GENERAL DESCRIPTION, TARGETED GROUPS AND SCOPE OF THE SERVICE

In a regulatory context aimed at eliminating single-use plastic packaging by 2040, and with consumers more sensitive to the fate of their waste, companies using plastic packaging must be aware of and reduce their plastic footprint. CRITT Agroalimentaire PACA, an active member of networks of experts on packaging and environment, offers to carry out a diagnosis of plastic packaging. This diagnosis could be implemented remotely or on–site if possible. It will enable companies to identify the sources of reduction of their environmental impact (and indeed their economic impact).

The objective of the present service is:

- To identify «plastic and environmental» issues within companies;
- To evaluate ways of improvement;
- To recommend solutions applicable by the company in the short and medium term.

This service is carried out as follows:

1 day of data collection, to visit the premises (if on-site diagnosis), interview staff (production, packaging, purchasing, etc.) and then for collection and analysis of data on the company packaging.

½ day for suggestions for improvement and writing a summary report:

- An analysis of the management of your packaging
- An update on the cost of packaging / packaging waste for the company
- Proposals for areas for improvement
- Contacts for the reduction of packaging at source, or the search for alternative packaging
- Transmission of elements and potential exchanges on these elements

POTENTIAL USERS AND THEIR INTERESTS ON THE SERVICES.

The new European directive about banning of single-use plastics in 2021, as well as the French EGALIM law and finally the draft circular economy law, are pushing companies to reduce the use of plastics in their finished products. The potential users of this service are all companies which package their products in plastic trays, bags, jars or other single-use plastic packaging. Companies that prepare pre-cooked dishes are also concerned for the disposal of plastic cutlery. The service will enable them to identify sources of savings in the management of packaging, from design to marketing.

SERVICE FEASIBILITY

To cover the platform launching and management labour it is possible to implicate national eco-organisms like CITEO for instance in France. Those eco-organisms could host or support this type of web platform. Inputs required in order to feed the platform:

- REINWASTE public deliverables
- Regulatory watch on plastic packaging in Europe
- Innovative solutions tested in Reinwaste countries and value chains
- Existing catalogues and publications related to plastic diagnostics

RECOMMENDATIONS FOR THE MEAT VALUE CHAIN

PRODUCTION SECTOR

1. It is essential to mobilize the eco-contribution system within the framework of Extended Producer Responsibility (ERP). The financing of the recycling of agricultural plastics is possible thanks to the contribution of marketers, industrialists or importers.

2. It is necessary to create a legal structure that brings together all the players in the recycling chain, from farmers to the industrial recycler (example: ADIVALOR in France).

3. The operation of the collections is ensured thanks to the agricultural distribution, cooperatives and traders, which provides its logistical and human resources.

4. The agricultural development organizations (Chambers of Agriculture, technical groups, experimental stations) ensure the animation of the system. They organize the setting up of collection and ensure the communication of information to farmers (calendar, collection points, sorting methods, etc.).

5. Farmers must be sensitized and trained to ensure correct sorting and to correctly inform the traceability system. Farm organizations must accompany them.

6. The public authorities can facilitate the mobilization and development of this system by financing :
- Certain phases of collection (e.g. in agricultural areas with severe handicaps).
- Programs to test and disseminate good practices to farmers.
- New recycling plants in Europe.

INDUSTRY SECTOR

1. Complexity of integrating a new technology in a company is linked to its know-how, to the types and number of products manufactured and the requirements of its own customers.

2. Suppliers can offer companies an easier integration of alternatives technology such as thermoforming by proposing new packaging associated to the corresponding technology.

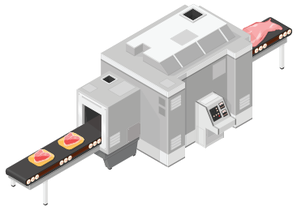
3. As for the whole ham cooking and packaging bags pilot, there is no available technology. The whole profession being concerned it seems interesting to think together about the evolution of technologies with the other actors, film and equipment suppliers, technical centres, recyclers.

4. Recommendations for the meat value chain:
- Refine the functional specifications and packaging purchase
- Benchmark technological solutions
- Validate the choices by an environmental impact study (eco-design, simplified LCA)
- Associate a communication towards customers
- Participate in collaborative research programs associating professionals in delicatessen and packaging
- Think about setting up local energy recovery systems for the non-recycling waste.

POSITION PAPER

MAIN RESULTS

The results of the pilot's actions, equally distributed on primary sector and food industry, carried out over 3 supply chains (meat, dairy, horticulture), have inspired the Regional Action Plans. These documents provide recommendations to policy makers and sector operators to continue the actions started within REINWASTE, aimed at reducing inorganic wastes, addressing the next steps to be adopted in each regional context to foster a more circular economy.
The main propositions to minimize the inorganic waste and EU Funds for 2021-2027 are listed below:
For pilot projects in R&D and innovation, use of biodegradable or compostable films, recycled & recyclable materials such as mono-material instead of multilayer, packaging optimization (reducing thickness, avoid unnecessary packaging) and Public-private partnerships to transfer solutions to commercial phase.
Is it also important to promote actors involved in the reduction of inorganic waste: farmers, agro-industries, waste managers, institutions, by extending the support for the use of new materials and improve waste management through associative models, EPRS (Enterprise resource planning System), traceability, valorisation plants, collection points, infrastructures for correct management of new materials.
In order to improve empowerment and abilities around waste management, different actions can be done: mentorship and consultancy for farmers and agro-industries to reduce inorganic waste, when possible, having a new teams members specialized on waste and, reinforce networking between actors to create new collaborations.
Last but not least, an effort must be done to inform and aware consumers in order to promote proper management of food packaging by clarifying differences among materials (compostable, biodegradable, bioplastics, etc.).



INSIGHTS FROM THE REINWASTE EXPERIENCE

Over the course of the REINWASTE project, several alternatives of various kinds have been tested and promoted, depending on the region and sector targeted by the project's partners. In Italy, the solutions focused more about biodegradable or compostable material. In France, the use of recyclable materials has been encouraged. As for Spain, eco-design, optimization, compostable and recyclable materials were the fostered alternatives.

Independently of these solutions, a major point must be highlighted regarding post-consumption inorganics wastes. The companies do not control the becoming of the packaging: the consumer is responsible for the sorting and the municipalities must be well organized to have an efficient sorting of inorganic waste. Moreover, every recyclable plastic is not necessarily recycled, even if it reaches a sorting center, mainly due to the fact that there isn't a recyclable chain for every kind of plastic.

As an example, for France, a real improvement will be done at the collect stage because by 2022, there will be an extension of the sorting instructions and all consumers will be instructed to sort all plastic packaging (rigid or flexible). This extension will not mean that all collected plastics will be recycled but that the collecting rate of all the recyclable plastics with recycling branch will hopefully increase.

Considering the three agri-food clusters participating in the project, it could be said that the sector, both in its agricultural and industrial chain, has a medium-high degree of general knowledge of the problem of waste in the sector, and they express an important concern in this matter. However, the general knowledge of the alternative solutions available on the market to reduce inorganic waste could be classified as medium or in some cases, medium-lower.

AGRICULTURAL SECTOR

Primary sector consider the waste problem as an important issue. Currently, there is a great opportunity to advance zero waste in the primary sector as this sector has shown a high predisposition to implement innovative solutions that minimize or avoid the generation of waste. In the future, policies and the design of socio-economic strategies should be focused on the main limiting factors for innovation: high costs and the lack of alternative materials. The sector considers it is necessary to promote research on the use of biodegradable materials or, at least, greater innovation in eco-design to reduce the use of plastic materials or facilitate the elimination of residual material. And, those alternatives should be universally validated for all farms. At the same time, the sector and the experts demand incentives and trainings.
Furthermore, the sector perceives that some alternatives currently on the market, like for example raffia and plastic mulch, do not fulfil the entire technical requirement. In this sense, the lack of research areas in productive areas is also perceived as a limiting factor for the adoption of innovation.

Some of the recommendations that can be put forward as strategies to build on the strengths of the agricultural sector are the following:

- Promote research and transfer of results of sustainable alternatives through different channels: field trials, workshops, videos in social networks, etc. and whenever possible in the productive areas
- Promote quality certifications related to respect for the environment, specifically the reduction of inorganic waste
- Promoting the existence of specific managers for each type of waste and improving the network of easily accessible collection points (green points) where waste can be delivered at an affordable cost in the immediate surroundings of the production areas.
- Developing a regulatory framework that includes all types of inorganic waste in a differentiated manner, guaranteeing their correct management through a system of extended responsibility.
- At the same time, the sector and the experts demand incentives and trainings

INDUSTRIAL SECTOR

The industry sector is highly conscious about the problems associated with packaging waste.
The companies have a good predisposition to implement innovative solutions such as: use of rPET, investment in machinery to replace plastic packaging by bands and eco design in primary and secondary packaging.

However, any change in packaging systems needs feasibility assessment to assure food safety. This last point is crucial for sensitive products, (meat for instance), shelf life of the production can be very short. A reduction of the packaging waste should note lead to an increase on food waste.

Innovative sustainable materials are available, the cost is expected to decrease in the next few years. Because of that, plastic should continue to be used, though in a wiser manner (i.e., optimisation of packaging materials in view of the best end-of-life and eco-design. R-PET, recycled polyethylene terephthalate represents an opportunity for plastic waste reduction since it allows a good circularity of plastic (return to the same use)).

There are several limiting factors such as: the high costs, the sanitary risks concerning the food contact aptitude, and the barrier properties. In addition, the sector perceives that the alternative material for packaging can induce a sanitary risk for the sealing. Policies and the design of socioeconomic strategies must therefore be aimed at reducing, minimizing, or eliminating this type of limiting factors.

The recommendations for the future to take into account are, from a political point of view, to display regional technical and financial supports for companies and to raise awareness of consumers.

Some of the recommendations that can be put forward as strategies to build on the strengths of the industry sector are the following:

- Lower plastic use by packaging light weighting allows reducing fossil sources exploitation and waste streams
- Compare bioplastic packaging environmental advantages to conventional systems with Life Cycle Assessment studies
- Use monomaterials to improves recyclability levels
- Implement an environmental contribution that considers the potential environmental impact of packaging and fixes a fee inversely related to recyclability
- Adopt non-destructive control systems prevents waste generation at the quality control level

CONCLUSIONS

We face environmental and productive challenges that, at times, are antagonist, but must yet be met with common solutions. To do this, the involvement of public administrations and the reflection of such challenges in public policies are absolutely necessary, but it is also fundamental to involve companies and citizens.

The Reinwaste project is already contributing and can contribute even more in the achievement of these objectives of sustainable development. The project has been an excellent planning exercise, and allows its members to continue working on waste reduction at the regional level, creating synergies between international agri-food clusters. The results show that solutions on the market are decisive to reduce inorganic waste from agriculture and industries, but there is still a long way to go, from research and development on new biodegradable materials to the training of professionals in the agri-food chain, without forgetting the improvement of the consumer's awareness.

The European Green Deal, as a new strategy for the growth of Europe, makes a new call to promote the circular economy, and consequently to continue working on the development of new markets for climate-neutral and circular products. This new framework offers financing opportunities, an important engine to continue working on reducing waste in all sectors of the economy, investing in environmentally friendly technologies, and supporting innovation in companies and industries.

As for us REINWASTE project partners, we will continue to collaborate for the sustainability, at the International, European (with the European Green Deal Call), national, regional and local levels. We encourage all the stakeholders involved in the project to contribute to guarantee that Southern Europe, and the Mediterranean area in particular, continues being a great place to live and work for future generations.

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