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REPORT

Labeling scheme for agricultural plastic wastes in Europe

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Abstract

Introduction The extensive and expanding use of plastics in agriculture results in increased accumulation of plastic waste in rural areas. The majority of this waste is left on the field or burnt uncontrollably by the farmers releasing harmful substances affecting human health, the safety of the farming products and the environment. *Materials and Methods* Specific key scientific challenges have been set to be resolved in the framework of this project through integrated pre-normative research activities that are associated with the characterization of the stream, meeting the specs, expanding the specs of the disposal processes by defining the technical requirements and limits for achieving technical and economically feasible solutions for each disposal option. *Results* A holistic environmentally sound waste management scheme that minimizes the costs and maximizes the revenues by transforming the agricultural plastic waste streams into labeled guaranteed quality commodities freely traded in an open market has been developed by the LabelAgriWaste project. *Discussion* Pilot tests have been run to optimise the scheme parameters and quantify the potential, the efficiency and the impact of the *LabelAgriWaste* scheme. The proposed solutions to the unresolved problems are expected to be achieved through the implementation of the LabelAgriWaste scheme. *Conclusion* The labeling management scheme proposed is designed to be technically feasible, economic and able to satisfy the geographic diversity and the various technical requirements of the major stakeholders throughout Europe, including farmers, plastics producers, recyclers and industrial facilities utilizing alternative fuels for energy production.

Agricultural plastics

The growing use of plastics in agriculture has enabled farmers to increase their crop production. Today's use of plastics in agriculture results in increased yields, earlier harvests, less reliance on herbicides and pesticides, better protection of food products and more efficient water conservation. In general, an estimated 2–3 million tons of plastics are used each year in agricultural applications world-wide (European Bioplastics; Plasticulture). Almost half of this amount is used in protected cultivation (greenhouses, mulching, small tunnels, temporary coverings of structures for fruit trees, etc., Figure 1). The vast majority of the protected cultivations area covered by plastic materials is dominated by the use of plastic made out of polyethylene (Briassoulis, 2005). In particular, low-density polyethylene is the most widely used polyethylene grade, due to its relatively good mechanical and optical properties, combined with a competitive market price.

Agriculture uses more and more plastic within Europe. The major applications are protected cultivations in the Mediterranean area and silage films in the north. The total amounts of Agricultural Plastic Waste (APW) generated in

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Figure 1 Use of agricultural plastics in the form of low tunnel, high tunnel and mulching films.

Figure 2 Agricultural plastic waste disposed in the fields and landfills.

several countries of Europe were estimated by the LabelAgriWaste project.* Some indicative estimated total amounts of APW are as follows: Spain 190 kt year^{-1}; Italy 210 kt year^{-1}; France 133 kt year^{-1}; UK 76.1 kt year^{-1}; Greece 30 kt year^{-1}; Finland 8.5 kt year^{-1}; Cyprus 0.86 kt year^{-1}.

Although the use of plastic by agriculture does not exceed 4% of the total plastic used (European Plastics Converters), the use is concentrated in some particular areas of intensive cultivations within a country (farmland). This fact facilitates their collection. Because within a specific rural region of the country the same cultivations take place, the agricultural plastics used by the majority of them are similar and they are removed at the same time of the year. So, the APW generated at a regional level is rather homogeneous, concentrated geographically and is generated at specific time periods each year (within a couple of weeks) except for silage films, bale wraps and related plastics. This makes its management particularly attractive. Unfortunately, this plastic may be heavily contaminated with soil, pesticides, stones, vegetation and other organic waste. The contamination level depends on the type of application, on the care taken during use and on the removal practices and storage conditions of the plastic waste in the field.

The problem of APW today

A major negative consequence of the expanding use of plastics for protected horticulture is related to handling the plastic wastes and the associated environmental impact as only a small percentage of the constantly rising amount of APW is currently recycled (this varies, however, from region to region or country and depends on the plastic category, e.g. most of silage films and bale wraps are recycled). A large portion of this is left on the fields or buried or burnt uncontrollably by the farmers releasing harmful substances with the associated obvious negative consequences to the environment and possibly for the safety of the food produced. In particular, in several European countries, the following 'mispractices' for managing the APW (or some categories of it, depending on the country, region, available disposal option, etc.) have been observed.

*LabelAgriWaste, http://LabelAgriWaste.aua.gr, 'Labelling agricultural plastic waste for valorizing the waste stream,' Collective research, LabelAgriWaste, Contract no. 516256-2; Project Coordinator: Agricultural University of Athens, Greece; Starting date: January 15, 2006, End day: July 14, 2009, 18 partners: European Association of Plastic Converters and Recyclers, Agricultural Associations, Universities and Research Institutions.

Figure 3 Mulching film during use (left) roto-tilled into the soil at the end of the cultivation season, irreversibly polluting the soil with polyethylene film remains (right).

Figure 4 Uncontrolled burning of low tunnel films in the fields following the removal of the films late in the spring.

Disposal of APW in the fields and landfills

The consequences of disposing APW in the fields or landfills (Figure 2) may be described as follows: *Aesthetic pollution and landscape degradation of regions of natural beauty and touristic areas; Threat to domestic and wild animals; Blocking of water flow through water channels; Overload of landfills with an immediate environmental and financial impact; Loss of material and energy.*

Burying of APW in the fields

The consequences of burying APW in the fields (Figure 3) may be described as follows: *Degradation of soil quality characteristics; Irreversible soil contamination; Possible danger for the safety and quality of the food produced in such fields.*

Burning of APW in the fields

The consequences of burning APW in the fields (Figure 4) may be described as follows: *Release of harmful substances with negative consequences to the environment (water, soil and air)*; *Release of harmful substances with negative consequences to the human health*; *Possible danger for the safety of the food produced in such fields with negative commercial impact*.

Toxic substances, including dioxins (Andreasen & Fitz, 2006), released to the environment (soil, water, crops, produce) through uncontrolled burning of APW, may enter the human body through direct exposure (breath, skin, etc.) or indirectly (bio-accumulated and introduction into the food chain).

Legal framework relevant to the APW chain

The reasons behind the APW mismanagement and the illegal practices observed are quite frequently the unawareness of their environmental and health impacts by the farmers and local authorities. Those situations are also favored by the lack of specific legislation at the European or national level dealing with the APW. There is limited local/regional legislation that is not uniform across regions (Liantzas *et al*., 2007).

The APW is considered solid waste and as such it is not allowed to be burned or buried uncontrollably. In particular, the European legal framework forbids:

1. *the uncontrolled burning (The Incineration Directive (Directive 2000/76/EC)* (EN. 2000)
2. *the uncontrolled burying of the waste (The Landfill Directive (Directive 99/31/EC)* (EN. 1999)
3. *the uncontrolled discarding (Revised Waste Framework Directive '2008/98/EC, including directive on Hazardous Waste (91/689/EEC)* (EN. 2008)

Despite this, every year tons of APW are burnt or uncontrollably disposed to the environment. However, the European legal framework states: *In accordance with the 'polluter pays' principle, the cost of disposing of waste must be borne by [ix]: the holder*[†] *who has waste handled by a waste collector or by an undertaking contractor and/or the previous holders or the producer*[‡] *of the product from which the waste came.*

The lack of a technically efficient, cost effective and environmental friendly APW management scheme in most European countries, or the inefficiency (technical and/or economic) of the existing schemes (with a few exceptions, applicable to certain categories of APW in some European countries), also facilitated by the lack of a European scheme for APW, is the main reason why the farmers, without any intervention or control on the part of the local authorities, apply the aforementioned illegal practices for disposing their APW.

Existing APW schemes

Characteristics of existing schemes

A few national or regional schemes have been developed through Europe. Several good elements of the existing schemes were incorporated to LabelAgriWaste but the main difference is that these schemes focus on managing the waste and not on valorizing it by treating it as a marketable product. In addition they exhibit the following limitations:

Selectivity: They target only some good quality materials for recycling (e.g. bale wraps).

Sustainability: The sustainability of existing schemes depends strongly on oil prices; if they are low, it is quite possible that no interest is expressed by recyclers even for good quality recyclable materials since recyclate prices do not cover recycling cost (based on the experience of 2009).

Free riders: No mechanism is provided to prevent non-contributors from profiting from the waste management scheme.

Cost: Economic inefficiencies increase the cost of the scheme that is born, in the majority of the cases studied, directly or indirectly by the farmers. These inefficiencies are: (a) The absence of a competing market causing the prices for the APW to be set by local industries. (b) The waste management operations are not optimized. (c) The absence of clear specs and economic rewards for the APW does not provide the necessary incentives to the farmers to justify their effort. (d) The absence of traceability and poor policing favor non compliance.

Legal framework: In cases when APW materials are not collected (e.g. due to low oil price) or are not included in the existing schemes (e.g. APW from mulching film that is difficult to recycle), there is no solution for managing these APW materials and there is no control on the fate of these materials either.

The LabelAgriWaste project

Objectives

The serious environmental problems related to the management of APW at European level, led to a European research project LabelAgriWaste (LabelAgriWaste), aimed at developing an economically viable scheme for the collection and valorization of the APW destined for recycling or energy recovery. After completing a study of existing schemes (for APW and for other waste streams) and a study of the existing legal framework and the legal tendencies, a first labeling scheme for APW was designed, tested and improved with subsequent version through a series of pilot tests (Briassoulis *et al*., 2008; Hiskakis *et al*., 2008a, b).

The main objective of LabelAgriWaste was to develop standardized procedures and integrated methodologies to label the APW streams in order to facilitate their routing to the best alternative processing and final disposal, that is the most environmental friendly and economically valuable and technically feasible solution. The LabelAgriWaste developed standardized procedures and integrated methodologies to label the APW streams through optimum processing (most environmental friendly, economically valuable and technically feasible) in order to facilitate their routing to the best final disposal alternative. The technical objectives of the project included:

- Transform used agricultural plastics into a commodity that can be transported across boundaries, traded in the open market and routed to the best alternative processing and disposal.
- Develop a systematic labeling scheme and policy recommendations for the appropriate disposal and/or utilization of the APW. This will support relevant standardization Comité Européen de Normalisation (European Comitee for Standadization) (CEN) and other legislation activities for cleaner environment and economy of natural resources.
- Develop farming practices that will improve the quality of the plastic waste.

[†]Holders' (the producer of the waste or the natural or legal person who is in possession of it).

[‡]Producers' (anyone whose activities produce waste).

• Maximize the range of the specs a waste stream should meet to qualify for a processing/disposal option.

Methodology

Organization of research work

The following steps describe the methodology used for the development of the scheme:

Analysis of the existing situation

1. Development for first time of a reliable mapping of the APW chain (quantities, compositions, disposal practices, disposers, quality requirements and limitations, etc.) and the legal framework in Europe.
2. The agricultural and packaging plastic waste schemes and other schemes around Europe were analyzed (operations, equipment, productivity, cost, sampling, analysis, etc.) through visits, interviews and literature surveys, as a source of ideas and an opportunity for synergetic stream consolidation.

Pre-normative research activities and evaluation of alternative labeling schemes

1. Pilot stations were established in Greece, Spain, France and Italy to identify problems, collect real data and test alternative procedures. Multiple trials in each pilot station allowed testing several alternatives, incorporating incremental improvements.
2. Universal quality specs for the APW were established by understanding the disposal processes and by focusing on the inherent limitations of the process instead of the factory specific limitations. The economic implications of the above specs were analyzed and the specs were circulated extensively in order to accept the required acceptability by the industry.
3. Innovative cost efficient wastes sampling and analysis methods (to quantify the above mentioned specs) were specially designed for the APW stream.
4. The APW chain process was analyzed from the manufacturing of the plastic to its delivery to the disposer through traceability, sampling, analysis and recording its detailed history in order to identify the factors affecting its quality (as this was defined by the previously mentioned specs) and correlate cause and effect. This led to a quality control scheme for the APW chain providing early detection and remedial actions.
5. The optimization of the process was achieved by combining the best technologies from the pilot trials with the best technologies observed and measured through visits and the best technologies reported or documented in the literature for each step of the APW chain. Costs, productivity, resources utilization and environmental print were calculated for each step.

This methodology culminated in the formulation of a final APW management scheme, consisting of:

1. Development of Labeling Scheme.
2. Definition of the role of each actor (e.g. plastic producers, farmers, local authorities, collection station, etc.) in the proposed Labeling Scheme.
3. Detailed operational guidelines for the key actors involved.
4. Definition of universal specifications for the various APW streams and exploitation-disposal options to transform them to commodities.

The final scheme and its operational justification and details have been supported through the development of:

1. Detailed sampling methodologies specific for APW.
2. Detailed analysis methodologies for the APW specs appropriate to the APW streams.
3. A quality control scheme over the entire APW chain with decision points and remediation actions.
4. A detailed list of alternative equipment options, productivity and costs for each step of the APW chain to provide technological and economic guidance for the optimum implementation of the scheme.
5. Life Cycle Assessment (LCA) analysis of the proposed scheme to provide environmental justification.

The research work methodology described above led to the development of the final LabelAgriWaste scheme, which is presented briefly in the following sections (the detailed technical components of the scheme will be published separately).

The LabelAgriWaste scheme

Basic principles of proposed labeling scheme

The proposed LabelAgriWaste labeling scheme is shown schematically in Figure 5. It is based on the following basic principles:

a. Traceability from the plastic converters level and the suppliers to the farmers and the collection area and final disposal.
b. Labeling of the plastic waste and the preferred or allowed disposal options.

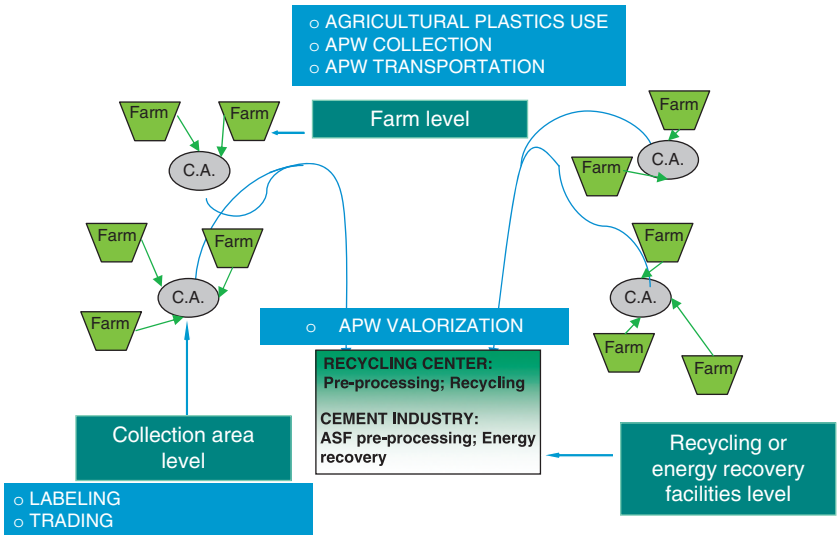

Figure 5 Schematic diagram of LabelAgriWaste labeling scheme.

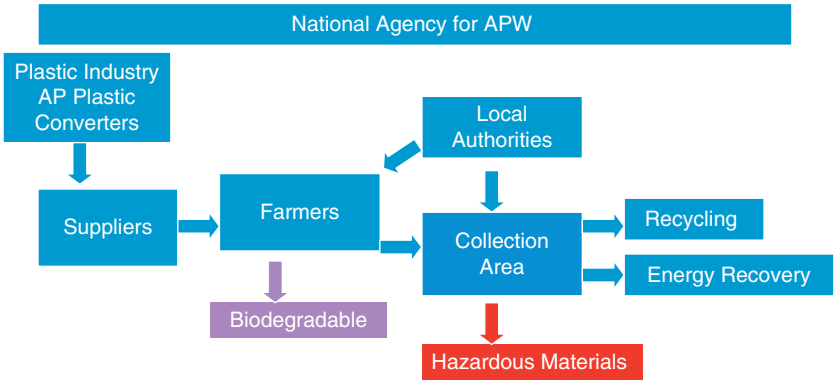

Figure 6 The agricultural plastic waste (APW) chain according to the LabelAgriWaste labeling scheme.

c. Specific guidelines for the use, collection, transportation and treatment of APW.
d. Financial scheme including payments and refunds to be controlled by a national agency in close cooperation with the associations of farmers and plastic converters.
e. Legislation framework implementation; penalties envisaged by existing European legislation.

The role of the parties involved in the APW chain through the LabelAgriWaste scheme

The main parties involved in the APW chain according to the LabelAgriWaste labeling scheme are shown schematically in Figure 6. The role of each party is briefly outlined below:

Plastic industry and AP plastic converters and importers: assure traceability of AP in all kinds of materials to be handled through the LabelAgriWaste scheme by disclosing coded information that might impede in disposal of the plastic produced; assure compliance of the virgin material with the disposal specs; provide use and removal instructions to the farmers.

Suppliers of agricultural plastics: assure traceability of AP put in the market: make sure that the materials sold are labeled according to the LabelAgriWaste scheme to allow for the APW to be handled accordingly; provide AP use and disposal instructions to the farmers; provide the farmer with the documentation to be used during the use of AP and delivered along with the APW to the collection area manager.

Farmers: follow very simple and practical guidelines for the use and installation of new plastic materials, and for the removal, sorting and storing the APW; record and report use of AP and application of agrochemicals following the guidelines; remove AP from the field and bring to the collection station.

Local authorities: provide area for the collection station; offer instructions and organizational and dissemination support to the farmers; policing the proper implementation of legislation.

Collection area managers/SMEs operating collection areas: organizing and equipping the collection station; recordkeeping (traceability); accepting and sorting the APW; sampling of sorted APW; sending samples for quality analysis; labeling analyzed APW; responsible for marketing issues and for selling the labeled waste for recycling or trading it for energy recovery, as appropriate; responsible for identifying and handling cases of hazardous waste (according to labeling scheme; in synergy with relevant schemes); responsible for taking action for unacceptable material in cooperation with the local municipalities.

Recycling industries and energy recovery (cement) industries: bid for the available APW; provide certification of disposal; offer suggestions on the improvement of the quality of the APW.

National agency for APW: collect funds from all parties involved in the AP chain; supervise and fund the scheme providing transparency/accountability; assign and inspect the collection station operators; provide updated information and adequate dissemination of the LabelAgriWaste scheme, follow up of the complete recycling process and consequent adjustments after a certain period.

The technical component of the LabelAgriWaste scheme

The goals of the labeling scheme may be summarized as follows: better sustainability of plastic use in agriculture, environmental soundness, efficiency, economy and fair distribution of costs. The technical means incorporated in the labeling scheme to achieve these goals include:

- Traceability/accounting/transparency.
- Standardization/Marketability for creation of open market.
- Best technology.

Traceability/accounting/transparency

The traceability/accounting/transparency represents a key technical component of the Labeling scheme. The accountability of the material put in the market is expected to promote environmental friendliness. The elimination of free riders through traceability/accounting/transparency will result in a fair distribution of cost. The simplification of the sorting, analysis and processing operations achieved through traceability/accounting/transparency will result in efficiency and economy. The transparency on the funding will be controlled by the National Agency.

The information encoded will ensure that the material can be handled through the LabelAgriWaste scheme, provide all basic information concerning elements that might impede in the disposal of the plastic produced following the LabelAgriWaste specs for each particular disposal option and allow for easy tracing of the material throughout the APW stream.

Standardization/marketability for creation of open market

The aim of standardization is to produce a waste stream that satisfies the recyclability/alternative fuel specs. The introduction of technical specifications in the proposed scheme transforms the waste into a product that can be freely traded. The APW stream-certified (i.e. Labeled) meets proper specs that satisfy the basic requirements of the recyclers/alternative fuel users across Europe. It also provides quality goals to meet through the waste chain management.

The technical issues involved in the standardization introduced in the labeling scheme include the following requirements:

- The proposed specs should satisfy the majority of the recyclers/alternative fuel users across Europe, considering also process particularities.
- The specs should be realistically met by the APW stream. This is achieved through the proposed best practices and the quality control scheme established through pilot tests.
- Ability to test the waste stream with simple cost-effective techniques. This is achieved by taking advantage of the traceability system combined with visual inspection and correct sorting to simplify the sampling requirements and minimize the need for analysis.

Best technology

Identification of the most adequate plastics traceability, deinstallation and removal methods of the used plastic in cultivations, sorting, and consolidation techniques, storing,

baling, sampling, analyzing, labeling and transportation, etc. for accountability and quality assurance of material through the agroplastics chain.

Disposal – valorization options

The possible end-of-life options for the labeled APW depend on the characteristics and quality of APW as compared with the specs defined by LabelAgriWaste. In general, APW is labeled as acceptable for:

- *Recycling* (two qualities). Two sets of specs were adopted based on the two distinct processes for the mechanical recycling: specs for APW acceptable to be recycled into pellets for film extrusion process (labeled Quality I) or APW acceptable to be recycled into profiles (labeled Quality II);
- *Energy recovery* (two qualities). These specs concern the non-recyclable APW that may be used as Alternative Fuel (first step: Alternative Solid Fuel Processing) to satisfy the needs of the Energy Recovery Industry (second step: Energy Recovery in Cement Factory): do not alter the productivity of the cement factory; do not increase the maintenance cost of the kiln; do not lead to harmful emissions; do not affect the clinker quality.

The quality control scheme

Based on the results of the pre-normative research work a quality control scheme has been developed (see previous section on methodology) and incorporated into the labeling scheme.

This scheme aims at achieving the best quality waste with a given agricultural plastic. It defines the check points within the APW chain, the parameters tested at each check point and the decision criteria including the remediation actions (details are presented in the corresponding research papers).

In addition to the quality optimization it allows traceability, accountability and transparency. These are some elements that compromised the success of previous schemes.

The financial component of the LabelAgriWaste scheme

The basis of the Financial Scheme is the establishment of a National Agency (NA). This agency is composed of the main stakeholders (i.e. farmers associations and the plastic converters and importers, possibly with the participation of local authorities) to ensure transparency, simplicity and efficiency. The participation in this agency of all the stakeholders and only the stakeholders gives an incentive to all parties to work synergetically to adopt the optimum solution and assures its acceptance by all the parties. Simultaneously, this approach does not represent an additional burden to the national administration. This synergy will ensure the minimization of the cost for the farmers as compared with the current situation. Two very important roles of this agency are the constant evolution of the scheme by resolving any operational or technical problems and supporting the dissemination and implementation of the scheme and the operational sustainability by constant adaptation to the economy.

The NA will be responsible for the execution of the proposed labeling scheme of LabelAgriWaste at the national level. All parties involved in the APW chain will bear a percentage of the APW management cost financed through the NA. The NA should be financed directly through a contribution by the plastic industry/importers/dealers, but also financed indirectly by the farmers (and eventually consumers), as a percentage of the direct contribution of the plastic industry will be transferred through a transparent scheme to all other parties involved in the APW chain (i.e. it will be finally shared among the producers, suppliers, farmers, etc.). In that way all parties involved will bear a percentage of the APW management cost. Note here that the APW management cost in the LabelAgriWaste scheme is lower than the cost of other APW management schemes since on the cost side LabelAgriWaste in addition of optimizing the cost, it provides economy of scale through waste consolidation in a well-established collection station and increases the revenues by improving and guaranteeing the quality of the waste and by freely marketing the waste to the highest bidder. The administrative cost of the collection station and the NA are calculated to be minimal.

The analysis of the possibilities or of alternative scenarios for supporting the implementation of the proposed scheme by national or EU funds (e.g. through subsidies) is beyond the scope of the present work as it concerns the relevant policies and politics and it remains open.

The cost categories involved in the management of APW include: removal from the field (e.g. for mulching); sorting and transportation to collection area; collection station (administrative, sorting/baling/loading-unloading/storage, traceability/sampling and analysis/labeling), transportation to final disposer; disposal cost (e.g. energy recovery of non-recyclable APW) or revenue (e.g. recycling).

The overall financial model of the LabelAgriWaste scheme and the sharing of cost among stakeholders are presented schematically in Figure 7. In particular, the overall financial

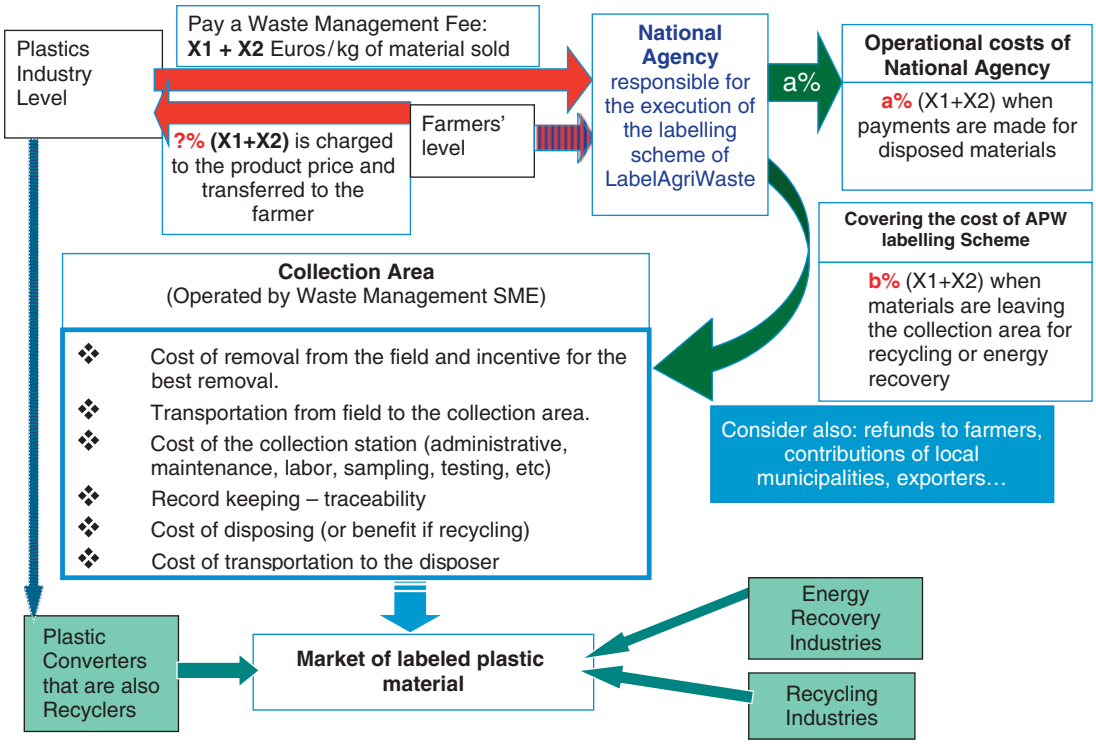

Figure 7 Schematic diagram of the financial components of the labeling scheme.

model of the LabelAgriWaste scheme may be described as follows:

- The plastics industry (raw material producer/converter/dealer/importer) is charged with a pre-defined by the NA waste management fee (X1+X2) Euros kg^{-1}, on the material put in the market.
- This waste management fee is collected by the NA responsible for the execution of the labeling scheme at the national level.
- A percentage of the waste management fee (contributed directly by the plastic industry to the NA) will be transferred through a transparent scheme to the farmers as a charge on the market price of the plastic products sold to farmers. The percentage of the waste management fee to be charged to the farmers is to be decided at the level of each NA.
- The municipalities and/or another party may provide the land and the infrastructure of the collecting areas where the plastic waste is to be collected.
- The NA contracts and supervises the management of the collection stations run by SMEs.
- The NA funds the SME, which is in charge of the management of the collection station based on the product provenance and quantities disposed. This is done according to the plan decided by the NA.
- The SME which is in charge of the management of the collection area is partially funded by the NA and partially by the revenues from the product to be recycled. Their expenses in addition to the operating and administrative costs may also comprise a refund to the farmers who transport themselves the APW from their farms to the collection station.
- The recyclers are usually paying for the product depending on its quality.
- The energy recovery units (comprising the pre-treatment of the alternative fuel and its combustion) may expect to be paid.

Therefore, in this scheme, the total APW management cost is assumed by the Plastic Industries/Converters/Importers and the Farmers through the Waste Management Fee they pay to the NA. The Waste Management Fee is composed of two components, X1 and X2:

- *X1 WMF component*: This is a flat waste management fee (Euro kg^{-1}) defined as a percentage of the price of total quantities of the material that are put on the market. It covers the total cost of the agricultural plastic chain from removal from the field to recycling for the best APW.
- *X2 WMF component*: This is a variable cost (Euro kg^{-1}) additional to X1 that reflects the additional costs over the base waste processing cost of the best material. It varies

depending on the material and product (i.e. polyethylene film, EVA film, pipes, etc.) and on the particular application of this material (mulching film, greenhouse film, etc.).

The NA is responsible for the execution of the labeling scheme of LabelAgriWaste. All parties involved negotiate and reach a voluntary agreement at the NA level on:

- Estimation of total cost for the full operation of the labeling scheme of agricultural plastics. The total cost, initially quantified through the pilot tests, may be revised as needed by the NA with the agreement of all parties involved.
- Way of sharing of total cost and collecting the funds (logistics).
- Distribution of the funds to cover the full operation of the labeling of agricultural plastics, based on the control of the collection areas managers (traceability, control and transparency).

The legal component of the LabelAgriWaste scheme

The overall legal framework of the LabelAgriWaste scheme is compatible with the existing general European Legislative framework mentioned earlier that need to be enforced. It must be emphasized, however, that the Revised Waste Framework Directive '2008/98/EC [ix] does not include specifically the category of the APW. Therefore, there is no legal basis for establishing the LabelAgriWaste scheme for APW under the current version of the Revised Waste Framework Directive '2008/98/EC [ix]. It is very important that the category of APW should be included in the next revision of the waste Framework.

At the moment, implementation of the legislative framework for APW should be based on the enforcement of the existing general Waste Framework Directive referring to the principles of 'producer responsibility' and 'polluter pays.' The experience gained with the legal component of simpler schemes already implemented in a few countries only for selected categories of recyclable APW suggest that there is a need of enforcement of a relevant legislation.

The steps to implement the LabelAgriWaste scheme for the management of APW may be summarized as follows:

a. Establish the required infrastructure (e.g. a network of collection areas in synergy with local authorities and the NA and the parties involved).
b. Reach a voluntary agreement on the total cost for the full operation of the labeling scheme of agricultural plastics at the NA level.
c. Implement the proposed final labeling scheme through the existing legislation described above (until a specific legal basis is incorporated in the next version of the Waste Framework Directive).
d. Disseminate the scheme, including the legal issues and train all parties involved.
e. Enforce penalties only when and if needed.

The proposed LabelAgriWaste scheme represents a standardized labeling scheme for APW to meet the European environmental legislation related obligations of all parties involved in the APW chain, in a well-justified way at European level.

Conclusions – The justification of the LabelAgriWaste scheme

Expected benefits for the industrial sector

A higher quality cheaper and labeled plastic waste stream for the recycling industry and the industry exploiting APW as alternative fuel will be available at European level through the open market. Business opportunities are also expected for the waste management and certification companies cooperating with the recyclers, cement industries and other end users of APW.

Benefits to plastic producers from LabelAgriWaste

As far as the plastic converters are concerned and their '*producer responsibility*' and their obligation according to the '*polluter pays*,' principle, under the current situation, they face several problems. These problems are expected to be solved through the implementation of the *LabelAgriWaste* scheme as follows:

The '*free riders*' problems through the *traceability*; the fact that there are no clear targets for *environmental friendly products* by the clear compositional *specs*; the *lack of transparency* on APW management cost through the operation of the NA that *assures transparency*. The *lack of accountability* on APW management through the combination of the NA operation and the implementation of traceability that *do assure accountability*. The *differences in contributions* according to national or local legal framework through *European harmonization*.

Benefits to farmers from LabelAgriWaste

For the farmers, their obligations against the '*polluter pays*' principle, and the solution of the major problems arisen

from the current illegal practices of management of APW with respect to the environmental friendly production of safe for the consumer products are to be met through the implementation of the *LabelAgriWaste* scheme as follows:

The *lack of clear targets* for the management of APW through the established *quality specs*. The *lack of clear operational instructions* through the established *guidelines and training material* and *quality control and remediation actions*. The *lack of operational and cost optimization* through the proposed Best Available Technology (*BAT)* that allows reduction of operational cost and improvement of productivity and the *open market trading* of APW to recover cost by selling to highest biter. The *lack of quantification of farmers contribution* to APW management (consolidation cost) through *costing*. The *lack of mechanisms to absorb yearly cost variations* due to the oil price variations and other external factors through the *National Agency intervention* and *consolidation of all APW categories* to profit from synergies (higher and lower value APW streams).

Benefits to waste management enterprises from LabelAgriWaste

The waste management enterprises are also expected to benefit from the implementation of the *LabelAgriWaste* scheme as follows:

The '*difficulties in trading outside the local market*' are to overcome through the universal specifications expected to be adopted by the majority of European Recyclers and Energy recovery plants. The *lack of clear operating requirements* through the *guidelines and training material, quality control and remediation intervention* and *sampling and analysis methods*, and also the application of the designed *decision making tree*. The *lack of accountability and sustainability* through the *National Agency accreditation and funding*. Finally, the lack of operational optimization through the adoption of the proposed *BAT*.

Benefits to recyclers and energy recovery from LabelAgriWaste

The recyclers and energy recovery industries are expected to benefit from the implementation of the *LabelAgriWaste* scheme as follows:

The *uncertainty on quality* is to overcome through the *guaranteed quality specs*. The difficulties in getting APW *outside the local/national market* through the *open European market to* allow for best offers and *competitive pricing*.

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