Increased EU Plastics Recycling Targets: Environmental, Economic and Social Impact Assessment

Final Report

Prepared for Plastic Recyclers Europe

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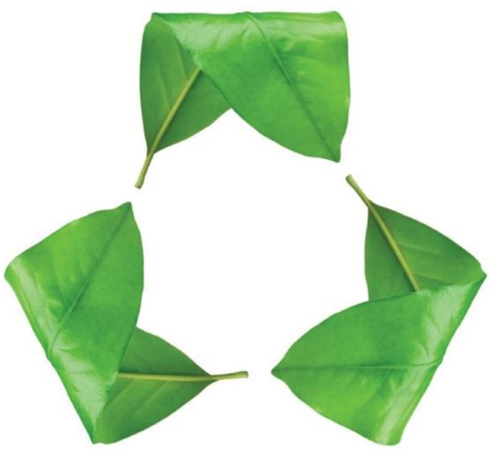

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Executive Summary

Plastics are valuable materials covering a wide range of applications in everyday life and are found everywhere, from households to industry. Plastics have the potential to be recycled many times while retaining their value and functional properties. However, within the EU-28, a large share of this material (74%) is currently wasted, either sent to landfill or incinerated for energy recovery.

In the context of a Resource Efficient Europe, increasing the reuse and recycling of materials is considered a high priority for realising the vision of a circular economy within the EU. The European Commission's recent Directive proposal, amending several waste related EU Directives (COM(2014) 397 final), includes proposals for higher targets for the recycling of different waste streams and materials and specifically includes significantly higher recycling targets for plastic packaging waste (45% by 2020 and 60% by 2025), as compared to the existing ones. This would require considerable expansion in the recycling of plastic waste in EU-28.

Taking into account the aspirations of the EU to increase recycling, both in quantity and quality, this report aims at highlighting the potential impacts of increased plastic recycling in EU-28 through an environmental, economic and social impacts assessment of recycling projections in 2020 and 2025.

The quantification of increased recycling impacts in EU-28 was enabled by the creation of a plastic waste management flow model, analysing in detail the potential future waste flows of plastics and the influence of the increased recycling targets within the different waste management options.

The scope of the impact assessment includes the plastics waste management value chain, beginning at the end-user's generated plastic waste until the production of final recycled plastic materials (e.g. flakes, pellets) at the output of the recycling process.

Plastic waste constitutes a wide range of waste types arising from many different economic activities, but in the scope of the impact assessment, only post-consumer plastic waste arising in six waste streams are considered, namely: Packaging waste, Waste from Electrical and Electronic Equipment (WEEE), End of Life Vehicles (ELV), Building and Construction waste (B&C), Agricultural waste, and 'Other plastic' waste which is a broad and non-specific category including all other types of plastic waste that might arise from various waste streams, excluding the five aforementioned waste streams.

The indicators analysed in the impact assessment of increased plastic recycling include the net operating costs (including investments), Greenhouse Gases (GHG) emissions and the potential of direct job creation (together with estimations about indirect jobs) along the entire waste management value chain of plastics.

Waste flows and modelling

In order to determine the minimum amount of plastic waste required to meet the proposed recycling targets, a bottom-up approach was used by first setting recycling targets for each individual waste stream according to the existing and proposed EU legislation (or in the absence of these, set voluntary targets by the industry), followed by defining the collection and treatment rates required to meet these targets (for detailed presentation of targets by waste stream, see Annex I and Table 2).

For the first time in EU legislation, in COM(2014) 397 final, the proposed recycling targets for the packaging waste stream refer to the output of the recycling process. The target setting within the plastic value chain model follows this approach and all the targets for the future scenarios have been calculated as 'output' targets for all the waste streams.

The plastic waste model includes the following steps in the waste management chain of the six waste streams defined in the scope of this study:

1. Collection of the plastic-containing waste (including transportation to sorting facilities);
2. Pre-treatment and sorting of the collected waste into different plastic resins (for ELV and WEEE, dismantling and sorting are modelled together);
3. Transportation of the sorted plastic resins to recycling facilities and other management options;
4. Recycling by type of resin;
5. Final disposal or energy recovery of plastic waste not collected for recycling and plastic waste from pre-treatment/sorting and recycling operations.

The model includes a *Baseline* scenario where the current situation (reference year 2012) and all associated parameters are analysed in detail. Using the *Baseline* as a point of departure, four possible future scenarios were developed, which refer to the years 2020 and 2025. Within each of these future reference years, two possible scenarios are explored:

- Firstly, a "business as usual" (*BAU*) scenario where no additional effort is made to improve recycling performance and the recycling rates remain the same as the Baseline.
- Secondly, an "EU Targets" (*Targets*) scenario where the EU recycling targets, as expressed in EU Directives, proposals or ambitions, are achieved.

It is important to stress the fact that imports and exports of plastic waste are excluded from the plastics waste value chain model and the calculations for the amounts required to meet the EU recycling targets. There are several implications which would distort the future recycling rates in EU-28 at the 'output' of the recycling process. Currently, the recycling rates are calculated as waste sent to recycling, including waste exported for the purpose of recycling. However, despite the fact that around 50% of plastics waste collected in the EU is exported, it is not always clear what happens to the exported waste and whether the conditions of recycling meet the standards set by the EU. The declared purpose for recycling therefore might not be upheld by the receiving parties overseas. Furthermore, the amounts calculated in EU-28 MS (Member State) pertaining to recycling exports might not have been recycled or used as intended. For these reasons, recycling rates accounted for at the 'output' of recycling overseas would be difficult to track and measure.

Impact assessment results

In order to calculate the impacts of increased recycling in EU-28, the two scenarios defined in the plastic waste value chain model (*BAU* and *Targets*), respectively for 2020 and 2025, are compared.

The results of the impact assessment show very positive results in saving considerable amounts of GHG emissions and in creating thousands of indirect and direct jobs within the EU economy. Moreover, the costs for achieving these results is quite moderate and certainly feasible:

- High environmental benefits, in terms of GHG emissions savings, demonstrate the significant contribution of plastic recycling in improving the sustainability of the EU-28 while at the same time safeguarding precious resources within the EU economy, making it more resilient to external pressures. Increased recycling performance, by fulfilling EU existing and proposed targets, could save up to 8 Mt of GHG emissions per year by 2020 and up to 13 Mt by 2025.
- In the aftermath of the recent economic crisis, increasing the recycling of plastics will have a reinvigorating effect to EU employment. It is estimated that nearly 50 000 new jobs could be created directly in the recycling value chain of plastics by 2020, with over 75 000 additional indirect jobs supporting the sector and its operations. By 2025, employment could increase considerably by 80 000 direct jobs and 120 000 indirect jobs.
- The economic impacts of increased EU recycling targets appear in a moderate cost range, around 1 billion EUR by 2020 and 1.45 billion EUR by 2025. These costs could be reasonably tackled by EU, national and market investments in the sector, e.g. with Public-Private Partnerships (PPP) and Extended Producer Responsibility (EPR) systems. The net cost incurred in the plastics recycling value chain, due to increased recycling in EU-28 in the future scenarios, could be compared to the annual participation costs to EPR systems, e.g. for packaging. For 2020, the net cost of 1 billion EUR corresponds to roughly 40 EUR/tonne of plastic waste generated while the EPR annual participation fees for the recycling of plastic packaging (e.g. green dot, etc.) reach much higher values than 40 EUR/tonne.

However, there are still a few challenges which need to be addressed in order to achieve high recycling in reality. Setting high targets is a prerequisite to spur higher recycling performance but would not necessarily lead to increased recycling if existing barriers within the plastics recycling value chain are not successfully overcome. Challenges for increasing plastic recycling in EU-28, both in quantity and quality include:

- Increase collection of plastic waste – ensure sustainable inputs to recycling industry;
- Increase the EU-28 recycling capacity;
- Limit exports and retain plastic waste as a valuable resource within EU-28;
- Increase demand of recycled plastics;
- Enhance recyclability of plastic-containing products – improve eco-design.

Glossary of terms and acronyms

Term/Acronym	Description
ABS	Acrylonitrile-Butadiene-Styrene
B&C	Building and Construction
CA sites	Civic Amenity sites
C&I	Commercial and Industrial
ELV	End of Life Vehicle
EPR	Extended Producer Responsibility
EU	European Union
FTE	Full time equivalent
GHG	Greenhouse Gases
LCI	Life Cycle Inventory
MBT	Mechanical Biological Treatment
MRF	Material Recovery Facility
MS	Member State
MSW	Municipal Solid Waste
"Other plastic waste"	*Other plastics stream* include bulky plastic waste and plastic waste not included in the other five waste streams, namely Packaging waste, WEEE, ELV, B&C waste and agricultural waste.
"Other plastic resins"	*Other plastic resins* include all other plastic resins used for manufacturing of plastic products except the six plastics resins specifically analysed in this report, namely PET, PE-HD, PE-LD, PP, PS and PVC.
PA	Polyamide
PE-HD	High Density Polyethylene
PE-LD	Low Density Polyethylene
PET	Polyethylene Terephthalate
PO	Polyolefin
PP	Polypropylene
PRE	Plastics Recyclers Europe
PS	Polystyrene
PUR	Polyurethane
PVC	Polyvinyl Chloride
RDF	Refuse Derived Fuel
SRF	Solid Recovered Fuel
WEEE	Waste Electrical and Electronic Equipment
WFD	Waste Framework Directive

1. Introduction

1.1. Context and objectives of the study

Plastic products are omnipresent in our everyday life. They are an extensively used material in a number of industries e.g. automotive, electrical & electronic, building & construction, and food & beverage sector, and their use is constantly rising (in packaging, construction, telecommunications, electronic equipment and extending to other novel applications). Their unique properties, such as strength, rigidity and flexibility, combined with affordability and durability, make plastics an interesting alternative to other materials (e.g. glass, metal, wood etc.).

The plastics industry is therefore an important sector of the European economy. Due to the distinctive properties of plastic, as well as its growing innovative applications, the production volume of this material will continue to grow. As a result, the amount of plastic waste is increasing. However, only 26% of plastics waste is recycled in Europe (EU-27, Switzerland, Norway), and almost 40% of plastics go to landfills (PlasticsEurope, 2013). Therefore, more emphasis should be put on plastic recycling in order to achieve environmental sustainability and promote circular economy in the EU.

The overall objective of the project is to carry out an assessment of the environmental, economic and social impacts of increased plastic recycling in EU-28, by 2020 and 2025, according to proposed and existing targets in EU legislation, as well as targets found in sector voluntary agreements (e.g. VinylPlus).

1.2. Structure of the report

The structure of the report follows the methodology undertaken by the project team, as follows:

- Definition of the scope of the study (section 2)
- Review of the legislative recycling targets and waste flow overviews defined by the prerequisite of achieving these targets (section 3)
- Modelling of the waste management chain for future scenarios according to the targets presented in section 3 and definitions of the parameters that influence the waste flows in each step of the waste management chain (section 4).
- Environmental, economic and social impact assessment based on the prospective waste management chain defined in sections 3 and 4 (section 5).

The assumptions and parameters that are used in the plastics waste management value chain modelling are based on a comprehensive literature review as well as close consultation with Plastics Recyclers Europe (PRE) to ensure good representativeness of recycling figures, while ensuring the workability of the model.

Disclaimer

All numerical values appearing in this report represent **average EU-28 values** and should only be interpreted in this way. The actual values applied in different Member States of the EU might be different (higher or lower) and therefore no direct comparison to individual MS values should be assumed by the reader. The average EU-28 values are the product of literature review performed during the course of this study, or estimations, assumptions and aggregated EU-28 data provided by Plastic Recyclers Europe (the European association of plastics recyclers representing over 115 members across Europe).

2. Scope of the impact assessment

The study was carried out within a specific scope, targeting the waste management value chain of plastics, as agreed between the project team and Plastic Recyclers Europe. The scope is summarised below:

1. **Players covered**: the study covers the waste management chain from the generation of plastic waste by the end user, to the production of final recycled plastic materials (e.g. flakes, pellets). Plastic converters are not included in the scope.
2. **Plastic waste studied:** All post-consumer plastic waste (including industrial, commercial and municipal waste) that can be found into six distinctive waste streams: Packaging waste, Waste from Electrical and Electronic Equipment (WEEE), End of Life Vehicles (ELV), Building and Construction waste (B&C), Agricultural waste, and 'Other plastic' waste which is a broad and non-specific category including all other types of plastic waste that might occur outside of the five aforementioned waste streams.
3. **Recycling targets**: the study considers targets found in the recent EC Directive proposal COM(2014) 397, as well as targets found in existing Directives, 2008/98/EC on waste, 2000/53/EC on end-of-life vehicles, and 2012/19/EU on waste electrical and electronic equipment. Non-legislative targets were also considered for the waste streams of B&C waste and agricultural plastic waste, based on best practice agreements.
4. **Timescale**: 2020 and 2025
5. Geographical scope: EU-28
6. **Indicators covered**: operating costs (including investments) and revenues (**economic**), Greenhouse Gases (GHG) emissions (**environmental**), direct jobs (**social**)
7. Steps included within the scope of the studied chain (see Figure 1):
    - Collection
    - Sorting
    - Trading and material preparation
    - Material Recycling
    - Disposal/Energy recovery

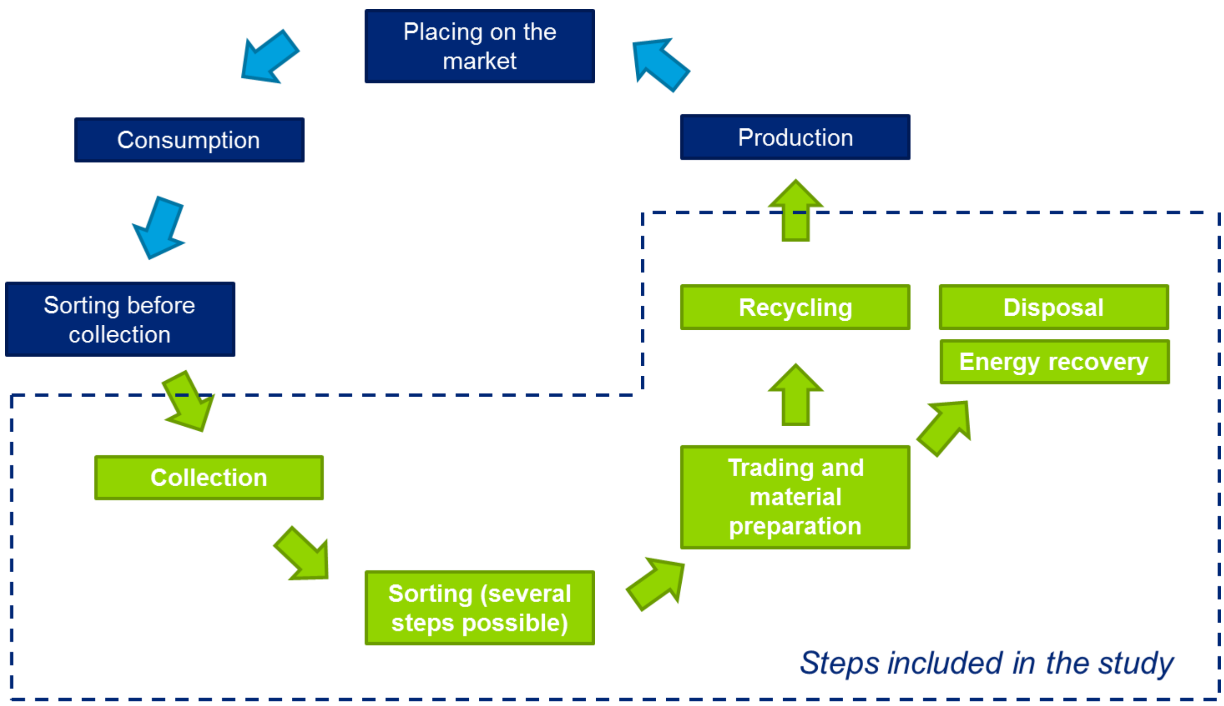

Figure 1 : Steps included within the scope of the impact assessment

3. EU plastic waste flows and recycling targets

In order to determine the amounts of recycled plastic waste that would be required to achieve the EU policy targets, both existing and proposed, the project team built waste flow overview tables, following a bottom up approach, to ensure consistency of the modelled situations. These tables have been extrapolated to future scenarios (2020 and 2025) and can be found in Annex I.

Two elements were of primary importance for the construction of the tables: firstly, the projected amounts of plastic waste generated in EU-28 by type of waste; and secondly, the use of the appropriate targets for each waste stream, as they result from EU Directives and the recent proposal of revised targets amending certain Directives (COM(2014) 397 final). Further assumptions were employed in order to get results that reflect the potential recycling situation in 2020 and 2025. The baseline data for the projections refer to the latest data available, which are data on plastics waste generation and treatment from 2012 (Plastics Europe, 2013).

In addition, any assumptions made for potential future improvements (by 2020 and by 2025) in the pre-treatment and recycling efficiencies in the different plastic waste streams are currently within the conservative range of 2-5 %. This is to avoid any technological overestimation, since future developments remain unclear based on the current European economic and infrastructure deployment situation.

Table 1 shows an example of the calculations for the plastic packaging waste stream. The inputs to the calculation tables which determine the amounts of waste going through the recycling value chain are visible. These inputs are the amount of plastic packaging waste generated (in light green) and the level of the target (in dark green: in this case, it is 45% as set in EU legislation (COM(2014) 397 final). Major assumptions which influence the amounts of plastic waste going through each step of the recycling chain are highlighted in blue colour. In the following sections, a thorough explanation of the inputs and the assumptions employed for the construction of the tables is provided (see the corresponding section number in the left column of Table 1). The full tables for the target years 2020 and 2025 can be found in Annex I.

Important note: Imports and exports of plastic wastes were excluded from the calculation for the amounts required to meet the EU targets.

The regulatory framework concerning the reporting of waste exports in relation to EU targets is currently unclear. Although there are several guidance documents by Eurostat on how to report waste exports, MS do not follow a uniform reporting methodology and therefore data on recycled amounts of waste are not directly comparable between MS. This is influencing the calculation methods for the targets as well. For example, France is not reporting the exported amounts of waste for recycling while on the other hand the UK does. In the recent proposal for amendments of certain EU Directives on waste, it is stated that the recycling rate will be measured in relation to the output of the recyclers in Europe. Exports for recycling can be reported on top of recycling within the MS, as long as the exporters can prove that the recycling processes followed abroad is equivalent to those in the EU. However, the regulatory framework that would enable this is still to be defined: **as a result, the model considers that plastic recycling should be carried out on EU-28 territory in order to ensure that the processes meet the EU standards.**

It is the aspiration of the EU to ensure that all waste is treated properly according to high EU standards and in a sound environmental manner. The EU is aiming at taking the responsibility for the treatment of plastic waste and keeping it under control so that all treatment operations, and especially plastic recycling, are performed with the highest possible environmental and technical standards, in order to produce high quality materials that can be reintroduced back to the economy. In addition, by avoiding exports for recycling, the EU can save GHG emissions from transport overseas.

Imports on the other hand do not affect the recycling targets but use additional capacity in the EU recyclers' facilities. Although it would be relevant to include imports for this reason, the amount of the EU imports from non-EU countries is not estimated substantial when considering the geographical scope of EU-28, even if imports could influence the modelling of scenarios (e.g. by requiring additional capacities for recycling, without increasing the achieved recycling rates).

Table 1: Example of targets calculation table for plastic packaging waste in 2020 (quantities in the table are expressed in Tonnes)

Section number	Target table 2020	
3.2	**Waste generated**	17 191 433
3.3	*share of recyclable plastics rate*	*80%*
	of which, recyclable plastics	13 753 146
3.4	*Disposal rate*	10%
	Landfilled waste	1 655 832
3.4	Energy recovery rate	20%
	Waste sent to energy recovery	3 518 643
3.5	*Collection rate*	*70%*
	Waste collected for recycling/going to sorting	**12 016 958**
3.6	*Pre-treatment process efficiency*	*85%*
	Pre-treatment output	**10 214 415**
	EU Recyclers inputs	**10 214 415**
3.7	*"Input" recycling rate*	59%
3.8	*Recycling yield*	*76%*
	EU Recyclers outputs	**7 736 145**
3.9	Recyclers and pre-treatment waste	4 280 813
	> incinerated	2 910 953
	> disposed	1 369 890
3.1	*"Output" recycling rate, of waste generated*	***45%***

In order to get a better overview of the waste flows through the recycling value chain of plastic packaging waste, as determined by the target table (Table 1), Figure 2 exemplifies the steps and the losses in the value chain. It is worth mentioning that the targets proposed in COM(2014) 397, for the first time in EU legislation, refer explicitly to the recycling rate at the output of the recycling processes and not the input, which was the case until now. The targets are analysed in more detail in section 3.1.

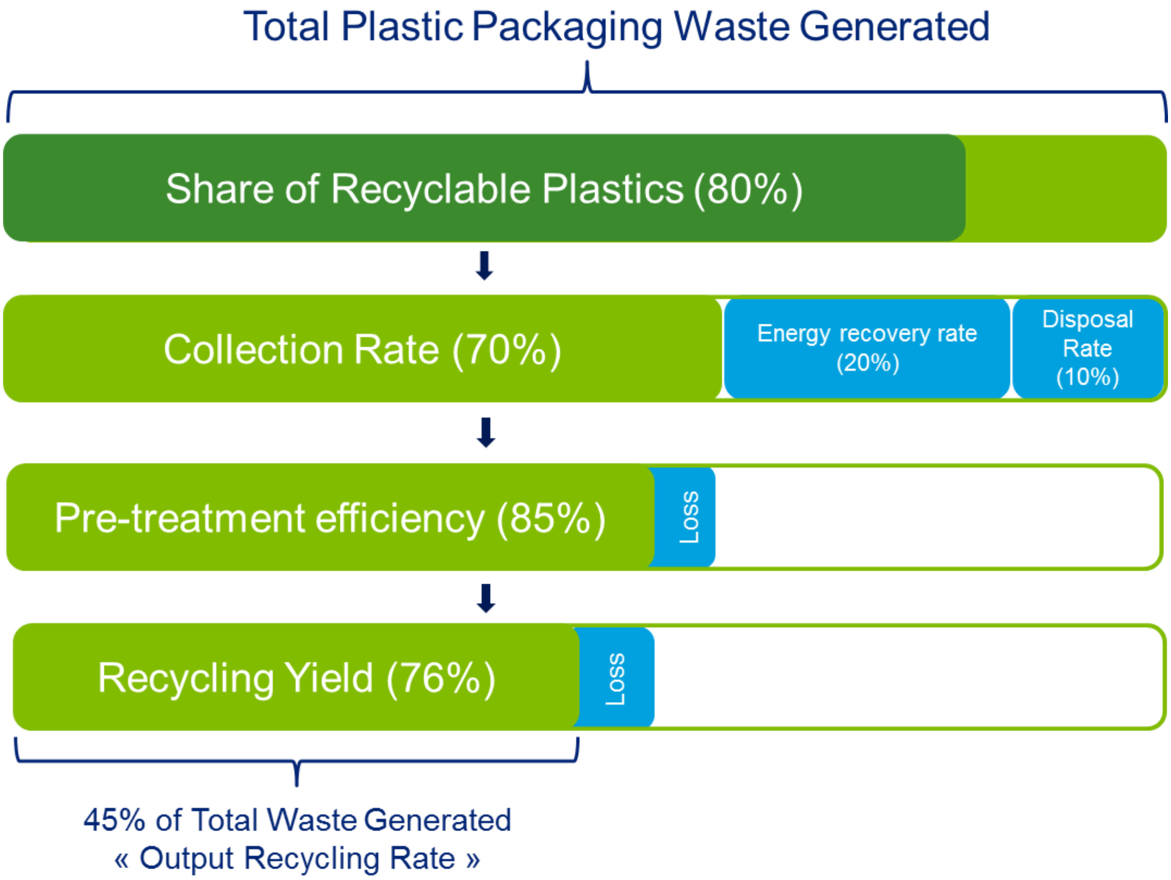

Figure 2: Illustration of the Packaging waste stream losses in 2020

3.1. Recycling targets and output recycling rates by waste stream

In this section the recycling targets in EU legislation are presented. The targets are either specifically targeting waste plastics or refer to a certain waste stream (e.g. WEEE) which can contain mixed materials. The targets identified derive from existing legislation or draft proposals by the European Commission (see Annex III for further details). Where specific targets for a waste stream were not found in legislation, targets by material or waste stream were determined (e.g. PVC recycling targets concerning B&C waste) by employing good practices and/or voluntary targets by the industry. Table 2 lists all the targets, stating the source and the rationale behind the specific targets selection. Mandatory targets (or targets resulting from regulations through some adaptation) are presented in green cells, while voluntary targets are presented in blue cells. Further analysis by waste stream follows in the sub-sections below.

For the first time in EU legislation, in draft COM(2014) 397 final, the recycling targets proposed for the packaging waste stream refer to the output of the recycling process. The target setting in the modelling of the plastic value chain follows this approach and all the targets for the future scenarios have been calculated as 'output' targets for all the waste streams. The detailed calculations and full target tables are found in Annex I.

Table 2: Plastics recycling targets considered for 2020 and 2025, by waste stream

Target	2020	2025	Source
Packaging recycling	45%	60%	2020 & 2025: COM(2014) 397 targets
WEEE recycling (of collected waste[1])	45%	55%	2020: Directive 2012/19/EU target, weighted average of the different targets by WEEE categories. The rate presented here represents the share of plastics in WEEE that needs to be recycled for reaching the overall target in the Directive 2025: Target progressively increased (estimation)
WEEE collection	85%	85%	2020 and onwards: Directive 2012/19/EU target
ELV recycling	30%	35%	2020: Directive 2000/53/EC, based on plastic content in ELV. The rate presented here represents the share of plastics in ELV that needs to be recycled for reaching the overall target in the Directive. 2025: Target progressively increased (estimation)
Building & Construction recycling	36%	41%	2020: Target adapted according to the VinylPlus target for 2020 and plastic content in B&C waste. 2025: Target progressively increased (estimation)
Agricultural recycling	30%	35%	2020: Target at the output of recycling corresponds to the voluntary 'collection for recycling' target of 70% proposed by APE Europe[2]. 2025: Target progressively increased (estimation)
Other plastic waste recycling	5%	7%	2020: Plastic content in MSW (except packaging waste) that needs to be recycled for achieving the WFD target of 50% for 2020. 2025: Target progressively increased (estimation)

By combining all the targets and sub-targets in Table 2, a recycling target of 36% (recycling output) for the total plastic waste generated in EU-28 by 2020 is established. The target increases to 46% by 2025 (Annex I).

Currently, the recycling rates are calculated as waste sent to recycling (including pollution), including waste exported for the purpose of recycling. However, it is not always clear what happens to the exported waste and whether the conditions of recycling meet the standards set by the EU. The declared purpose for recycling therefore might not be upheld by the receiving parties overseas and the amounts calculated in EU-28 MS (Member State) as exported for recycling, might not have been recycled or used as intended. For these reasons, **imports and exports of plastic wastes were excluded** from the calculations for the amounts required to meet the EU recycling targets.

[1] The other recycling targets are always related to generated waste.
[2] http://www.apeeurope.eu/missions-objectifs.php

3.1.1. Plastic packaging waste

For 2020, the 45% output recycling target is set for plastic packaging waste (see COM(2014) 397 final). The target for recycling of plastic packaging waste rises to 60% (COM(2014) 397 final) in 2025.

3.1.2. Waste Electric and Electronic Equipment (WEEE)

There are varying recycling sub-targets for different categories of WEEE, as described in Directive 2012/19/EU (see Annex III), applicable from 15 August 2018 onwards. These targets however are related to the collected amounts of WEEE and not the generated WEEE. Taking into account the fact that pre-treatment and sorting of plastics in WEEE still shows very low efficiency and the fact that recycling of other materials in WEEE (e.g. metals) contribute mostly to the fulfilment of the targets, the potential share of recycling of WEEE plastics seems to play a limited but nonetheless important role in fulfilling the WEEE targets. A realistic target to set for plastic recycling in WEEE is assumed to be 45% in 2020, which reflects the low sorting and pre-treatment efficiency but at the same time stresses the importance of this step for achieving higher recycling shares for plastics in WEEE. This target is estimated to increase to 55% by 2025. A recent study in the Nordic countries places the upper bound on the estimates for current recycling rates of WEEE plastics at 30% (Nordic Council, 2014). It becomes therefore apparent that the targets used in the model for the future scenarios (2020 and 2025) are quite ambitious compared to the situation today, but still feasible. If Europe is to become a resource efficient circular economy, such targets constitute a prerequisite for achieving high recycling.

Besides, WEEE is slightly different than other waste streams in the way that the overall flow is estimated, as two targets are set for the WEEE waste stream (and not just one): the one at the recycling stage (presented in this section), and one at the collection stage (see 3.5).

3.1.3. End of Life Vehicles (ELV)

The current data of Eurostat show 81% of ELV recycling in 2012 for EU-27 which is in line with the target of 85% of re-use and recycling by 2015 found in Directive 2000/53/CE, if the trend continues. Approximately 75% of ELV consist of metals (ferrous, non-ferrous) and is easily recycled. There is still 10% of the weight of ELV that needs to be recycled additionally for the 2015 target to be met. Other materials in ELV such as rubber (3%), glass (3%), plastics (12%) and textiles (2%) have a high potential to contribute to the target. It is estimated that the contribution of plastics recycling for reaching the target of ELV should be a minimum of 30% by weight of the plastics in ELV, considering that recycling of other materials (e.g. glass, rubber) is taking place as well. However, in 2010, only 17% of ELV went to a dismantling/treatment facility in Germany (Deloitte data). The rest was exported or did not enter the official take-back systems for ELV in MS. The situation may depend upon the MS considered, but it becomes apparent that a big share of the recycling potential in this waste stream is lost. Nevertheless, this 30% is estimated to be realistically feasible given the current situation. 35% recycling target is assumed for 2025.

3.1.4. Building & Construction Waste

The Waste Framework Directive (WFD, 2008/98) states that *'by 2020, the preparing for re-use, recycling and other material recovery, including backfilling operations using waste to substitute other materials, of non-hazardous construction and demolition waste excluding naturally occurring material defined in category 17 05 04 in the list of waste shall be increased to a minimum of 70% by weight.'* However, this target is difficult to apply to plastic waste recycling since the majority of B&C waste is mineral waste which is much heavier than plastics and mostly recovered (e.g. backfilling) than mechanically recycled. For this reason alternative targets were sought that would suit better the ambition of increased mechanical recycling of plastics. The voluntary commitment of the PVC industry (VinylPlus) is setting a target of recycling 800 000 tonnes of PVC by 2020. Taking into account the fact that the majority of B&C plastic waste are PVC waste from buildings, this target was considered as an input in absolute value, leading to a 36% recycling rate in 2020 in the B&C stream. The target for 2025 was set at 1 000 000 tonnes of PVC recycling, i.e. 41% recycling rate.

3.1.5. Other Plastic Waste

Other plastic waste usually ends up in the municipal waste stream and is collected for recycling either mixed by kerbside collection or separated at civic amenity sites. In the WFD (2008/98/EC) there is a target for recycling 50% of the generated Municipal Solid Waste (MSW) by 2020, while the proposal for revised targets (COM(2014) 397 final) increases further the target for recycling and preparing for re-use of MSW to 70% by 2030. There are four different calculation methods for measuring this target according to Commission Decision 2011/753/EU. The method with the broadest scope, used here, refers to the recycling of 50% by weight of mixed municipal waste. Taking into account the average composition of mixed MSW in EU-28, it is possible to set a partial target for plastic waste found in the MSW fraction. From the background documentation of the EU Waste Model (Eunomia et al, 2014) the average content of plastic in mixed MSW is calculated at 11.5% for

EU-28. In this percentage, a large amount of plastic packaging waste is included as well (70-85%). The remaining plastic waste can also contribute to the achievement of the targets but the contribution would be very low given its limited weight share in MSW. Conservative assumptions were therefore made for recycling of 'Other plastic waste' in MSW with 5% recycling by 2020 and 7% by 2025.

3.1.6. Agricultural Plastic Waste

In the case of agricultural plastic waste, there are no legally binding targets by EU regulation, however there is a voluntary commitment in place by Agriculture Plastic & Environment (APE) Europe for collecting and recycling 70% of used agricultural plastics films across Europe by 2020. APE Europe is a professional association bringing together companies and organizations involved in agri-plastics. The target of 70% collection for recycling is translated into the recycling output target of 30%, taking into account technical constrains in the recycling of agri-plastics (see Annex I). This target is considered feasible by PRE and its members, however it is considered necessary that systems for the collection and recycling of agricultural plastic are needed in all MS. Currently, such systems are only limited to a few EU-28 countries. A hypothetical increase of this target could take place by 2025, since the economic interest for recycling agricultural plastic might spur the interest for industry voluntary commitments. By 2025, the target for agricultural plastic waste could rise to 35%.

3.2. Waste generated

The amount of post-consumer plastic waste generated in 2012 is provided by PlasticsEurope's statistics published in their yearly report (PlasticsEurope, 2013). This amount refers to total waste and not specifically to waste categories. In the modelling of the plastics recycling value chain in this study, plastics waste is divided into six different streams: Packaging, WEEE, ELV, Building and Construction, Agricultural and Other plastic waste. For the determination of the waste amount for each category, a percentage breakdown to different sources of plastic was used (BIO et. al, 2011), as presented in Table 3. Similar percentages in the proportion of post-consumer plastic waste can be found in other sources as well (OECD, 2010).

To build the scenarios (in 2020 and 2025), projections of future waste amounts are made based on the current situation. The point of departure for calculating the annual growth rates of plastic waste is the Plastics Europe reports 2009-2013. The development of waste generation in these reports is rather slow, not surpassing annual growth rates of 1.6% at any instance. An annual growth rate of 1.2 - 1.4% is considered as an average value over the period 2009-2013.

In order to fine tune the annual growth rates of each group of plastic waste, certain assumptions were made based on literature review and consultation with PRE. The annual growth rate of packaging waste is set to 1% (BIO, 2013) and the rate for WEEE is set at 3.5%, remaining within the 3-5% range (BIO, 2013; Zero Waste Scotland, 2012). The annual growth rate of plastic waste from ELV is set to 2.5% (WRAP, 2006). For agricultural plastic waste no significant growth is expected in the future concerning the generation figures (WRAP, 2006) but certainly collected amounts will increase. For the calculations, a marginal growth rate of 0.5% is attributed to the agriculture plastic waste stream. For the remaining two categories, B&C and Other plastic waste, the annual growth estimation is coupled to the GDP annual growth projections for EU-28 (OECD, 2013; EC, 2014). The annual growth rate for both streams was estimated not to surpass 2% (more than the GDP growth rates). The annual growth rates for all waste streams used in the model are quite conservative and show slower increase compared to previous studies, which employed a quite optimistic approach in the development of the plastics sector and the consumption of plastics. The projections of growth rates in the model take into account the effects of the recent economic downturn which affects the plastics sector at a medium term perspective.

The overall figure for the annual growth rate of all plastic waste was calculated at 1.4%, which is within the range of the figures provided by Plastics Europe (annual reports), ensuring consistency of the assumptions.

Table 3: Distribution of plastic waste by source and annual growth rates

	Packaging	WEEE	ELV	B&C	Agricultural	Other plastic waste	TOTAL
Proportion of post-consumer waste	63%	5%	5%	6%	5%	16%	100%
Post-consumer waste (2012) (ktonnes)	15 876	1 260	1 260	1 512	1 260	4 032	25 200
Annual growth	1.0%	3.5%	2.5%	2.0%	0.5%	2.0%	1.4%

The extrapolated figures of waste generation for 2020 and 2025 were used as inputs in the bottom-up approach to calculate the waste flow overview of the different waste streams (see Annex I).

3.3. Share of recyclable plastics rate

The share of recyclable plastics refers to the share of theoretically possible recyclable plastic waste in each waste stream. In other words, it quantifies the proportion of the amount of plastic waste that is recyclable. The recyclability of plastics depends on several parameters, primarily on the type of plastic resin or the mix of different resins in composite products, and additionally on the different technologies currently available for recycling of plastics.

The amount that is not recyclable is automatically lost to disposal or incineration and cannot contribute to recycling targets. The potential impact of this proportion is related to the amount of plastic waste available for recycling. If the target for recycling is too high and the proportion of recyclable plastic is too low, then it could be possible that the amounts of waste collected for recycling would not be sufficient to meet the targets.

The recyclability rates are taken from literature and other commercial sources. The rates are directly related to the composition and the types of plastic resin(s) used in different products. Some products, e.g. bottle packaging, are usually made from one or two different plastic materials while more complex products, e.g. electronic equipment, are made from many plastic resins either as separate units or mixed in composite polymers.

The recyclability rates in the overview tables (Annex I) reflect future, possibly improved, recyclability compared to today. The recyclable share of plastic packaging is about 76% (Eco-emballages, 2012), according to French figures. For the future scenarios, higher recyclability rates are assumed taking into account potential eco-design improvements. For 2020, the recyclability rate is set to 80%. For WEEE, the recyclability rate is quite high, as nearly 90% of plastics in WEEE are potentially recyclable (Nordic Council of Ministers, 2013; Chalmers, 2011). However, there is high uncertainty in the fact that the theoretically recyclable plastics in WEEE can actually be recycled, since there is large proportion of plastics contaminated with chemicals (flame retardants, etc.). About 85% of plastics in ELV can be potentially recycled (Zero Waste Scotland, 2012). Recyclability rate of 90% is set for Agricultural plastic waste (EPRO, 2012; Zero Waste Scotland, 2012). Building and Construction waste recyclability rate is estimated at 80% (Zero Waste Scotland, 2012). For Other plastic waste, a maximum of 50% recyclability is estimated (with a high uncertainty), based on a weighted average of the recyclability of the resins composing the plastic demand of these "Other" plastic products (Plastics Europe, 2013). This approach is followed in the absence of more detailed data. Depending on which resins are present in each waste stream, the recyclability potential was assessed. For example, unspecified categories of "other engineered plastics" and types such as PUR are considered non-recyclable. All percentages are summarised below and calculated by weight (Table 4). For all waste streams, the rates appear realistic and it is expected that they might increase in the future. For this reason, marginal increases are appointed to obtain the rates considered in 2025.

Table 4: Plastic waste recyclability rates assumed for future scenarios

	Packaging	WEEE	ELV	B&C	Agricultural	Other plastic waste	TOTAL
2020	80%	90%	85%	80%	90%	50%	76%
2025	85%	92%	87%	82%	92%	52%	80%

3.4. Disposal/incineration rates

The disposal and incineration rates indicate the amount of waste that is lost during the collection and sorting steps together, and were calculated based on the current rates presented by Plastics Europe (2013).

In 2012, only 26% of the total plastic waste generated was recycled while 36% was incinerated (with energy recovery) and 38% was landfilled. Using these figures, future incineration/disposal rates were projected for the future scenarios. The quantities of waste managed according to each waste management option were linearly extrapolated to 2025 based on data from 2012 (Plastics Europe, 2013). There is a clear decreasing trend for landfilling while incineration is gaining a progressively larger share. Incineration rates eventually overtake landfilling with these assumptions.

However, the extrapolation of the landfilling rate is only used for the 2020 scenario and not for the 2025 scenario, because Directive proposal COM(2014) 397 plans the ban of recyclable plastics landfilling from 1 January 2025. As a result, all waste resulting from the collection and sorting steps is considered to go to incineration with energy recovery in 2025. The approach is slightly different for waste coming from the recycling operations (see section 3.9) as the regulatory target is not considered to apply to this waste.

3.5. Collection for recycling

In the overview tables (Annex I), the *collection for recycling rate* indicates the minimum percentage of waste that has to be collected to meet the recycling target(s), also given the assumptions made on the other flexible parameters. For example, in Table 1, in order to achieve the 45% recycling output rate, 70% of plastic packaging must be collected (with the pre-treatment and recycling efficiencies considered). The only exception to this approach is the collection rate for WEEE, which is not calculated like the other plastic products, because there is a specific target for collection in EU legislation. This target is set to 85% of WEEE generated within the territory of MS, starting from 2019, and it is one of the possible collection targets presented in 2012/19/EU Directive on WEEE. This specific target is selected because it is directly related to WEEE amounts and not to EEE put on the market as in the case of the other collection target of the WEEE directive: *'the minimum collection rate to be achieved annually shall be 65% of the average weight of EEE placed on the market in the three preceding years in the Member State concerned'*. These two targets are considered by the European Commission as equivalent in the effort of meeting the collected quantities.

3.6. Pre-treatment process efficiency

The pre-treatment process efficiency is relatively high for the packaging waste stream. The pre-treatment efficiency for packaging waste from households is 75% and that of commercial/industrial post-consumer packaging is 95% according to a recent study by Expra (2014). Taking into consideration that the split between post-consumer plastic packaging waste from households and commercial sources is 62%/38%[3] in EU-28, the pre-treatment efficiency of 82% is considered for the packaging waste stream in the model *Baseline* situation.

For all the other waste streams, given the lack of data available, estimations were made with consultation of PRE. In the case of WEEE and ELV, the steps of dismantling and shredding precede that of sorting and the plastics that are collected can be then forwarded to a sorting facility for further sorting into different resins. There is a certain percentage of loss during the dismantling stage that usually ends up to incineration or landfilling, which is reflected in reduced efficiency rates in these two waste streams. It is estimated that the pre-treatment process efficiency of ELV waste stream is about 50%. Considering the high growth rate of these waste streams and the pressure put into treatment facility operators to improve efficiencies, the sorting rate is projected to increase considerably in the future scenarios (see Table 5). Specifically for the WEEE plastics waste stream, the pre-treatment efficiency rate is a calculated value (because there are two targets imposed at different steps in the WEEE stream, see tables in Annex I) and it is directly related to the targets set out in the recast of the WEEE Directive 2012/19/EU. Considering the 2020 targets for collection (85% of generated WEEE) and the 'output' recycling rate (where 45% is estimated to be a realistic recycling target for plastics for WEEE, see section 3.1), a minimum pre-treatment efficiency of 61% is required by 2020 in order to achieve the recycling targets, according to the model. The pre-treatment efficiencies for all waste streams are considered to increase in the future scenarios, taking into consideration prospective improvements in the sorting/dismantling processes and advances in technology that would enable higher yields without compromising the quality of sorting, producing better sorted material with fewer contaminants. An important issue which needs to be tackled effectively in the coming years for the improvement of the sorting yields is the efficient sorting of black plastics. Today, it is not possible to sort black plastics effectively and high volumes of these materials are lost from potential recycling.

Table 5: Pre-treatment yields by waste stream (baseline and future yields)

	Packaging	WEEE	ELV	B&C	Agricultural	Other plastic waste
Baseline (2012)	*82%*	*50%*	*50%*	*80%*	*50%*	*70%*
2020	*85%*	*61%*	*55%*	*82%*	*55%*	*72%*
2025	*90%*	*73%*	*60%*	*85%*	*60%*	*75%*

Source: Expra (2014) for packaging, Plastic Recyclers Europe for all other waste streams

3.7. Input recycling rate

The input recycling rate indicates the recycling rate achieved by taking into account materials at the input stage of the recycling operations. This rate has been historically used by MS to express recycling rates. Due to the clarifications found in the proposal for revised targets (COM(2014) 397 final), this rate is not valid anymore to

[3] The split between household and C&I packaging waste was provided by PRE, based on data from PlasticsEurope

reach the targets and only the output recycling rate will be considered. It is therefore presented for informative purposes only.

3.8. Recycling yield

The recycling yield refers to the recycling efficiency of the recycling operations. Data on the recycling yields by plastic resin were provided by European recyclers through PRE. Data by resin derive from the actual recycling operations currently available in EU-28 and reflect the efficiencies in processing different plastic resins received from one or more waste streams to the recycling plants. Table 6 shows the recycling yields by resin. For the calculation of the waste flows in the overview tables (Annex I), appropriate recycling yields are needed by waste stream, which do not correspond to actual plastic resin yields, but to an average for the sake of modelling. In order to determine the recycling yields by waste streams, the data from plastics recyclers were weighted by the content share of each plastic resin to the respective waste stream. The recycling yields in Table 6 were combined with Table 24 showing the plastic resin content share by waste stream.

Table 6: Recycling yields by plastic resin (baseline and future yields)

	PET	PE-HD	PE-LD	PP	PS	PVC	Other plastic resins
Baseline (2012)	*72%*	*74%*	*78%*	*72%*	*70%*	*82%*	*70%*
2020	*75%*	*76%*	*79%*	*75%*	*72%*	*83%*	*72%*
2025	*78%*	*79%*	*80%*	*78%*	*73%*	*84%*	*73%*

Source: Plastic Recyclers Europe

The figures in Table 7 show the recycling yields by waste stream and are the ones used for the calculations in the overview tables (Annex I).

Table 7: Recycling yields by waste stream (baseline and future yields)

	Packaging	WEEE	ELV	B&C	Agricultural	Other plastic waste
Baseline (2012)	*73%*	*71%*	*72%*	*78%*	*76%*	*72%*
2020	*76%*	*73%*	*74%*	*80%*	*78%*	*74%*
2025	*78%*	*75%*	*76%*	*81%*	*79%*	*76%*

The recycling yields are considered to improve marginally in the future scenarios (2020 and 2025), taking into consideration prospective improvements in the recycling processes and advances in technology that would enable higher yields without compromising the quality of recycling, producing quality material in line with the outputs achieved today.

3.9. Recyclers and pre-treatment waste

Waste rejected from the pre-treatment and recycling processes end up as recyclers waste. Please note that there is also a certain share of water that is evaporated during these operations. The residual waste amount is diverted into either landfilling or incineration with energy recovery. Here, the same ratios for disposal and incineration are used as in section 3.4, based on the linear extrapolations of the disposal and incineration rates (no landfill ban is considered to apply in 2025, based on the legislation).

4. Modelling parameters in the plastic waste management chain

The model for the plastic recycling value chain maps the different parameters and criteria influencing the amount of plastic waste that can be recycled, together with the associated costs and labour required for the different scenarios considered.

The recycling value chain of plastics is very diverse and involves a multitude of actors in each step of the chain, from collection, transport, dismantling, sorting (possibly several steps) and finally to recycling. Especially, when the model parameters refer to different waste streams (e.g. packaging, WEEE, agricultural plastic) with very different properties and management options, it becomes clear that the level of complexity in the model rises considerably. Furthermore, complex or composite products (e.g. EEE), but also simple plastic products (e.g. PET bottles), which have very different applications, gradually converge through the recycling chain to their constituent materials, by being sorted out by plastic resin type in order to be recycled.

The overall structure of the model, the associated parameters and all necessary assumptions are presented in the following sections. The model is constructed in a simple and comprehensive way, avoiding over-complication of the value chain, by integrating the flows of different plastic waste streams and plastic resins.

4.1. Description of the model

The model follows plastic waste through the value chain, by firstly presenting the different waste streams containing plastic waste (e.g. packaging, WEEE, ELV) and their associated operations (collection, pre-treatment/sorting), and then converging to recycling by type of resin (transport to recyclers and recycling operations) where plastics coming from the different waste streams can be mixed and enter the recycling process as separately sorted materials (e.g. PET, PP, PE). Finally, the final disposal and energy recovery of uncollected or rejected plastic waste is considered throughout the waste management chain.

Therefore, a uniform approach is employed in all waste streams, where five distinctive operations (or steps) are presented:

1. Collection of the plastic-containing waste (including transportation to sorting facilities);
2. Pre-treatment and sorting of the collected waste into different plastic resins (for ELV and WEEE, dismantling and sorting are modelled together);
3. Transportation of the sorted plastic resins to recycling facilities and other management options;
4. Recycling by type of resin;
5. Final disposal or energy recovery of plastic waste not collected for recycling and plastic waste from pre-treatment/sorting and recycling operations.

In reality, there could be many more intermediate steps, with some of the steps occurring at the same location, eliminating the need for further transport of the materials, but for the purpose of this study a basic linear approach is considered including only the five steps mentioned above. A schematic representation of the model is found in Figure 3.

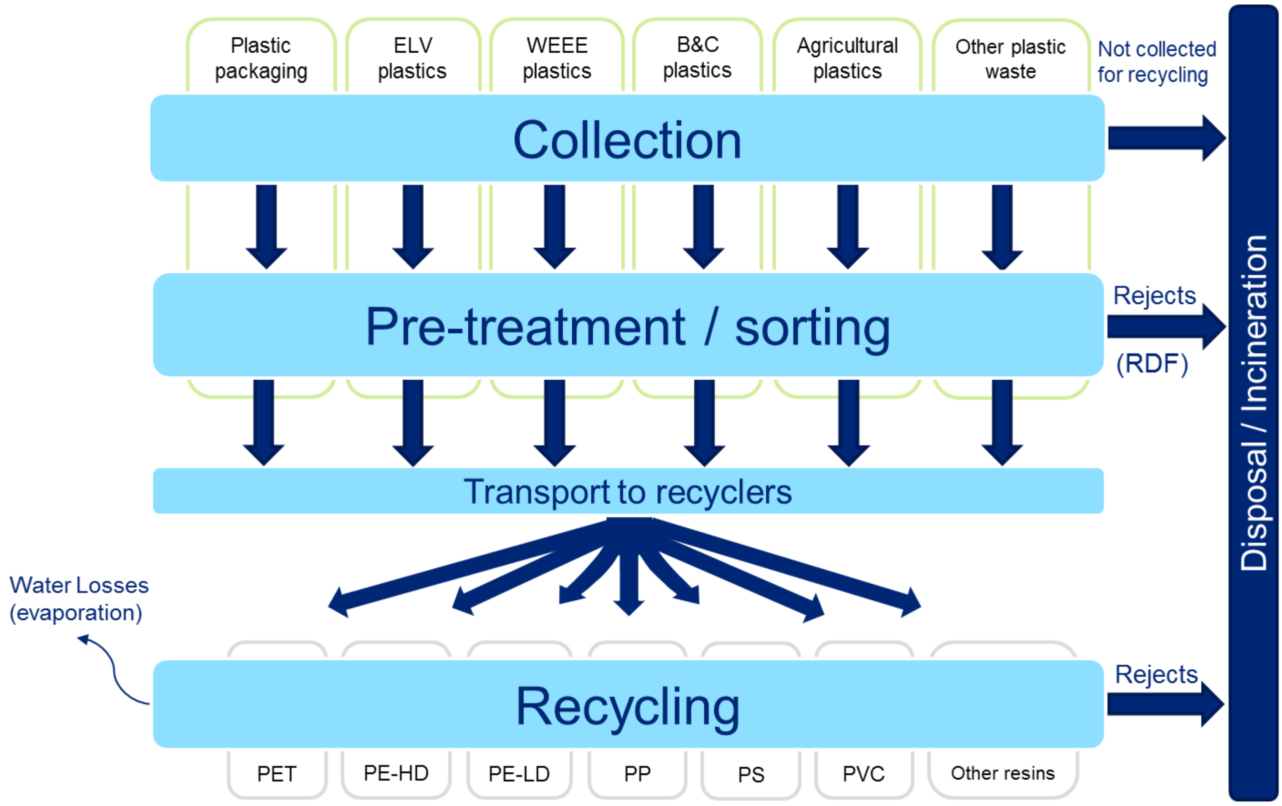

Figure 3 : Structure of the plastic waste value chain model

Important Note: After the transport step, the recycling module considers the individual resins (and not the waste streams anymore), as recyclers can mix different sources of plastic waste for their operations. The operational parameters are therefore only relevant when related to plastic resins, and not plastic waste streams. However, please note that the considered options for recycling lines (PET, PE-HD, PE-LD, PP, PS, PVC, Other plastic resins) do not include all existing recycling situations. In particular, it is estimated that around 300 ktonnes of mixed polyolefins (PE-HD and PP) are recycled together in the EU-28. Such cases were not included specifically in the model (i.e. as separate modules) because of the lack of specific data concerning these processes (operating costs, job intensity, etc.). However, the amounts and flows of recycled plastics are consistent overall, and these mixed PO amounts are still accounted for in the model. It is considered that the PE-HD recycled as mixed PO is processed through the PE-HD module, and the PP recycled as mixed PO is processed through the PP module in the model. The recycling yields of the PE-HD and PP modules are adapted accordingly in the model, as in reality these yields are different when PE-HD/PP is recycled separately or as mixed PO. As a result, the overall outcomes of the model and the impact assessment are still considering these types of recycling, with the best available data, even if there is not explicit module for all types of recycling.

4.2. Definition of scenarios

The model includes a *Baseline* scenario where the current situation (reference year 2012) and all associated parameters are analysed in detail. Using the *Baseline* as a point of departure, four possible future scenarios were developed, which refer to the years 2020 and 2025. Within each of these future reference years, two possible scenarios are explored:

- Firstly, a "business as usual" (*BAU*) scenario where no additional effort is made to improve recycling performance and the recycling rates remain the same as the *Baseline*. These *BAU* scenarios consider (unless otherwise specified) the same technical inputs as the baseline data (2012) presented in the following sub-sections; and
- Secondly, a "EU Targets" (*Targets*) scenario where the EU recycling targets, as expressed in EU Directives, proposals or ambitions, are achieved. The details of the targets were presented above in section 3.1.

4.3. Parameters of the model

In order to assess the potential of increased plastic recycling in terms of environmental, economic and social impacts, only the most critical parameters were considered in the model. These parameters are, for each step in the chain:

- Plastic materials inputs and breakdown (if relevant), in weight
- Plastic materials outputs and breakdown (if relevant), in weight
- Other materials outputs and destination, in weight
- Capacity of treatment facilities, in tonnes per year
- Efficiency of treatment facilities, in terms of processing yields
- Operating costs of treatment facilities, in EUR per tonne processed (excluding waste materials purchasing costs, but including energy, infrastructure, depreciation, labour costs, etc.)
- Number of jobs required in each step of the waste management chain, in full time equivalents (FTE) per 10 000 tonnes processed waste.

Data for all the parameters used in the model were retrieved from literature sources at EU and Member State level (preferably from the 7 following countries: Belgium, Germany, France, Italy, Poland, Spain, and the UK), complemented with estimations and additional assumptions when no literature data was found.

4.4. Data and assumptions used in the model

The model is based on concrete data from literature sources for the parameters presented above. Where relevant data was not found, it was necessary to make certain assumptions in order to fill the gaps and have a complete model. The assumptions mostly concern gaps in treatment capacities, costs, employment, sorting yields and collection modes in certain waste streams.

Important note: The values presented in the following subsections may result from calculations in the model. Therefore, the level of precision should be considered with caution (e.g. costs are not rounded up or down while the uncertainty on these costs is much higher than 1 €/t). The final impact assessment takes into consideration ranges of values for the most sensitive parameters, so that the final result is also presented as a range in section 5.2.3.

4.4.1. Plastic waste inputs to the model

The plastic waste material inputs is the primary parameter which influences the outputs and therefore the amounts of recycled plastics. The projected generation of plastic waste in 2020 and 2025 is presented in Table 8. The amounts of post-consumer plastic waste are derived from PlasticsEurope statistics and are gross plastics waste amounts, i.e. including potential contaminants (already presented above in section 3.2).

Table 8: Projections of plastic waste generation in 2020 and 2025 (in tonnes)

	Packaging	ELV	WEEE	B&C	Agricultural	Other plastic waste	Total
Post-consumer plastic waste (2020) (tonnes)	17 191 433	1 535 188	1 659 179	1 771 549	1 311 291	4 724 131	28 192 771
Post-consumer plastic waste (2025) (tonnes)	18 068 369	1 736 924	1 970 585	1 955 933	1 344 403	5 215 822	30 292 035

Out of the generated amounts of plastic waste, only a certain percentage is collected and sent to recycling while the remaining is diverted to incineration or disposal. The current rates (2012) of plastic waste sent to recycling, incineration and disposal are presented in Table 9, and come from Deloitte and PlasticsEurope data. The rates of plastic waste sent to recycling in Table 9 cover both the collection and sorting/pre-treatment steps of the model (i.e. represents inputs to recycling, or in other words outputs of the sorting/pre-treatment centres).

Table 9: Sent to recycling, incineration and landfilling rates of plastic waste in 2012 (Baseline scenario)

2012	Packaging	ELV	WEEE	B&C	Agricultural	Other plastic waste
Sent to recycling rate	34%	17%	14%	25%	23%	5%
Incineration rate	35%	26%	42%	33%	27%	43%
Landfilling rate	31%	57%	44%	42%	50%	53%

As the percentage of plastic waste sent to recycling in Table 9 includes the collection and sorting steps with the respective collection and sorting/pre-treatment rates, the actual collection rates of the municipalities, EPR systems and private collection entities of plastic waste, sent initially to sorting/pre-treatment facilities, are higher than those in Table 9, as a certain share of the materials is lost during the sorting/pre-treatment operations:

"Sent to recycling" rate = Collection rate x Sorting/pre-treatment yield

Taking into consideration the assumed sorting/pre-treatment yields in Table 22, the actual plastic waste collection rates for each waste stream is calculated in Table 10.

Table 10: Collection of plastic waste by municipal, EPR or private systems in the *Baseline* scenario (2012), considered also for the *BAU* scenarios in 2020 and 2025

2012	Packaging	ELV	WEEE	B&C	Agricultural	Other plastic waste
Collection rate of plastic waste	41%	34%	28%	31%	46%	6%

The sent to recycling, incineration and disposal rates (Table 9) are kept constant in the *BAU* scenarios in 2020 and 2025, because in these scenarios no additional efforts are estimated to be made in order to improve recycling of plastic waste and consequently the separate collection of plastics for recycling. Therefore, the collection rates remain also the same as in the *Baseline* scenario (Table 10).

These rates however are different in the *Targets* scenarios. Driven by the increased recycling required by the condition of fulfilling the targets, the collection rates need to increase considerably. The increased collection rates (and also the rates for energy recovery and disposal) are presented in the tables below.

Table 11: Collection for recycling, incineration and landfilling rates of plastic waste in the 2020 *Targets* scenario

2020	Packaging	ELV	WEEE	B&C	Agricultural	Other plastic waste
Collection rate for recycling	70%	74%	85%	55%	70%	9%
Incineration rate	20%	18%	10%	31%	20%	62%
Landfilling rate	10%	8%	5%	14%	10%	29%

Table 12: Collection for recycling, incineration and landfilling rates of plastic waste in the 2025 *Targets* scenario

2025	Packaging	ELV	WEEE	B&C	Agricultural	Other plastics waste
Collection rate for recycling	85%	77%	85%	60%	74%	12%
Incineration rate	15%	23%	15%	40%	26%	88%
Landfilling rate	0%	0%	0%	0%	0%	0%

4.4.2. Data and assumptions in the collection of plastic waste

All data and assumptions for the parameters of costs and employment which are presented in this section **are kept constant** for all future scenarios in the model. The values used in the model for the average EU-28 operating costs and employment in the collection of plastic waste by stream are summarised in Table 13. Further details by stream are provided in the following subsections.

In reality, these costs are expected to evolve in the future depending on technical development, organisational changes, and other factors. However, due to the uncertainty of the direction and the level of developments, costs are kept constant throughout the modelling exercise.

Table 13: Summary of average EU-28 operating costs and employment in the collection of plastic waste

All scenarios	Packaging	ELV	WEEE	B&C	Agricultural	Other plastic waste
Average costs (€ per tonne)	186	41	183	50	50	110
Average employment (FTE per 10 000t)	28	-	20	10	10	22

4.4.2.1. *Plastic packaging waste*

There are different collection systems in EU Member States (MS) for collecting recyclables, including kerbside collection, bring site collection, deposit/refund systems, recycling centres, civic amenity sites and privately organised on-site collection for the industrial and commercial sector.

The collection systems are generally influenced by different regional and economic parameters and even within one single MS there could be many different collection schemes in the different regions or cities, while sometimes more than one collection system exists at the same time in the same place.

Recyclable plastics are collected in different ways that may include:

- separate collection as a single stream,
- mixed collection with other similar recyclables (e.g. light packaging),
- mixed collection with all dry recyclables (e.g. paper, glass, etc.), and
- mixed collection with residual waste.

It is clear that the plurality of collection systems could add a profound complexity to the model. As stated earlier, the idea is to keep the model as simple and practical as possible without compromising the main results. For this reason, a screening of all collection systems in EU MS was conducted in order to identify the most prominent collection schemes which are used most often in the EU for the collection of plastic recyclables.

The literature review concluded that in the EU (especially among the 7 MS with the higher plastic waste generation) plastic packaging waste is mostly collected either with other light packaging materials and separately from paper and glass, or together with all packaging including paper and cardboard, but still without glass. Most of the times glass is collected separately from other recyclables, **therefore the model considers two different ways of collection**:

a) collection of mixed packaging without glass; and
b) collection of mixed packaging without paper and glass.

Collection option (b) is more common and therefore accounts for a larger share of collection in the model. Additionally, there is a distinction between kerbside collection and bring sites. In Table 14, the share of collection systems, as identified above, is presented for MS with available data.

Table 14: Share (%) of collection modes in MS with available data

Share (%) of collection modes in MS with available data				
Member State	Kerbside collection		Bring site collection	
	Separate collection of glass and mixed packaging	Separate collection of glass, paper and mixed packaging	Separate collection of glass and mixed packaging	Separate collection of glass, paper and mixed packaging
Austria	33%			66%
Belgium		60%		40%
France	95%		5%	
Spain				100%
United Kingdom	50%	39%	11%	
Germany		85%		15%
Netherlands	50%			50%

Sources: Eunomia et al. 2014, ADEME 2014, RECOUP 2014, EIMPack 2014, Wageningen UR 2013

In order to calculate the share of different types of collection which is used in the model, the shares in Table 14 are grouped and weighted by the amounts of plastic packaging waste generated in each of the countries in the table. Data for the generated amount of plastic packaging waste is taken from Eurostat for the year 2012. The resulting figures are summed up and divided by the total generation (of the selected countries). The results are shown in Table 15.

Table 15: Collection of packaging waste at EU level (% share by mode of collection)

Collection of packaging waste at EU level (% share by mode of collection)			
Household packaging waste collection	Kerbside	Separate collection of mixed recyclables (without glass)	35%
		Separate collection of paper and mixed rec. (without glass)	37%
	Bring site	Separate collection of mixed recyclables (without glass)	4%
		Separate collection of paper and mixed rec. (without glass)	24%
Collection of packaging waste (total)			**100%**

Finally, there is a split between household packaging collection and commercial packaging collection. The respective shares are variable in each MS. Data from PlasticsEurope indicate that 62% of the total packaging waste stream derives from households while the rest 38% comes from commercial and industrial sources. The complete picture of packaging waste by mode of collection is shown in Table 16, with the shares of collection for household waste (from Table 15) recalculated to account for 62% of the collection of total packaging waste.

Table 16: Collection of packaging waste at EU level (% share by mode of collection)

Collection of packaging waste at EU level (% share by mode of collection)			
Household packaging waste collection	Kerbside	Separate collection of mixed recyclables (without glass)	21%
		Separate collection of paper and mixed rec. (without glass)	24%
	Bring site	Separate collection of mixed recyclables (without glass)	2%
		Separate collection of paper and mixed rec. (without glass)	15%
C&I packaging waste collection	Private collection		38%
Collection of packaging waste (total)			**100%**

An overview of the costs of the different collection schemes of packaging waste is presented in Table 17. The average EU-28 costs of each collection scheme in the table come from the average costs of collection in Member States (where data was available). The average EU-28 cost of collection (EUR per tonne) is calculated by weighing the costs of each collection scheme by the respective share found in Table 16.

Table 17: Average costs of collection of packaging waste at EU level (EUR per tonne)

Average costs of collection (EUR/t)			
Household packaging waste collection	Kerbside	Separate collection of mixed recyclables (without glass)	183
		Separate collection of paper and mixed rec. (without glass)	253
	Bring site	Separate collection of mixed recyclables (without glass)	111
		Separate collection of paper and mixed rec. (without glass)	*280**
C&I packaging waste collection	Private collection		111
Collection of packaging waste (total)			**186**

** Only one value (Spain) was found for this input which influences disproportionately the resulting cost.*

Assumptions were made regarding the costs and employment of the private collection of plastic packaging from businesses. The costs are competition-based and are bilaterally agreed by the waste collector and the client. Since no public information is available for such type of schemes, it was assumed in the model that the collection costs are equal to the lowest costs identified for the collection of plastic packaging in the household collection schemes. The same applies for the employment factor.

Table 18: Average employment in the collection of packaging waste at EU level (FTE per 10 000 tonnes)

Employment in the collection of packaging waste (FTE per 10 000 tonnes)			
Household packaging waste collection	Kerbside	Separate collection of mixed recyclables (without glass)	40
		Separate collection of paper and mixed rec. (without glass)	40
	Bring site	Separate collection of mixed recyclables (without glass)	21
		Separate collection of paper and mixed rec. (without glass)	21
C&I packaging waste collection	Private collection		21
Collection of packaging waste (total)			**28**

4.4.2.2. *ELV plastic waste*

The collection of end-of-life vehicles is specific, as the collection is performed by the dismantling actor, which includes this service in its prices, either from commercial dealers or from households. As a result, the specific costs of collection can be derived from the total costs, reported by the ELV pre-treatment and sorting facilities, by isolating the cost incurred for the acquisition and transport of the ELV to the dismantling facility. However, the same approach could not be followed for the direct jobs created by the collection of ELV. Therefore, no jobs are allocated in the collection of ELV but the employment intensity is kept aggregated within the sorting/dismantling step of the chain. The breakdown of costs is taken from a French study (ADEME, 2003) and **the average costs associated with the acquisition of ELV is 41 EUR per tonne.**

4.4.2.3. *EEE plastic waste*

Detailed data for this waste stream allow the distribution of costs and employment between the different steps of the recycling value chain. The costs are divided to collection, transport and treatment (WEEE Forum, 2006). Moreover, the costs are broken down to the 10 different categories of WEEE. By weighing the cost of collection in each category by the amount of generated WEEE, an average overall value for cost in EUR per tonne was calculated. **The average EU-28 cost for the collection of WEEE is 183 EUR per tonne.**

The collection of WEEE requires 20 FTE per 10 000 tonnes collected. This was based on an estimation of the distribution of labour intensity between collection and sorting, taking into consideration that the dismantling and sorting steps are much more labour intensive than the collection of WEEE and that data from France[4] indicate that collection and sorting require 60 FTE per 10 000 tonnes.

4.4.2.4. *B&C and Agricultural plastic waste*

In these two waste streams, similar assumptions are made concerning the collection costs and the employment intensity. By analysing the recycling sector of agricultural plastic waste in France, the cost allocation of collection and sorting (the steps before plastics are sent to recycling) is approximately 150 EUR/t. In France, it is widely agreed that the transportation costs amount to 50 EUR/t, which roughly can be appointed to the collection of plastic waste from farms. There are no complicated collection paths for agricultural waste, therefore the transportation costs can be roughly attributed to the collection and the remaining 100 EUR/t to sorting.

For B&C plastic waste, similar values for the costs of collection and sorting of PVC waste have been identified in literature sources. Using the same logic as in agricultural plastic waste, the cost of collection of B&C plastic waste is assumed to be 50 EUR/t. However, this partition might not be as straight forward because there can be selective sorting at the source (at the construction site) before the collection step and the borders between sorting and collection are not definitely set. For simplification reasons and due to lack of detailed data, a similar approach to agricultural plastic waste is used for B&C plastic waste.

It is considered that the employment intensity of the collection in these two waste streams is lower compared to the other waste streams. An employment factor of 10 FTE per 10 000 tonnes is assumed in the model, since there is complete absence of any data in literature sources.

4.4.2.5. *Other plastic waste*

The waste stream ‘Other plastic waste’ is a very diverse category which may include all types and sizes of plastic products, from small plastic toys and everyday utility equipment to big garden furniture and plastic installations. Therefore, it becomes extremely challenging to adopt a “one-size-fits-all” approach.

In Member States, other plastic waste in the form of bulky plastic products (e.g. garden furniture, utility installations, etc.) is collected exclusively through two different collection paths: either by kerbside collection or though civic amenity sites (recycling centres).

Collection through the kerbside system usually exists in two forms: either in the form of collection at specific days of the year (waste calendar) or by prior notification to the municipal authorities (or waste collector) for the collection of such waste door-to-door. In Member States with less developed collection systems, plastic bulky waste is deposited on the side of the kerbside bins and it is collected at a later point in time by the responsible authorised entity.

In all Member States, civic amenity (CA) sites are receiving bulky waste at no cost from citizens while there is usually some costs for small businesses. CA sites cover the MS territories at variable levels but in general a high national coverage is reported (Eunomia et al., 2014).

Although the above two modes of collection are identified for the collection of plastic bulky waste, the extent to which they cover each MS is variable. For example, CA sites are covering the majority of the population, while kerbside collection of bulky waste is mostly found in urban areas. For this reason, CA sites are assumed to receive marginally higher amounts of plastic waste in the model. The percentages in Table 19 are mainly assumptions based on the rationale analysed above in this paragraph.

Smaller plastic waste are usually deposited together with residual waste in households and most likely never reach the sorting and recycling steps in the value chain.

Here, again a 62%-38% split is assumed between household and commercial plastic waste. The same assumptions are made for the costs and employment as in the collection of C&I packaging waste.

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[4] http://www.cgeiet.economie.gouv.fr/Rapports/2014_01_06_industrie_du_recyclage.pdf

Table 19: Collection of other plastic waste at EU level (% share by mode of collection)

Collection of other plastic waste at EU level (% share by mode of collection)		
Household waste collection	Kerbside	28%
	CA sites	34%
C&I waste collection	Private collection	38%
Collection of packaging waste (total)		**100%**

An overview of the costs of the different collection modes of other plastic waste is presented in Table 20. The average EU-28 costs of each collection mode in the table come from the average costs of collection found in Member States (where data was available). The average cost of collection (EUR per tonne) is calculated by weighing the costs of each collection mode by the respective share found in Table 19.

Table 20: Average costs of collection of other plastic waste at EU level (EUR per tonne)

Average costs of collection (EUR/t)		
Household waste collection	Kerbside	183
	CA sites	49
C&I waste collection	Private collection	111
Collection of other plastic waste (total)		**110**

Concerning the employment in the civic amenity sites, the value of 9 FTE per 10 000 tonnes of plastic waste received is assumed in the model. This figure is the result of rough calculations of the personnel needed to run a recycling centre (theoretical value) coupled with the total capacity and annual throughput of recycling centres in Scotland (due to availability of data). This figure may vary by country. In the absence of any other solid data, this figure is incorporated in the model. For the kerbside collection and the private collection modes, the same employment intensity figures were used as in the packaging waste stream. Table 21 presents a detailed overview of employment intensities by mode of collection for the ‘Other plastic waste’ stream.

Table 21: Average employment of collection of other plastic waste at EU level (FTE per 10 000 tonnes)

Employment in the collection of other plastic waste (FTE per 10 000 tonnes)		
Household waste collection	Kerbside	40
	CA sites	9
C&I waste collection	Private collection	21
Collection of other plastic waste (total)		**22**

4.4.3. Data and assumptions in sorting/pre-treatment of plastic waste

All data and assumptions for the parameters of costs and employment that is presented in this section **are kept constant** in all future scenarios in the model.

The main assumptions taken in this step refer to the sorting capacities for plastic waste of all waste streams and to the sorting yield of certain waste streams.

According to German data (AGVU, 2012), in 2010 there was a capacity of over 3 Mt available in Germany for sorting of light packaging (separately collected) while only 2.57 Mt of light packaging was sorted in the German sorting plants. This means that potentially 15% additional unutilised capacity for plastic waste (among other light packaging) exists in the sorting plants. Therefore, an assumption is incorporated in the *Baseline* of the model that 15% rest capacity will be available at EU-28 level for the sorting of separately collected plastic packaging waste. Although this 15% refers only to packaging waste, further assumptions in the model consider that all waste streams have a potential 15% overcapacity.

All the sorting yields in the model, except from packaging, are estimations and are based on inputs from Plastics Recyclers Europe (PRE) and expert judgement. The sorting yields for all waste streams are presented above in section 3.6. (Table 22 below is a reminder). For the future *Targets* scenarios progressive improvements in the sorting yields are assumed, taking into consideration the fact that the demand for increased recycling might trigger relevant demand in the development of improved sorting and recycling technology. The sorting yield is assumed to increase progressively and add up to 5% for B&C plastic waste and Other plastic waste, up to 8% for plastic packaging waste, up to 10% for ELV and Agricultural plastic waste and up to 23% for EEE plastic waste by 2025. The last, high increase of the sorting/pre-treatment yield results from the 85% collection rate target of the WEEE Directive. A high yield of 73% (proportionate for plastics in WEEE) would be required in order for the target to be achieved. However, in the model baseline a sorting yield of 50% is assumed for WEEE. This is attributed to the fact that the WEEE stream includes a highly diverse content of plastics that is not sorted successfully most of the times and also contaminated parts which are rejected. This low sorting yield in WEEE is considered to be realistic. Similarly low is the sorting yield of ELV.

Table 22: Sorting/pre-treatment yields (%) by waste stream

	Packaging	WEEE	ELV	B&C	Agricultural	Other plastic waste
Baseline	82%	50%	50%	80%	50%	70%
Targets 2020	85%	61%	55%	82%	55%	72%
Targets 2025	90%	73%	60%	85%	60%	75%

In Table 22, the sorting/pre-treatment yields should be understood as the percentage of plastics waste that is sorted for recycling against that which is going to landfill or incineration, only considering the sorting/pre-treatment step (excluding collection). In the case of packaging waste for example, 18% of plastics packaging waste that is being sorted in a MRF or PRF is rejected from the process and is disposed of. However, this 82% yield in the sorting of plastic packaging waste consists an average figure and includes many different sorting processes. At this point, it would be relevant to point out that the sorting/pre-treatment processes are different for each of the waste streams examined in the model. Plastic packaging waste might go through one or multiple sorting operations, according to different technologies used at sorting/pre-treatment plants and the desired level of purity. By increasing the sorting steps, the sorting yield changes as well. For WEEE and ELV waste streams, for example, there are additional steps before the sorting of plastics, usually including dismantling and shredding of the plastic components. All these operations – dismantling, shredding, sorting – are included in what is called 'sorting/pre-treatment yields' in the model.

The average costs and employment in the pre-treatment/sorting of plastic waste are summarised in Table 23. Most of the data was retrieved from literature sources. The costs for B&C and agricultural waste follow the same rationale as in section 4.4.2.4 where the costs of collection for these two waste streams were analysed. The employment in the sorting of B&C and agricultural plastic waste is assumed to be low, as sorting of B&C and agricultural waste is not considered to be more intensive than that of packaging waste. In the absence of any reliable data source, the value of 7 FTE per 10 000 tonnes of plastic waste is considered for B&C and agricultural plastic waste, which is equal to the employment intensity of sorting packaging waste from businesses (excluding household packaging waste). For the 'Other plastic waste' stream, the same average costs and employment as in packaging waste were used in the model.

In reality, these costs are expected to evolve in the future depending on technical development, organisational changes (average capacity of sorting plants, level of automation, etc.), and other factors.

Table 23: EU-28 average costs and employment intensity in the pre-treatment/sorting of plastic waste

All scenarios	Packaging	ELV	WEEE	B&C	Agricultural	Other plastic waste
Average costs (EUR per tonne)	191	272	187	100	100	191
Average employment (FTE per 10 000t)	17	20	40	7	7	17

At the sorting step, it is necessary to distinguish the output by resin in each waste stream. The allocation by resin was possible by comparing several data sources. The distribution to each waste stream is summarised in Table 24. This distribution of plastic waste by resin was used as a baseline (2012) and it is **kept constant** in all the scenarios in the model. In theory, as the collection of plastics improves this breakdown should tend towards the virgin breakdown per market – of each waste stream. However, the breakdown presented below is based on the scope of the current collection systems in EU-28.

Table 24: Breakdown of the plastic resins content in the six waste streams analysed in the model, at the output of the pre-treatment/sorting step, (%)

	Packaging	ELV	WEEE	B&C	Agricultural	Other plastic waste
PET	34%	0%	0%	0%	0%	0%
PE-HD	15%	8%	2%	12%	27%	9%
PE-LD	21%	0%	0%	2%	68%	25%
PP	17%	43%	27%	0%	3%	10%
PS	3%	0%	22%	0%	0%	19%
PVC	1%	3%	4%	62%	0%	2%
Other plastic resins	8%	46%	45%	24%	2%	35%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Sources: Deloitte (2014), TRIPTIC (2014), Wageningen UR (2014), Nordic Council (2014), PVC Forum (2010), PRE

It should be noted that in Table 24 the values of *0%* do not necessarily reflect the complete absence of a specific plastic resin from the respective waste stream. Quantities less than 1% are presented as 0% in Table 24, due to the low significance of these quantities in the model calculations.

4.4.4. Data and assumptions in transportation

The amount of sorted plastic waste which is transported to recycling derives directly from the two previous steps in the recycling value chain. The *'transportation to recycling'* step is connecting the sorting/pre-treatment operations of the different waste streams with the recycling of plastics by resin, irrespective of the source waste stream. Therefore, this step has a bottleneck function. No losses of plastic material occur in this step, but the cost of transport to recyclers is added up to the total costs of the recycling value chain. Furthermore, there is a potential for moderate job creation in the case of increased plastic amounts transported to recycling.

Data for the average cost of transport (EUR per tonne), the average truckload of sorted recyclables and the average distance travelled to recyclers are found in literature (Table 25). The average employment can be roughly calculated by these figures.

The total amount of plastic output from the sorting plants, if divided by the number of working days per year, gives the amount of plastic that is transported daily. This amount divided by the average truck load gives the number of trucks required to transport this amount in one day. For every truck, one driver is assigned as employed. Summarising the rationale above, approximately 2 FTE per 10 000 tonnes is required for transport.

In reality, these costs are expected to evolve in the future depending on technical development, organisational changes and other factors.

Table 25: Transport to recyclers and other waste management options

	Average costs (EUR/t)	Average load per truck (t)	Average distance travelled (km)	Employment (FTE/10000t)
Recycling	15	16	380	2
Energy recovery	2	10	30	0.5
Landfilling	2	10	30	0.5

Sources: Eunomia et al. (2014), Eco-Emballages (2014), EeB Guide (2012)

Except from recycling, there is a significant amount of waste that is not entering the recycling value chain and is diverted to other less favourable waste management options, according to the waste hierarchy, such as energy recovery and disposal at landfills. The average distances to energy recovery facilities and landfills are much shorter that for plastic recycling facilities and as a result the average costs per tonne transported as well as the employment intensity are lower than the transport of plastics waste for recycling. The average costs and employment intensity were calculated following a similar line of thought as with recycling, explained above.

4.4.5. Data and assumptions in recycling of plastic waste

The recycling yields assumed in the model were determined in close collaboration with PRE and its industrial partners and represent highly reliable data on average recycling yields for each plastic resin at EU level (see Table 6 and Table 7). As a general trend, it is estimated that the higher the added value/quality of the recycled pellet, the lower the recycling yields (for a given input quality). For future scenarios, a conservative approach was used in increasing the recycling yields about 3-5% for each resin by 2025.

Recycling operations costs by resin are presented in Table 26. Data for the sale prices of recyclables and operating costs were received from PRE and its members. The average cost for recycling of plastics (in total) is around 450 EUR per tonne. The employment intensity of plastic recycling is 30 FTE per 10 000 tonnes (data from PRE). In reality, these costs are expected to evolve in the future depending on technical development, organisational changes and other factors. There is no aggregated data available concerning ‘other plastic resins’ and therefore assumptions were employed in the model. The average recycling cost for ‘other plastic resins’ was estimated by taking the average value of the recycling costs of rest six plastic resins presented in Table 26.

Table 26: Average recycling costs and employment by resin

	PET	PE-HD	PE-LD	PP	PS	PVC	Other plastic resins
Recycling costs (EUR per tonne)	400	450	500	450	500	400	450

The capacity of plastic recycling facilities in EU-28 is 3.7 million tonnes according to the latest available data from Plastics Recyclers Europe.

4.4.1. Data and assumptions in incineration and landfilling

Since not all plastic waste is collected for recycling, the operations of incineration with energy recovery, co-incineration for energy production and landfilling are also included in the model. Plastic waste not collected for recycling and low quality plastic waste rejected from the sorting and recycling processes are diverted to lower waste hierarchy treatment options. The amounts of waste entering these two operations are determined by the energy recovery (incineration) and landfilling rates (see section 3.4).

While landfilling refers to the amount of plastics waste sent to landfills, the management option of energy recovery includes different paths according to the specification of plastic waste and the point in the waste management chain in which the waste occurs. Plastic waste collected together with residual waste might avoid any kind of treatment and be diverted directly to a waste incinerator. On the other hand, residues of sorting processes, either at the level of MRF or even MBT facilities for mixed wastes, can be processed to RDF (or SRF depending on quality) which is a better option for use in energy recovery operations, reducing the costs of disposal and improving the calorific value of the waste product. There are many different pathways in which plastic rejects and residues can be reprocessed to RDF and sent to cement kilns or other dedicated facilities for co-incineration and energy production. Figure 4 shows a simplified general diagram of the different pathways concerning plastic waste.

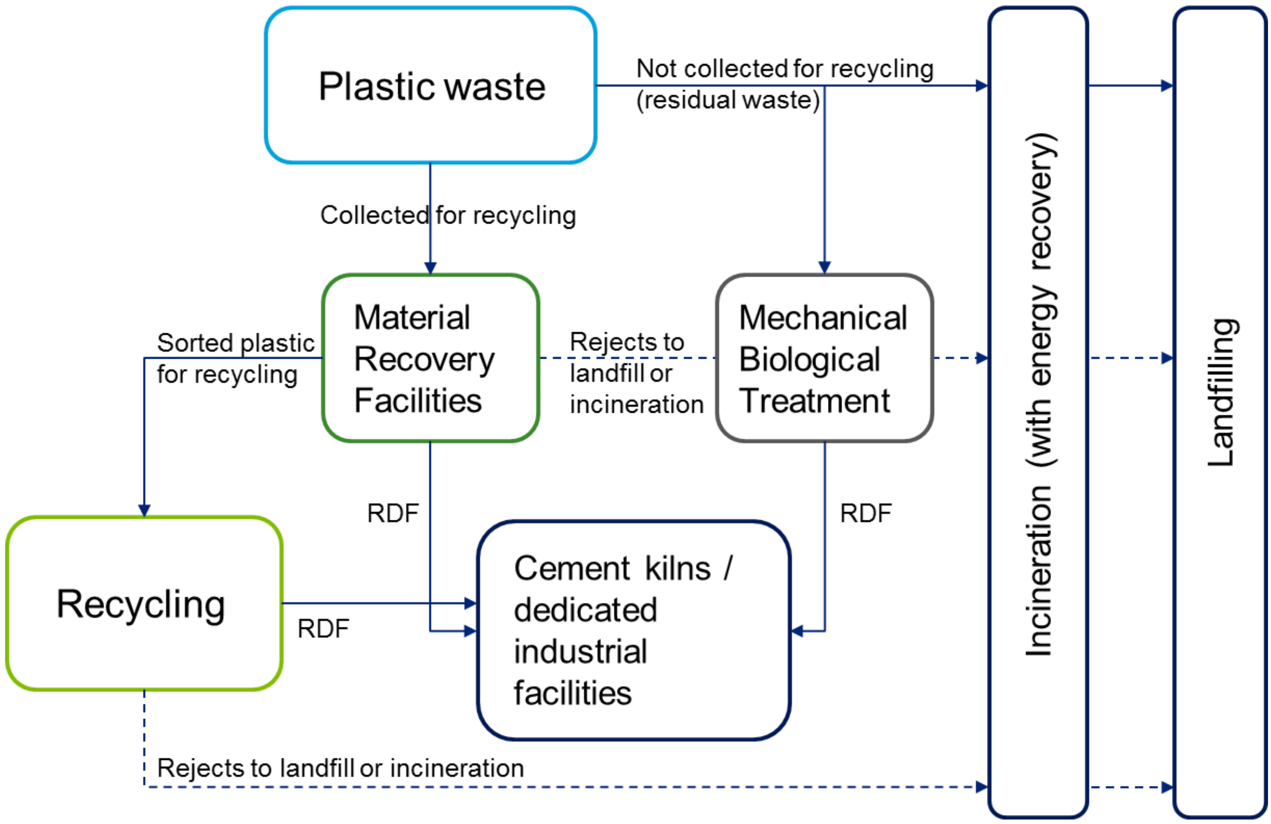

Figure 4: RDF production and use in the plastics recycling value chain

Combining data from Germany and France (BIPE, 2011), it was determined that 22% of all plastic waste sent for energy recovery was prepared as RDF while the rest were diverted to waste incinerators without prior treatment.

Data for the parameters of net costs and employment were found in literature (Eunomia et al., 2014 and CEWEP, 2014). The average cost of incineration in EU-28 is approximately 88 EUR per tonne and the average cost of landfilling is about 73.5 EUR per tonne. The net costs for RDF valorisation in cement kilns and other dedicated industrial facilities is about 24 EUR per tonne (ADEME, 2009). It should be noted that these net costs of energy recovery and landfilling include the revenues resulting from the selling of recovered energy.

All final disposal and energy recovery operations are characterised by very low labour intensity and according to the same data sources, they employ approximately 1 FTE per 10 000 tonnes of waste treated.

5. Environmental, economic and social impact assessment of increased recycling based on prospective EU targets

The assessment of environmental, economic and social impacts draws upon the comparison of different scenarios for the plastic recycling value chain in the future, taking into account existing and prospective targets set in EU legislation (section 3). A *Targets* scenario was defined for 2020 and for 2025 (section 4), which forecasts the future plastic recycling value chain meeting the respective targets. This scenario is compared with the 'Business as usual' scenario *(BAU)* respectively in 2020 and 2025, where no additional effort is made to increase recycling of plastics compared to the current situation, and the recycling performance remains the same as the *Baseline* (reference year 2012). Table 27 presents the basic elements comprising the waste flows of each scenario which influence the impacts analysed in this section of the report. The figures in Table 27 correspond to the quantities and recycling rates of ***Total*** plastic waste generation in the EU, i.e. including all the six waste streams analysed in the plastic recycling value chain model (Packaging, WEEE, ELV, B&C, Agricultural and Other plastics waste stream). For further details, please see Annex I.

Table 27: Waste inputs and outputs of Total plastic waste in *BAU* and *Targets* scenarios for 2020 and 2025

	***BAU* 2020**	***Targets* 2020**	***BAU* 2025**	***Targets* 2025**
Plastic waste generated	28 192 771	28 192 771	30 292 035	30 292 035
Recycling rate at the output of recycling	20%	36%	20%	46%
Recycled plastics	5 375 208	10 097 637	5 707 546	14 014 183

Note: The recycling rates at the output of recycling are product of calculations in the plastic recycling value chain model and appear in the table as rounded figures.

By comparing the future scenarios, potential positive and negative impacts are identified that shed light in the prospective future actions and decision making processes concerning plastics recycling in EU-28. The impacts analysed in this report refer to the basic axes of sustainability, namely environmental, economic and social impacts, with the view of promoting the sustainability of plastics recycling and showcasing the benefits of the transition to a more circular plastics value chain in a European perspective, while at the same time safeguarding valuable resources within the EU-28 and boosting economic development coupled with new employment opportunities.

5.1. Environmental impacts

Recycling is considered as the most beneficial management option, after preparation for reuse and waste prevention, according to the waste hierarchy. The environmental benefits of plastics recycling compared to alternative management options have been studied extensively in numerous research projects and include, among others, reductions in energy consumption, greenhouse gas (GHG) emissions, resource depletion (and land use), particulate emissions, acidification, noise, odours and visual disturbance (BIO, 2013).

In order to assess the environmental impacts of the scenarios, the GHG emissions indicator was selected. On the one hand, the operations throughout the plastics recycling chain require energy consumption in the form of diesel fuel, grid electricity and thermal energy, which contributes to GHG emissions as well as fossil resource depletion. On the other hand, the materials recovered as a result of recycling enable environmental benefits from the avoided production of virgin plastics and related impacts. In order to quantify the overall balance of recycling, the net GHG emissions of the whole chain (substitution of 1 kg of virgin plastics with 1 kg of recycled plastics) are calculated. Major greenhouse gases include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and some fluorinated gases. For the calculation of GHG emissions, a multitude of sources have been used with various levels of alignment to the full scope of GHG. In particular, LCI data include impacts from all GHG, while direct emissions from combustion processes (e.g. incineration) include only CO_2 emissions.

The scope of the plastics recycling value chain in the model includes all the steps from collection to final production of recycled plastic material (pellets or flakes) ready for use in the production of new plastics end products (at the exit of the recycling facility - not including further transportation of recycled plastics to converters' facilities). Apart from the recycling operations, the scope of the study also includes alternative management options, namely energy recovery and landfilling, for the materials that are not recycled. In the energy recovery step, a differentiation is made between the amount of plastic waste diverted directly to incineration with energy recovery (without any prior treatment) and the amount prepared as Refuse Derived Fuel (RDF) or Solid Recovered Fuel (SRF), depending on quality, which usually is diverted to industrial facilities (e.g. cement kilns) as substitution fuels for thermal energy.

The emission factors used for each step of the chain are presented in Figure 5, while further details on the operations included in each step and the sources of information are included in the following sub-sections. It is important to note that the emission factors are **kept constant** over the full time period of the *BAU* and *Targets* scenarios as no reliable or straightforward information about the evolution of these factors is available.

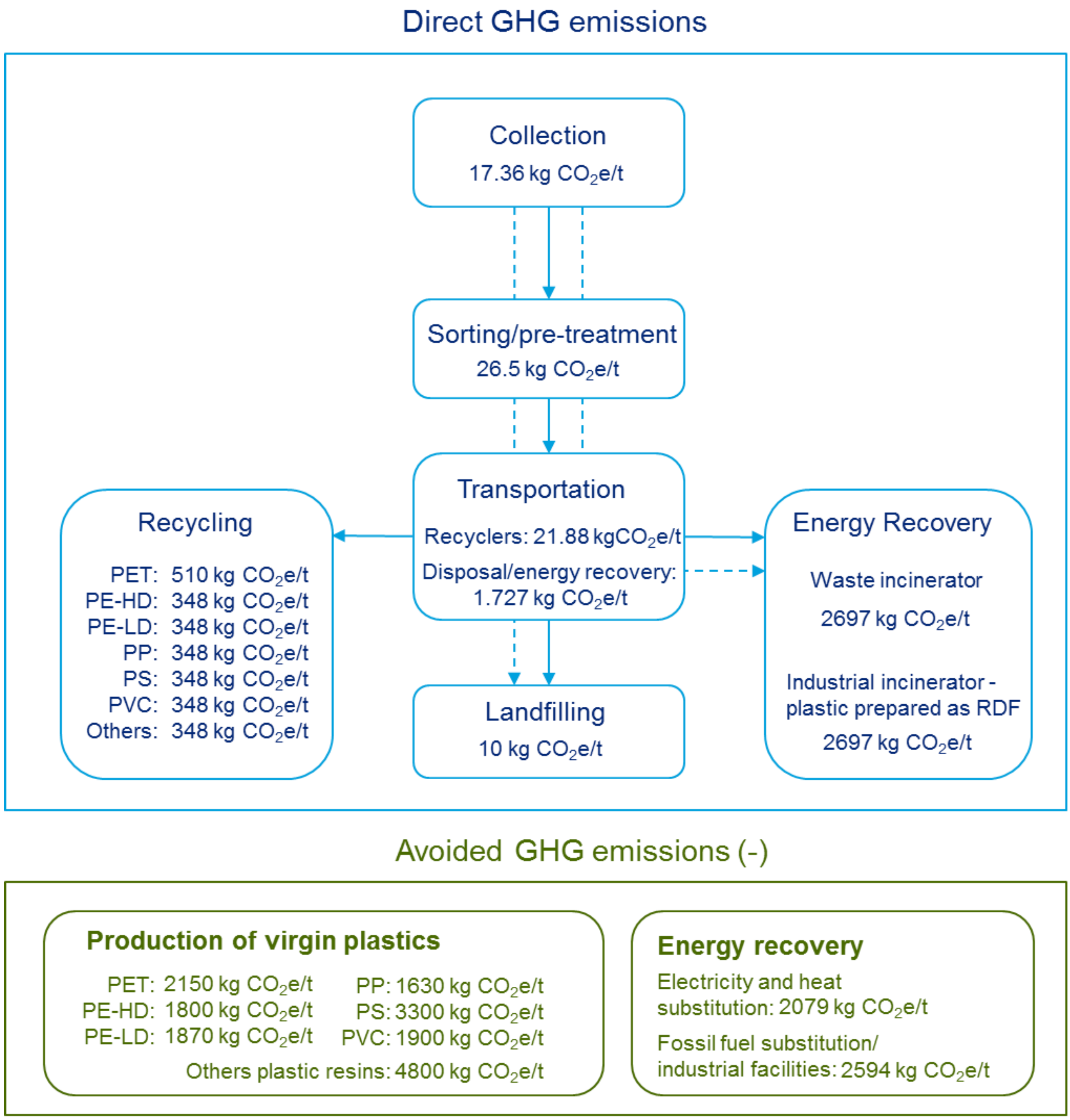

Figure 5 : GHG emissions factors used along the plastics recycling value chain

All emission factors presented above correspond to 1 tonne of input plastic waste, except the operations of recycling and the production of virgin plastics where the emission factors refer to 1 tonne of output material.

5.1.1. Plastic waste collection

The collection step in the model includes the collection of plastics in separate collection systems for recyclables (usually mixed with other recyclables) and explicitly excludes collection of plastics found in mixed wastes (e.g. mixed MSW or commercial waste).

For the separate collection of plastic waste (or together with other recyclables – light fraction) the emission factor considered refers to German derived data and the following conditions: Refuse collection vehicle; collection tour of 11.32 km; distance to sorting plant at 15.44 km (medium data for Germany). The GHG emission factor resulting from these conditions is 17.36 g CO_2e/kg material (ETC/SCP, 2011). The same factor is used for all the different collection systems included in the model as an assumption. The fact that the transport distances are drawn from German data leaves some room for uncertainty. Other modelled countries might have higher or lower distances compared to Germany, but the uncertainty of this assumption does not significantly affect the overall results since, in terms of GHG emissions from waste management, the collection of waste and its transportation to any treatment operation have a low contribution (ETC/SCP, 2011). Additional uncertainty arises from the fact that the only data available so far concern municipal collection schemes for packaging and do not reflect other collection activities e.g. collection of agricultural or building and construction plastic waste. But given that packaging waste represents 63% of the total plastic waste produced, this assumption is estimated to be acceptable.

5.1.2. Pre-treatment/sorting of collected plastics

The pre-treatment step in the model includes operations of dismantling and sorting of plastics from other recyclables in sorting facilities and may also include shredding and further sorting by plastic resin, either at the same sorting facility or a secondary sorting operation (prior to recycling). There is considerable lack of data concerning GHG emission factors of sorting and pre-treatment operations. However, through PRE, it was possible to gather information on the energy use of a sorting facility for plastic packaging waste. The specific sorting plant is using 50 kWh of electricity per tonne of input material. Taking the average GHG emissions factor for EU-28 electricity mix, it was calculated that the emission factor at the sorting step is 26.5 kg CO2e/t. The average GHG emissions factor for EU-28 electricity mix was calculated by combining GHG emission data from the Ecoinvent LCI database with data on the electricity sources by fuel at EU level from the International Energy Agency (IEA).

The emission factor assigned to the pre-treatment/sorting step is not representing satisfactorily the operations of dismantling, shredding and sorting in other waste streams besides packaging waste, but nevertheless it constitutes a relevant approximation of the impact of sorting in the plastic recycling value chain due to the fact that packaging waste represents 63% of the total plastic waste produced. However, GHG emissions from sorting of plastics have been found to be insignificant (Nordic Council, 2015) and therefore the impact of the assumption made in this step of the chain will not have any noticeable effect throughout the whole value chain.

5.1.3. Transportation of plastics to recyclers

The transportation module in the model includes all plastic waste transferred from the sorting facilities to recyclers, but also includes the transportation of plastic waste unfit for recycling to other treatment options (e.g. RDF preparation, incineration, landfilling). The Life Cycle Inventory (LCI) 'Transport: lorry 16-32 t, EURO4/RER' from Ecoinvent database was used for the transportation step of the chain. The emissions factor of diesel fuel is 3.07 kg CO_2e per litre of diesel and the fuel consumption of lorry type 16-32 tonnes is 0.3 litres per kilometre. The average load per truck is estimated at 16 tonnes (Eunomia, 2014) and the average distance travelled to recyclers is 380 km (Eco-Emballages, 2014). This average distance concerns specifically the situation in France and refers only to plastic recycling facilities within the context of packaging waste. However, plastic recyclers are specialised by plastic resin and not by waste stream, so in principle the same facilities receiving packaging waste could potentially treat waste from other streams as well (depending on quality and end applications). The density of recyclers and the distances are different in MS but the figure above is a good approximation at EU level, since extensive areas in EU periphery are far away from plastic recycling facilities. A general figure for the average distance to recyclers used extensively in literature is 250 km but this refers to all recycling facilities in general, irrespective of the material. It is considered more reliable to use data specific for plastic recyclers. For the treatment options of incineration and landfilling, the average distance is assumed at 30 km (EeBGuide, 2012). The resulting GHG emissions factor for transportation of plastics waste to recyclers is estimated at 21.88 g CO_2e/kg material, while the GHG emissions factor for transportation to incinerators or landfills is estimated at 2.76 g CO_2e/kg material.

5.1.4. Recycling of plastics

Recycling includes operations of plastic recycling by resin at specialised recyclers' facilities, from receiving the sorted material (bales) to the production of pellets or flakes of recycled plastics. In the recycling step, there are two different effects which are accounted in the impact assessment.

5.1.4.1. *Direct emissions from recycling*

Data on direct GHG emissions factors from the recycling processes of plastics by resin are scarce and the existing ones refer only to a few major resins, namely PET, PE-HD and PE-LD (Wisard database). Assumptions were required for the GHG emissions factors of all the other plastic resins that are recycled in recycling plants across Europe. Table 28 summarises all the GHG emissions factors used for the impact assessment. The data for PET (bottle/fibre), PE-HD and PE-LD in Table 28 comes from the Wisard LCI database. For PET, there is a distinction between the emissions factors of bottle grade and fibre recycled material. Documented data exist for PE resins but not for all other resins. The main assumption employed at this stage is that all other resins have similar GHG emissions factors to the ones used for the recycling of PE. This assumption is strongly backed up by evidence from a site specific study in a recycling plant in Japan, where the GHG emission factors for PE, PP, PS and mixed plastics are reported to be the same (Menikpura et al., 2014). The main uncertainty in the assumptions comes from the direct GHG emissions factor of other plastics (e.g. ABS, PA, etc.) for which data is not available. In the absence of data, the same factor is used (348 kg CO_2e/t) for 'Other plastic resins', as seen Table 28.

Table 28: GHG emission factors of recycling by plastic resin, expressed in kg CO_2e per tonne of plastic (output)

	PET (bottle/fibre)	PE-HD	PE-LD	PP	PS	PVC	Other plastic resins
Direct GHG emissions from recycling	510 / 280	348	348	348	348	348	348

5.1.4.2. *Avoided emissions from recycling*

Avoided GHG emissions occur when recycled plastic is used instead of virgin plastic by substituting the production process of virgin plastic and its associated life cycle GHG emissions.

The avoided emission factors are based on the Eco-profiles of plastics by resin maintained by PlasticsEurope (2014). Eco-profiles are Life Cycle Inventory datasets (LCI) and Environmental Product Declarations (EPD) for plastics and contain up-to-date GHG emission factors for the production of 1 tonne of virgin plastic (by resin). The avoided GHG emissions factor for 'Other plastic resins' is a weighted average of all other plastics resins having available and valid Eco-profiles in the PlasticsEurope database.

Table 29: GHG emission factors for the production of virgin plastics by plastic resin, expressed in kg CO_2e per tonne of plastic (output)

	PET (bottle/fibre)	PE-HD	PE-HD	PP	PS	PVC	Other plastic resins
Direct GHG emission from virgin plastics production	2 150 / 2 050	1 800	1 870	1 630	3 300	1 900	4 800

5.1.5. Energy recovery of plastics

The energy recovery options are modelled thanks to two distinct operations.

5.1.5.1. *The incineration of plastic waste directly as collected from the source*

The calculations of direct GHG emissions from incineration are based on the IPCC guidelines (2006) and follow the general formula:

kg CO_2 = kg waste for incineration • oxidation factor of carbon in incinerator (0.98) • conversion factor of C to CO_2 (3.67) • Σ(waste fraction (in %) • dry matter content • carbon content (g/g dry weight))

The dry matter content of plastic waste is equal to 1. The carbon content of plastic waste is 0.75 (Gg C/Gg dry weight waste) (IPCC, 2006). The GHG emissions factor from incineration is calculated at 2 697 kg CO_2e/t of plastic waste.

5.1.5.2. *The preparation of plastic waste as RDF/SRF for co-incineration in industrial facilities*

Direct emissions from co-incineration of RDF in cement kilns is between 1.35 t CO_2/t (ADEME, 2009) and 1.44 t CO_2/t of RDF (BIPE, 2011). However, it would not be accurate to consider that 1 tonne of plastic waste is equivalent to 1 tonne of RDF as the calorific value of plastic waste is much higher on average: RDF used in cement kilns have typically a calorific value between 17 and 22 MJ/kg. As a result, the calculation method used for determining the GHG emissions factor for plastics in RDF is the same as above (section 5.1.5.1), using the same parameters specific to plastic waste. It is only based on the chemical composition of the plastics, assuming the emissions produced from plastics either in incineration (under the form of plastics) or in industrial facilities (integrated in RDF) are similar. Therefore the GHG emissions factor from co-incineration of RDF is calculated at 2 697 kg CO_2e/t of plastic waste.

5.1.5.3. *Avoided emissions from incineration*

Similarly to virgin plastics substitution, besides the direct emissions of plastic waste incineration, there are also benefits resulting from the production of energy from the incineration of waste. Such benefits are characterised by avoided GHG emissions from the production of energy from fossil fuels. In order to estimate the avoided emissions from incineration, first the amount of energy produced in the incineration plants must be calculated. The potential for energy production was calculated as follows:

Energy content = kg waste incinerated • Σ(waste fraction (%) • calorific value (J/kg))

The calorific value of the plastics waste fraction is 30 (GJ/Mg) (IPCC, 2006). The avoided emissions from incineration are calculated as follows:

kg CO_2 savings = energy content (MJ) • (electricity share • efficiency of electricity conversion • CO_2 emissions/MJ for electricity + heat share • efficiency of heat conversion • CO_2 emissions/MJ for thermal energy)

The CO_2 emissions per MJ electricity and CO_2 emissions per MJ thermal energy represent the average emissions of the energy mix in EU-28. For electricity the emissions factor is 0.147 kg CO_2/MJ and for thermal energy 0.086 kg CO_2/MJ. These emission factors were calculated from data on the average energy mix for the production of electricity and heat in EU-28 provided by the International Energy Agency (IEA) for the year 2009, and life cycle inventories of the Ecoinvent LCI database for different electricity and heat production technologies.

The distribution of production of electricity and thermal energy in the incineration plants are estimated on the basis of CEWEP national reports (CEWEP, 2014) and the background information for the European Reference Model on Municipal Waste Management (Eunomia, 2014). The aggregated average distribution is estimated at 40% electricity and 60% heat production in the incinerators of EU-28. The efficiency of electricity conversion is considered at 38% and the efficiency of heat conversion at 91% (European Commission, 2006). The GHG emissions factor for the avoided emissions from incineration is therefore estimated at 2 079 kg CO_2e/t of plastic waste.

5.1.5.4. *Avoided emissions from RDF/SRF*

In the case of co-incineration in industrial facilities, the energy source substituted is hard coal, coke or oil, all with emission factors around 0.095 kg CO_2/MJ (BIPE, 2011). The same equation as above (section 5.1.5.3, with an electricity share of 0%) is used and the resulting GHG emissions factor is 2 594 kg CO_2e/t of plastic waste.

5.1.6. Landfilling of plastics

Landfilled plastic waste does not emit any greenhouse gases, as the decomposition of plastics exceeds the time span of 100 years (ETC/SCP, 2011). However, some direct emissions occur through the landfill operations (machinery and facility energy use). Direct GHG emissions from landfilling operations have been calculated at a range between 6-16 kg CO_2e/tonne of waste (Manfredi et al, 2009). For the calculation of GHG emissions from landfilling operations, the factor 10 kg CO_2e/tonne is used for the impact assessment.

5.1.7. Assessment of scenarios

Taking into account the whole plastics recycling value chain, including collection, pre-treatment/sorting, transportation, recycling and the options of energy recovery and landfilling, a significant reduction in GHG emissions is expected in 2020 if the targets set in EU legislation are met**. Compared to the *BAU 2020* scenario, the *Targets 2020* scenario results in a reduction of nearly 8 Mt CO_2e throughout the whole value chain. For 2025, the *Targets 2025* scenario results in a reduction of 13 Mt CO_2e compared to the *BAU 2025***.

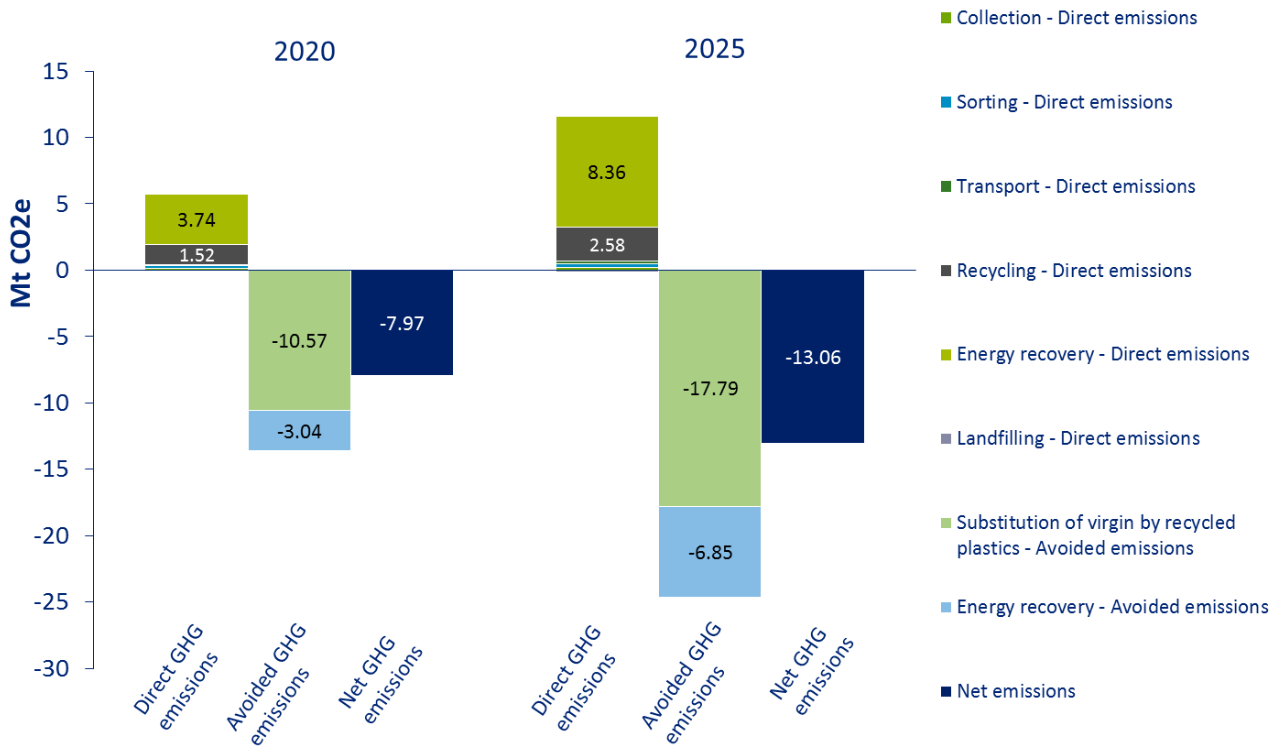

Figure 6: Comparison of annual GHG emissions in the scenarios (*Targets*, compared to *BAU*) for 2020 and 2025

Taking into account the quantities of plastic waste generated per MS, it is possible to allocate GHG emissions savings per MS. The higher GHG savings are observed in Germany with 1.4 Mt less GHG emissions per year by 2020 and 2.3 Mt less GHG emissions per year by 2025. The UK could save up to 1.2 Mt by 2020 and 2 Mt by 2025. France and Italy are following with about 1 Mt in 2020 and 1.7 Mt in 2025 less GHG emissions each. Spain could save up 0.7 Mt by 2020 and just over 1.1 Mt GHG emissions by 2025. Finally, Poland would save about 500 thousand tonnes of CO_2e per year if EU targets are reached in the country by 2020 and up to 700 thousand tonnes per year by 2025. For the full list of environmental impacts by MS, please refer to Annex II.

The production of virgin plastics in EU-28, in order to cover the demand for plastics in 2012, produced nearly 124.5 Mt of GHG emissions. The production of plastics in EU-28 has remained at the same level for the last four years (PlasticsEurope, 2015). **The GHG savings of plastic recycling could therefore result in 6.5% less emissions of the EU plastics industry by 2020 and 11.5% less emissions by 2025, considering a constant level of plastic production.**

As seen in Figure 6 and in Table 30, the GHG emissions savings from replacing virgin plastics with recycled plastics are high, while replacing district heating or oil/electricity with the energy generated from the incineration plastics results in slightly positive emissions.

Table 30 shows in detail the breakdown of GHG emissions savings at each step of the plastic recycling value chain. Negative values in the table indicate GHG savings.

Table 30: GHG emissions savings along the plastic recycling value chain in 2020 and 2025 (comparison of *Targets* and *BAU* scenarios) in million tonnes (Mt) of CO2e

GHG emissions by step of the chain	2020	2025
Collection – *Direct emissions*	0.13	0.19
Sorting/pre-treatment – *Direct emissions*	0.19	0.29
Transport – *Direct emissions*	0.12	0.20
Recycling – *Direct emissions*	1.52	2.58
Recycling – *Avoided emissions* (substitution of virgin plastics)	-10.6	-17.8
Energy Recovery – *Direct emissions*	3.74	8.63
Energy Recovery – *Avoided emissions* (substitution of energy)	-3.04	-6.85
Landfilling – *Direct emissions*	-0.06	-0.11
Net GHG emissions	**-7.97**	**-13.1**

As a conclusion, the increased material recycling of plastic waste induced by the targets set in EU legislation can save up to 8 Mt of GHG emissions per year in 2020, equivalent to 0.15% of total EU-28 GHG emissions or twice the amount of GHG emissions produced by Malta (in 2012) and up to 13 Mt of GHG emissions per year in 2025, equivalent to about 0.3% of total EU-28 GHG emissions or as high as the amount of GHG emissions of Luxembourg[5].

5.2. Economic impacts

Recycling is increasingly important for the European economy, contributing to growth and providing materials that can be returned directly back to the economy, substituting virgin raw materials and thereby improving the resource efficiency of production and reducing the dependency upon imports of raw materials.

5.2.1. Operating costs in the value chain and revenues from sales of recycled plastics

To calculate the costs along the plastics recycling value chain, the average operating costs of all steps at EU-28 aggregated level have been identified. These costs include all costs (including investment depreciation) except the purchase of input waste materials. Details on costs by waste stream and literature sources have been presented in section 4. The average costs for each step, resulting from the model calculation, are presented in Table 31 below. The costs of transport take into account the two distinct operations defined in the scenarios: a) transport to recyclers (15 EUR/t) and transport to other waste management options (2 EUR/t).

Table 31: Operating costs in each step of the plastics recycling value chain (ranges covering all scenarios)

	Collection	Pre-treatment	Transport	Recycling	Energy Recovery	Landfilling
Operation costs (EUR/t)	151	185	2/15	446	74	73

The operating costs in Table 31 correspond to current costs (baseline, reference year 2012). According to the modelling assumptions, these **costs remain constant in the future scenarios** (*BAU* and *Targets*), not taking into account potential evolution, such as increase of energy costs, optimisation of processes, etc. in absence of any reliable projections for future development of costs.

The selling prices of virgin, recycled, and sorted (for recycling) plastics are presented in Table 32. They are compiled and cross-checked from a number of different sources (PIEweb, Plasticker, PRE questionnaires,

[5] Eurostat database: Greenhouse Gas Emissions (source: EEA) (env_air_gge), at: http://ec.europa.eu/eurostat/web/environment/air-emissions-inventories/database

Deloitte) and represent the most accurate range of prices available to date, over the last 3 years. For the 'other plastic resins' the prices of virgin plastics as well as the prices of recycled and sorted plastics are calculated as the simple average of the prices of all the other six plastic resins in Table 32.

Table 32: Prices of virgin, recycled and sorted (for recycling) plastics in EUR/t

	Virgin plastics	Recycled plastics	Sorted waste plastics
PET	1300-1400	650-1000	250-350
PE-HD	1350-1450	800-960	350-450
PE-LD	1420-1490	700-950	170-270
PP	1430-1500	900-950	250-350
PS	1650-1950	900-1000	50-150*
PVC	950-1300	750-850	170-270
Other plastic resins	1400-1600	800-1000	210-310

** not reliable sources – best estimates*

Revenues from energy sales or fuel substitution are included in the aggregated net costs of energy recovery operations. These net costs also take into account the "gate fee" prices of energy recovery operations.

5.2.2. Investment necessary for expanding processing capacity at sorting and recycling facilities

There is less recycling capacity today in EU-28 (baseline, reference year 2012) than the amount of plastic waste sent to recycling. This undercapacity in recycling represents around 50% of the total plastic waste generated in the EU-28, while the rest 50% of plastic waste is exported for recycling overseas. Additional capacity is therefore required for the future scenarios in order **to cover the missing current capacity but also to accommodate increasing amounts of plastic waste** that will be diverted to recycling in response to increased recycling targets at EU level. This will result in further investment costs. The investment costs are provided as an additional separate indicator, as they are also included in the operating costs calculated.

Data from various sources have been used in order to identify the investment costs per tonne of treated waste in recycling and sorting operations. It should be noted that it is not always clear whether the data collected consider the whole investment cost that would be required to build extra-capacity through depreciation accounting, or only a certain share of these. Depending on the size of the facility and annual throughput the investment costs differ substantially.

- For sorting, the investment cost vary from about 500 EUR/t to 800 EUR/t (ADEME, 2014). These costs are indicative for packaging sorting facilities and the costs might be highly variable in other types of pre-treatment facilities which include many intermediate operations such as dismantling and shredding of plastics waste. Due to lack of detailed data on sorting and pre-treatment facilities accepting plastic waste other than packaging, the range of investment cost per tonne for packaging sorting facilities is assumed to apply for all waste streams in the model. This simplification might have certain impacts in the range of investment costs required for additional pre-treatment capacities in EU, especially for waste streams such as WEEE and ELV.
- For recycling, the investment cost vary from 275 EUR/t (e.g. PET recycling facility with treatment capacity of 36 500 t/y) to 750 EUR/t (e.g. specialised facility of high quality PP and PE recycling).
- For collection and transportation, the extra capacity required is not considered in the model, as it mostly consists of additional trucks and it is therefore neglected (no information was found).
- Regarding incineration and landfilling, it is estimated that the current capacities in the EU-28 are already sufficient to handle the targeted quantities in the scenarios.

5.2.3. Assessment of scenarios

Achieving all targets in EU legislation by 2020 could result in **a net cost of about 700 million EUR to nearly 1.6 billion EUR** throughout the plastics recycling value chain, compared to the *BAU* scenario. These net costs include the operating costs of all operations in the chain minus the revenues from the sales of recycled plastics at the end of the recycling value chain. The high range of results is due to the uncertainty range of prices of recycled plastics. The high end of the range represents the situation where recycled plastics are sold at the lowest prices considered, while the opposite happens when assuming that all plastics are sold at the highest prices considered. **Taking an *'average prices'* approach**, increased recycling of plastics could result in **net costs of approximately 1.1 billion EUR per year in 2020**. It should be mentioned that these costs are not to be seen as absolute barriers to the scenarios: they would have to be supported by actors not considered within the scope of the assessment (e.g. public subsidies, EPR), which play a key role in the development and sustainability of the waste management sector today.

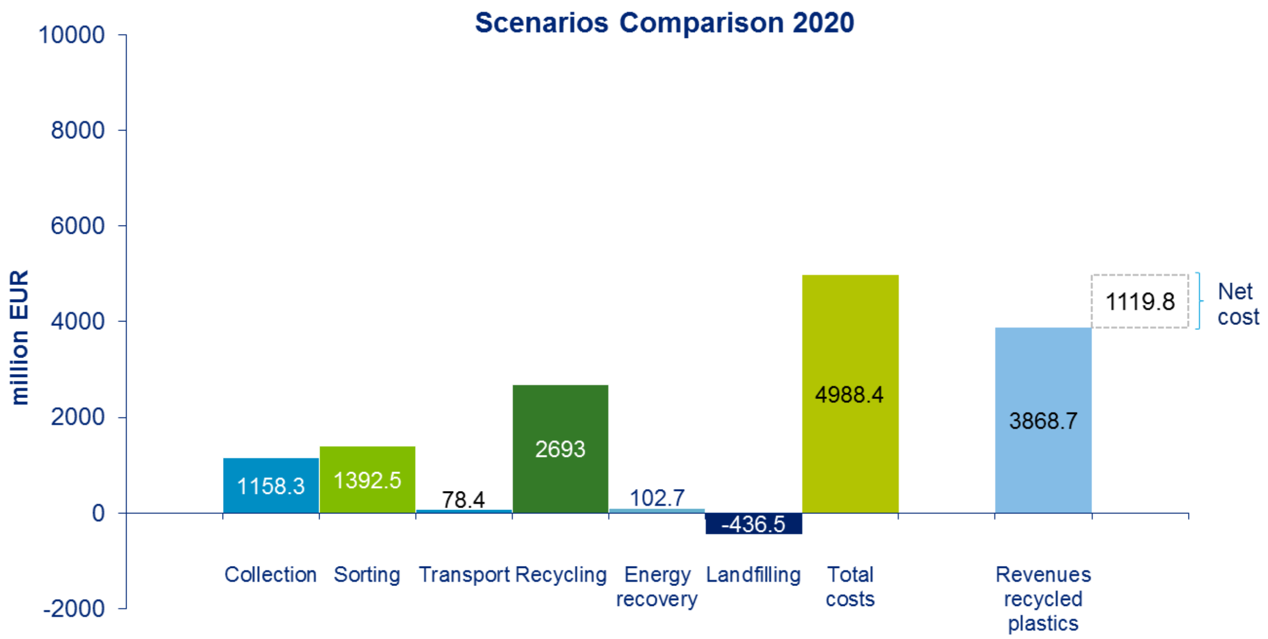

Figure 7: Average operating costs of the plastic recycling value chain and revenues from recycled plastics at the end of the chain in 2020 (comparison of *BAU* and *Targets* scenarios)

The operating net cost of the plastic recycling value chain at *'average prices'* approach in the *Targets* 2020 scenario, compared to *BAU* 2020 (Figure 7), is broken down by MS taking into account the plastic waste generation figures of each MS. The net cost per year is about 200 million EUR for Germany, 170 million EUR for the UK, around 150 million EUR for France and Italy, nearly 100 million EUR for Spain and up to 65 million EUR for Poland. For the full list of economic impacts by MS, please have a look at Annex II.

The comparison in 2025 results in **a broader range of possible costs** than that of 2020, showing a **net cost of 720 million EUR**, if all recycled plastics are sold at the highest prices possible, and a **net cost of 2.3 billion EUR**, if recycled plastics are sold at low prices. **Considering average sale prices for all recycled plastic resins, the net costs represent about 1.45 billion EUR per year in 2025** (see Figure 8).

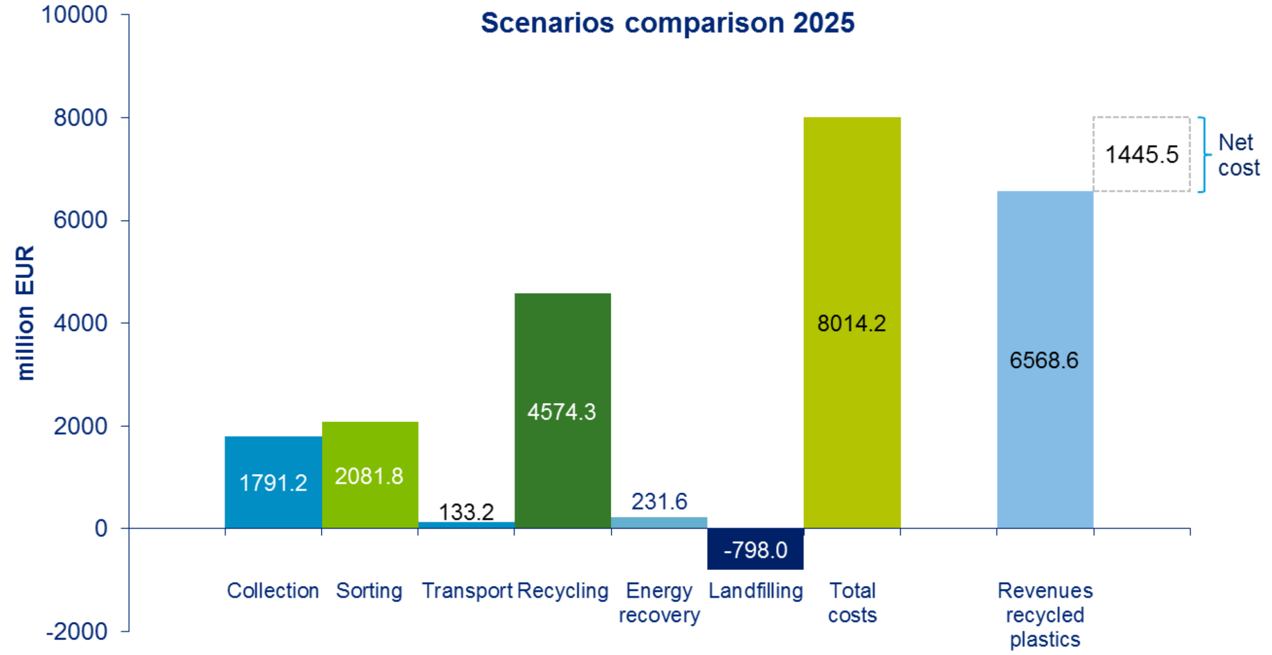

Figure 8: Average operating costs of the plastic recycling value chain and revenues of recycled plastics at the end of the chain in 2025 (comparison of *BAU* and *Targets* scenarios)

The operating net cost of the plastic recycling value chain at *'average prices'* approach in the *Targets* 2025 scenario, compared to *BAU* 2025 (Figure 8), is broken down by MS taking into account the plastic waste generation figures of each MS. The net cost per year is 255 million EUR for Germany, 220 million EUR for the UK, around 190 million EUR for France and Italy, 125 million EUR for Spain and nearly 85 million EUR for Poland. For the full list of economic impacts by MS, please have a look at Annex II.

The cost structure for both 2020 and 2025 is similar. Recycling appears to be the most costly step along the chain (in other words, where most of the added value is brought) and accounts for more than half of the total operating costs. Collection of plastics and sorting operations contribute to similar costs while the transportation cost is very low. Landfilling costs decrease as more and more plastic waste is diverted from landfills to recycling (and energy recovery). The sales of recycled plastics at the end of the value chain represent significant revenues, especially in the case of the high prices option. However, a moderate approach of average prices in sales seems more realistic. The ability of recyclers to produce high quality materials, where there is demand, and to sell them at high prices is a key aspect in the development of the whole plastic recycling chain. It should be noted that the average EU-28 collection, sorting and recycling costs used for the economic impact assessment and in the plastic value chain model are within a very conservative range, ensuring that the results will not reflect any unrealistic situations. However, there is potential for optimisation of these costs which could lead to reduced overall costs throughout the plastics recycling value chain and close the gap between costs and revenues from the sale of recycled plastics.

Table 33: Summary of economic impacts of increased recycling in 2020 and 2025 (*Targets*), compared to *BAU*, presented in billion EUR

	2020	2025
Operating costs (including collection, sorting, transport, recycling, energy recovery and landfilling)	5	8
Revenues from the recycled plastics	3.4 to 4.3	5.7 to 7.3
Overall balance	**-0.7 to -1.6**	**-0.7 to -2.3**

** Negative values in the overall balance indicated costs*

Due to the fact that quantities of plastic waste and the recycling targets will increase in the future, additional processing capacities will be needed by 2020 and 2025. The investment costs related to the additional capacities are included in the annual operating costs presented above. The total investment costs have also been calculated separately based on the additional capacities required. These costs are derived from the data presented in section 5.2.2. **However, they only represent the investment required to go from the *BAU* to the *Targets* scenarios**: in other words, the investment required to go from the *Baseline* situation (current capacities, with around 50% of plastic waste being exported out of the EU) to the *BAU* in 2020 and 2025 (same recycling performance as the baseline, but considering only recycling within the EU) is not included.

The investment required to cover the recycling of all plastic waste from the *Baseline* situation (with 50% undercapacity) to *BAU* 2020 (100% recycling in EU-28) lies between 1 billion and 2.7 billion EUR.

The 2020 *Targets* scenario requires additional total investment in sorting and recycling capacity **between 5-10 billion EUR overall (i.e. by 2020, not annually), compared to the *BAU*,** while the same investment **by 2025 would represent between 8.4-16.6 billion EUR** for the 2025 *Targets* scenario. In other words, the investment costs required for increasing recycling and sorting capacity in EU-28 is within the range of 0.7-1.3 billion EUR per year.

Table 34 : Results of annual and total investment costs (in billion EUR)

	2020	2025
Total investment costs (from current situation, until targets)	5.2 – 10.1	8.4 – 16.6
Investment costs for additional recycling and sorting capacity, per year	0.7 - 1.3	0.7 - 1.3

Considering an average plant capacity for sorting and recycling facilities, an estimation of the number of new plants that needs to be constructed in EU-28 was made: assuming an average processing capacity of 45 000 tonnes per year for a new sorting facility and 35 000 tonnes per year for a new recycling facility, approximately **150 additional sorting facilities and 170 recycling facilities would be built by 2020 in the EU-28. These figures rise to 250 sorting facilities and 300 recycling facilities by 2025.**

5.2.4. Discussion

The results presented above show that plastic recycling in the future would not be entirely financially self-standing, given that the operating costs across the whole value chain are higher than the revenues from the sales of secondary raw materials (in the average situation presented). This illustrates the fact that, like in the current situation, a certain share of these costs needs to be supported by other revenues than the sales from the materials, including Producer Responsibility Organisations' schemes and local taxes which are required in order to supplement collection and sorting costs. The objective of the plastic recycling chain should therefore be to reduce progressively this "external" financing, in order to improve its sustainability. The examples of other materials recycling chain (e.g. metals) which are only financed by the value from the recovered materials illustrate this possibility.

There are several drivers that could lead to this situation, which can be internal or external to the value chain.

- The first one is the prices of secondary raw materials: as shown in the range of results, if the prices are higher, the revenues are higher as well and may cover large part of the costs. Such an increase could result from different effects: regulatory measures such as GHG taxes or mandatory recycled plastics integration in products, future increase of the oil prices which determines the virgin plastics prices and has an effect on the secondary raw materials prices, etc.
- The second driver would be the landfill taxes: similarly to the increase of recycled plastics, the increase of landfill taxes would virtually increase the revenues of the recycling value chain, and therefore improve the balance between the operating costs and the revenues from the sales of recycled plastics
- Finally, the reduction of the collection/sorting/recycling costs (through e.g. technical performance improvement and innovation, eco-design of the plastic products, etc.) would reduce the operating costs in the different steps of the chain.

5.3. Social impacts

Increased recycling of plastic will also have beneficial impacts in the EU society by creating employment and contributing to community prosperity. The benefits of increased recycling can be direct, in terms of direct employment in recycling and waste management operations, or indirect resulting from supporting operations, such as construction of new recycling facilities, manufacturing of equipment for recycling, maintenance and repair of recycling facilities and equipment, as well as administrative and management positions. In addition, direct employment in the waste management chain is mostly attached to low-skilled jobs that could be performed by workers who may have fewer options available elsewhere in the economy, a fact that contributes to social integration and poverty alleviation.

The average job intensity in each step of the plastics recycling value chain in the EU-28 is summarised in Table 35. Details on job intensity by waste stream and literature sources have been presented in section 4.

Table 35: Job intensity in the plastics recycling value chain

	Collection	Sorting/Pre-treatment	Transport	Recycling	Energy Recovery	Landfilling
Direct jobs (FTE per 10 000 t plastic)	23	17	1	30	1	1

The scenarios reveal significant benefits in direct employment throughout the chain, if the targets in EU legislation are met by 2020 and 2025. In 2020 *Targets* scenario, increased recycling results in **about 50 000 additional direct jobs (FTE)** compared to *BAU*, as it can be seen in Figure 9. The most significant areas of job creation are the collection of plastics for recycling as well as the sorting and recycling operations, each contributing to around 14 000-18 000 additional jobs in 2020. In 2025 *Targets* scenario, nearly **80 000 direct jobs would be created**, compared to the *BAU* scenario where no additional effort is being made to increase recycling. Again, recycling shows the highest benefits in job creation, by adding around 30 000 jobs, just before collection with about 27 000 jobs and sorting operations with 21 000 additional jobs. Energy recovery, being a very low job-intensive waste management activity contributes only with about 300 jobs in 2025. On the other hand, the diversion of plastic waste from landfills creates a negative balance in jobs related to final disposal operations in landfills but this effect is very limited: around 600 jobs in this sector would be lost in 2020 and 1 000 in 2025. This is counterbalanced with job creation in the transportation step only, which could create about 1 500 direct jobs by 2025.

Similarly to the economic assessment, it should be noted that **these results only represent additional jobs created by comparing the *BAU* to the *Targets* scenarios**: in other words, the jobs required to go from the *Baseline* (current employment level, with around 50% of plastic waste being exported out of the EU) to the BAU in 2020 and 2025 (same recycling performance as the baseline, but considering only recycling within the EU) are not included.

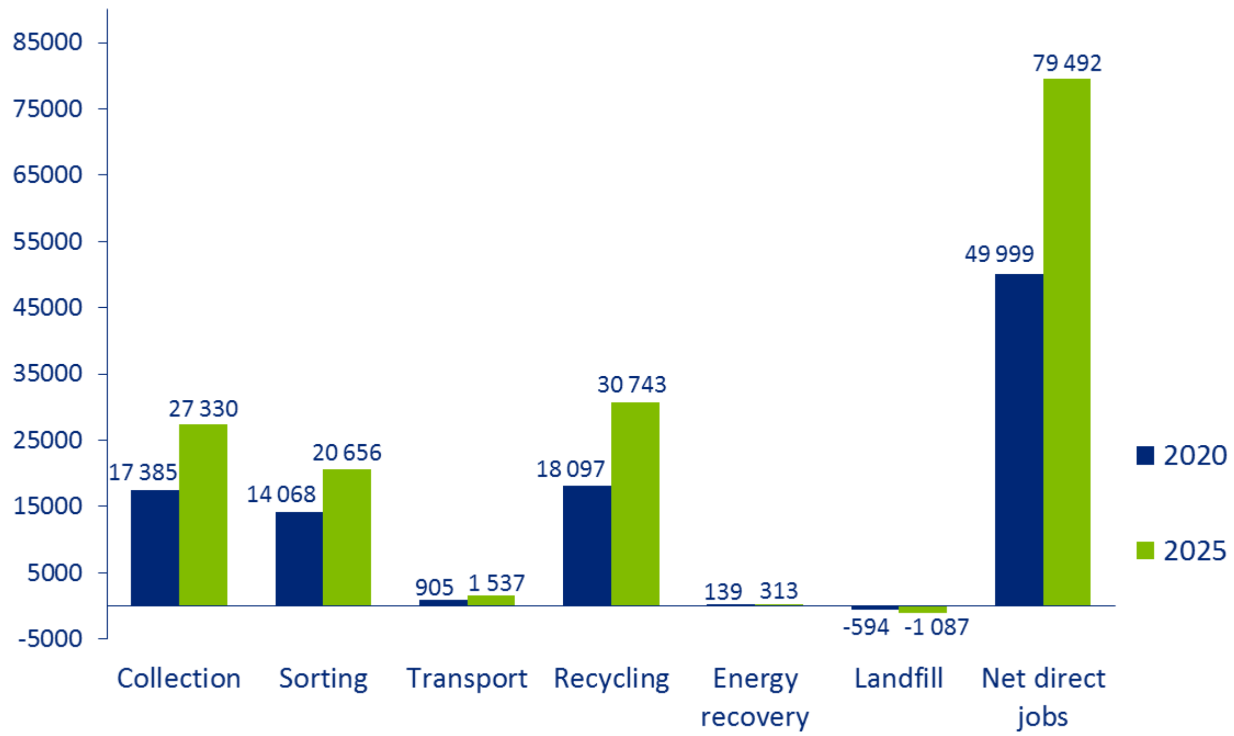

Figure 9: Number of direct jobs created along the plastic recycling value chain in *Targets* 2020 and *Targets* 2025 compared to respective *BAU* (in FTE)

As a conclusion, there is a significant gain in direct job creation thanks to the fulfilment of EU targets and the increase in plastic waste recycling.

Taking into account the quantities of plastic waste generated per MS, it is possible to allocate direct job creation throughout the plastic recycling value chain per MS. The higher potential for direct job creation is observed in Germany with approximately 8 800 additional jobs in 2020 and 14 000 in 2025. Around 7 500 direct jobs could be created in the UK by 2020 and 12 000 by 2025. France and Italy are following with about 6 500 direct jobs in 2020 and 10 500 in 2025. Spain could benefit from the creation of 4 300 additional jobs in the plastic recycling value chain by 2020 and from 6 800 in 2025. Finally, in Poland nearly 3 000 new jobs directly linked to the plastic recycling value chain could be created by 2020 and over 4 600 by 2025. For the full list of social impacts by MS, please have a look at Annex II.

Besides the direct employment in the plastics recycling value chain, there is a great potential for the creation of indirect jobs, as discussed in the beginning of this section. However, it is challenging to quantify the indirect employment and little evidence is available that can support this assessment. In previous studies, there has been extensive use of so-called ‘multipliers’ which determine the indirect employment attached to the direct employment of various waste management operations. The multiplier of 1.5 for indirect employment was found based on a review of previous reports (FOE, 2010 and SITA, 2011). This multiplier is considered conservative by the sources, since it is lower than those generally applied in other economic sectors such as mining, construction, manufacturing, transport, communication and utilities. **The total indirect employment in EU-28 associated with the increased recycling of plastic waste could thus represent around 75 000 indirect jobs in 2020 and 120 000 indirect jobs in 2025.**

6. Conclusions

Plastics are indispensable materials used in all aspects of EU citizens' everyday lives, making it easier and safer for all. At the same time, plastics are currently wasted to a high degree either by being disposed into landfills or incinerated. However, thermoplastics have the capability to be recycled and used back in their original application a certain number of times. Recycling of plastics could deliver high benefits in environmental, economic and social terms and should be the preferable option of waste management in EU-28, fully in accordance with the waste hierarchy as illustrated in the Waste Framework Directive (2008/98/EC).

The results of the impact assessment of higher plastics recycling targets in EU-28 show very positive results in saving considerable amounts of GHG emissions and in creating thousands of jobs directly and indirectly within the EU economy, while the costs for achieving this is quite moderate and certainly feasible:

- High environmental benefits, in terms of GHG emissions savings, demonstrate the significant contribution of plastic recycling in improving the sustainability of the EU-28 while at the same time safeguarding precious resources within the EU economy, making it more resilient to external pressures. Increased recycling performance, by fulfilling EU existing and proposed targets, could save up to 8 Mt of GHG emissions per year by 2020 and up to 13 Mt by 2025.
- In the aftermath of the recent economic crisis, increasing the recycling of plastics will have a reinvigorating effect to EU employment. It is estimated that nearly 50 000 new jobs could be created directly in the recycling value chain of plastics by 2020, with over 75 000 additional indirect jobs supporting the sector and its operations. By 2025, employment could increase considerably by 80 000 direct jobs and 120 000 indirect jobs.
- The economic impacts of increased EU recycling targets appear in a moderate cost range, around 1 billion EUR by 2020 and 1.45 billion EUR by 2025, and could be reasonably tackled by EU, national and market investments in the sector, e.g. with Public-Private Partnerships (PPP) and Extended Producer Responsibility (EPR) systems, showing a good example of management and sourcing of plastic waste from the municipal and commercial sphere to the plastics recycling value chain. Such approaches could lead to increasing benefits for both communities and recycling operators. The net cost incurred in the plastics recycling value chain, due to increased recycling in EU-28 in the future scenarios could be compared to the annual participation costs to EPR systems for packaging (or other waste, e.g. WEEE). For 2020, the net cost of 1 billion EUR corresponds to roughly 40 EUR/tonne of plastic waste generated (Total plastic waste generation in 2020, Table 8). The EPR annual participation fees for the recycling of plastic packaging (e.g. green dot, etc.) reach much higher values than 40 EUR/tonne. Examples include, Netherlands: 387.6 EUR/tonne of plastic packaging put on the market, Spain: 377-472 EUR/tonne, France: 242 EUR/tonne, Italy: 188 EUR/tonne, Estonia: 409 EUR/tonne, Czech Republic: 189 EUR/tonne and Greece: 66 EUR/tonne (Expra, 2015 and PRO Europe, 2015). Only a few countries have lower participation fees than 40 EUR/tonne of plastic packaging put on the market, including Germany, Poland and Romania. Therefore, it is considered that the net cost result of the economic impact assessment of increased recycling is certainly feasible and within a moderate range.

However, there are still a few challenges which need to be addressed in order to achieve high recycling in reality. Setting high targets is a prerequisite to spur higher recycling performance but would not necessarily lead to increased recycling if existing barriers within the plastics recycling value chain are not successfully overcome.

Increase accountability, limit exports

First of all, regarding the regulatory framework, the approach used in the determination of future targets (following the recommendation in COM(2014) 397 final) requires increased accountability and transparency in the way data are collected at the output of the recycling process and how the recycling rates and the targets are calculated. Ultimately, it will be up to the recyclers to report on the actual amounts of recycled plastics. Moreover, although exports of plastic waste for recycling are seen as economically beneficial at the moment (instead of the costly option of increasing domestic recycling), it might not be the case in the future when the recycling targets would be calculated at the output of the recycling process. On top of that, certifications and compliance documents would be required in order to make sure that the recycled amounts reported by the recyclers overseas are corresponding to the exported waste of a specific MS so that it could be accounted to its national recycling target. On the other hand, domestic recycling could contribute into the safer and more economical fulfilment of the targets in controllable manner and with the environmental standards prescribed by EU regulations. Finally, the environmental externalities throughout the plastic recycling value chain are currently not accounted, a fact that would result in reduced net costs due to the high GHG emissions saving potential of plastic recycling, compared to the environmental burden of other waste management options.

Improve collection of plastic waste

One of the most significant factors which can directly influence the amount of plastics going to recycling facilities is the collection of plastic waste. Currently, the collection rate of plastic waste for recycling is relatively low (26% according to PlasticsEurope, 2013), especially compared to other materials like paper or glass, and several plastic waste streams have a substantial potential for collection improvement. The performance targets in EU legislation (existing and proposed) targeting plastic waste, are setting ambitious recycling rates, which would almost double the amount of plastic waste needed to collect for recycling by 2020.

Taking the packaging waste stream as an example, according to the latest data available by waste stream, 41% of the packaging waste currently generated in EU-28 is collected for recycling (separate collection) and about 34% is sent to recyclers, leading to only 25% actually being recycled (output of recycling process). The proposed target for packaging waste at the output of recycling (COM(2014) 397) is 45%. Therefore, an increase of nearly 20% in the output recycling rate needs to take place in order to fulfil the target at EU-28 level. This also means that separate collection of plastic packaging needs to increase by 29%, reaching 70% of the generated plastic packaging waste in the EU-28 (see Table 1, Annex I). As a result, significant effort is needed to reach this level of collection for plastic packaging waste within the next 5 years.

The need for improved collection becomes more acute when analysing the situation of plastic waste in WEEE, ELV, B&C and agricultural waste. The current (*Baseline* 2012) collection and recycling rates in these waste streams are considerably low and an extraordinary effort will be required in order to collect substantial quantities of plastic waste from the respective streams for meeting the targets. The collection rate of ELV plastic for recycling is currently only 35%, while the minimum rate required to meet the target would be 74% (Annex I) in 2020. This means that the collection rate will have to double in the following 5 years. For WEEE, a tripling of the collection rate would be required for meeting the minimum EU targets. Therefore, it becomes obvious that urgent measures should be taken to limit the leakage of ELV and WEEE quantities and to redirect plastic waste to recycling. Otherwise, there is no chance of meeting the targets in the specific waste streams.

Despite the apparent difficulties, it is not unrealistic to propose such high targets since there is wide room for improvement in the majority of MS where the collection of plastic waste for recycling is low either because other management options are preferred (e.g. energy recovery) or the local waste management system is insufficient (e.g. lack of separate collection, reliance on landfilling, etc.). New systems need to be introduced, targeting specifically the separate collection of plastics. Moreover, collection and sorting costs have the potential to be further optimised in the future, resulting in higher performance at no or little additional cost.

For packaging waste, appropriate systems for the separate collection of plastic packaging would be required in order to increase the quantity of clean plastic material entering the plastic recycling value chain (i.e. not lost to landfilling or energy recovery). Optimisation of collection routes and proper illustrative information for correctly sorting and depositing plastic waste to separate collection bins (or bags), addressed to the general public, would also contribute to increasing the collection of plastic packaging.

There should be selective dismantling of plastic components from WEEE, ELV and B&C waste in order to achieve higher rates of clean plastic waste that could be diverted to recycling. Furthermore, especially in the waste streams of ELV and WEEE, it is important to tackle the illegal activities of dealing with plastic waste and incorporate the informal sector as much as possible to the formal channels of waste management within each MS. Illegal exports should be tracked and effectively restricted, applying tighter enforcement in cases where such practices are identified. Incorporating falsely notified exports and collected amounts from the informal sector, a significant amount of plastic waste could be redirected back to the plastic recycling value chain and assist considerably in achieving higher recycling rates at National and EU level.

For agricultural plastic waste, there is a need for introducing appropriate collection systems (either voluntary or mandatory). There are already a few systems in place today in countries such as Germany, Sweden and France, but in most of the other MS there is no appropriate collection scheme to deal with agricultural plastic waste and as a result most of it is lost to other waste management options. Agricultural plastics are considered as easily collectible and can be sorted quite easy since there are only limited types of plastic resins used in application such as agricultural films or canisters. There is great potential for plastics recycling in the agricultural waste stream which remains untapped.

Increase recycling capacity and processes

Despite the fact that current collection of plastic waste for recycling in EU-28 is low, there is a lack of sorting and recycling capacity in EU-28. European plants are only able to handle around half of the amount of plastic waste collected, the rest being exported overseas mostly for economic reasons. The exporting tendency prevents the expansion of domestic capacity, since there is uncertainty in the new recycling facilities about finding enough plastic waste to process. However, in order to increase recycling within EU-28 it is necessary to increase the European capacity in sorting and recycling facilities for accommodating increased quantities of plastic waste. Expanding current capacity might require extra costs but also there is the potential of creating economies of scale that will enable higher recycling efficiency at lower costs and thus improve the economic situation of recyclers in the medium term by allowing higher added value per unit of recycled plastic.

The results of the economic impact assessment showed only a moderate cost for improving capacity EU-wide, as analysed above in this chapter. Compared to the high environmental and social gains, it would be beneficial for EU-28 Member States to increase recycling of plastic waste domestically and limit as much as possible exports for recycling. Avoiding exports overseas, available materials remain within the EU for further use, thousands of jobs are created, that will stay in the EU, and the important GHG savings remain within the EU and contribute to achieving EU climate targets. However, in case some MS find it uneconomical to increase domestic infrastructure, the option of intra-EU exports could be a good alternative to shipping plastic waste overseas. Since the impact assessment assumed no exports in the comparison of scenarios (see Chapter 3), the potential job creation, as presented above, in the EU-28 would decrease if plastic waste is exported overseas. There is also a possibility that the environmental benefits would also be reduced, due to increased transport distances and lower process efficiencies in the receiving countries.

Eco-design measures and increased sorting and recycling efficiencies will also contribute to increased recycling in EU-28. Designing future packaging and plastic parts in cars, electronic equipment and other plastic-containing products with a life cycle perspective will enable easier sorting and dismantling which makes recycling easier and less expensive. Furthermore, careful use of recyclable plastic resins and avoidance of excessive use of chemicals and other additives in plastics will render recycling possible for more and more plastic products put on the market. Finally, by improving the sorting lines it will be possible to redirect increased quantities of collected plastic waste to recycling (e.g. improving technology for sorting black plastics in the future).

Increase demand of recycled plastics

Any advances in collection, sorting and recycling processes however, would not make much sense if no demand for recycled plastics exists in order to absorb the quantities of recycled plastics. Therefore, it is considered of high importance to boost the demand of recycled plastics in the market and increase the quantities of recycled plastics that go back to manufacturing and production of new products. Certain measures could be introduced (e.g. GPP, tax incentives for products with share of recycled content, etc.) that will create stable market conditions for recycled plastics and enable recyclers to invest in capacities and new technology with the aim to increase plastic recycling. The ability of recyclers to produce high quality materials, according to demand, and to sell them at high prices is a key aspect in the development and sustainability of the plastic recycling value chain.

Ultimately, a balance in supply of plastic waste and demand of recycled plastics needs to be established in order to enable a healthy and sustainable recycling sector that can contribute the maximum to fulfilling the increased targets and high expectation of the EU in creating a truly circular economy.

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Annex I

Target tables for the calculation of the amount of plastic waste required for recycling in the EU in the future scenarios of 2020 and 2025. Waste amounts presented in tonnes.

Target table 2020							
	Packaging	WEEE	ELV	B&C	Agricultural	Other	TOTAL
Waste generated	**17 191 433**	**1 659 179**	**1 535 188**	**1 771 549**	**1 311 291**	**4 724 131**	**28 192 771**
share of recyclable plastics rate	*80%*	*90%*	*85%*	*80%*	*90%*	*50%*	*76%*
of which, recyclable plastics	13 753 146	1 493 261	1 304 910	1 417 239	1 180 162	2 362 065	21 510 784
Control	ok	ok	ok	ok	ok	ok	ok
Disposal rate	*10%*	*5%*	*8%*	*14%*	*10%*	*29%*	*13%*
Landfilled waste	1 655 832	79 641	128 858	254 701	124 699	1 370 353	3 614 083
Energy recovery rate	*20%*	*10%*	*18%*	*31%*	*20%*	*62%*	*27%*
Waste sent to energy recovery	3 518 643	169 236	273 823	541 239	264 985	2 912 000	7 679 926
Collection rate	*70%*	*85%*	*74%*	*55%*	*70%*	*9%*	*60%*
Waste collected for recycling/going to s	**12 016 958**	**1 410 302**	**1 132 506**	**975 610**	**921 607**	**441 778**	**16 898 762**
control (disposal rate + energy recovery rate + collection rate)	100%	100%	100%	100%	100%	100%	100%
Pre-treatment process efficiency	*85%*	*61%*	*55%*	*82%*	*55%*	*72%*	*79%*
Pre-treatment output	**10 214 415**	**865 452**	**622 878**	**800 000**	**506 884**	**318 080**	**13 327 710**
EU Recyclers inputs	**10 214 415**	**865 452**	**622 878**	**800 000**	**506 884**	**318 080**	**13 327 710**
"Input" recycling rate	*59%*	*52%*	*41%*	*45%*	*39%*	*7%*	*47%*
Recycling yield	*76%*	*73%*	*74%*	*80%*	*78%*	*74%*	*76%*
EU Recyclers outputs	**7 736 145**	**634 636**	**460 556**	**636 706**	**393 387**	**236 207**	**10 097 637**
Recyclers and pre-treatment waste	4 280 813	775 666	671 950	338 903	528 220	205 572	6 801 125
> incinerated	2 910 953	527 453	456 926	230 454	359 190	139 789	4 624 765
> disposed	1 369 860	248 213	215 024	108 449	169 030	65 783	2 176 360
"Output" recycling rate, waste generate	***45%***	***38%***	***30%***	***36%***	***30%***	***5%***	***36%***
"Output" recycling rate, waste collected	***64%***	***45%***	***41%***	***65%***	***43%***	***53%***	***60%***

Target table 2025							
	Packaging	WEEE	ELV	B&C	Agricultural	Other	TOTAL
Waste generated	**18 068 369**	**1 970 585**	**1 736 924**	**1 955 933**	**1 344 403**	**5 215 822**	**30 292 035**
share of recyclable plastics rate	*85%*	*92%*	*87%*	*82%*	*92%*	*52%*	*80%*
of which, recyclable plastics	15 446 649	1 812 938	1 511 124	1 603 865	1 236 850	2 712 227	24 323 653
Control	ok	ok	ok	ok	ok	ok	ok
Disposal rate	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
Landfilled waste	0	0	0	0	0	0	0
Energy recovery rate	*15%*	*15%*	*23%*	*40%*	*26%*	*88%*	*30%*
Waste sent to energy recovery	2 637 330	295 588	403 057	779 463	354 275	4 572 149	9 041 861
Collection rate	*85%*	*85%*	*77%*	*60%*	*74%*	*12%*	*70%*
Waste collected for recycling/going to s	**15 431 039**	**1 674 997**	**1 333 867**	**1 176 470**	**990 128**	**643 673**	**21 250 174**
control (disposal rate + energy recovery rate + collection rate)	100%	100%	100%	100%	100%	100%	100%
Pre-treatment process efficiency	*90%*	*73%*	*60%*	*85%*	*60%*	*75%*	*85%*
Pre-treatment output	13 887 935	1 229 807	800 320	1 000 000	594 077	482 755	17 994 893
EU Recyclers inputs	**13 887 935**	**1 229 807**	**800 320**	**1 000 000**	**594 077**	**482 755**	**17 994 893**
"Input" recycling rate	*77%*	*62%*	*46%*	*51%*	*44%*	*9%*	*59%*
Recycling yield	*78%*	*75%*	*76%*	*81%*	*79%*	*76%*	*78%*
EU Recyclers outputs	**10 841 021**	**921 248**	**607 923**	**808 341**	**470 541**	**365 108**	**14 014 183**
Recyclers and pre-treatment waste	4 590 017	753 749	725 944	368 129	519 587	278 566	7 235 992
> incinerated	3 488 413	572 849	551 717	279 778	394 886	211 710	5 499 354
> disposed	1 101 604	180 900	174 227	88 351	124 701	66 856	1 736 638
"Output" recycling rate, waste generate	***60%***	47%	***35%***	***41%***	***35%***	***7%***	***46%***
"Output" recycling rate, waste collected	***70%***	***55%***	***46%***	***69%***	***48%***	***57%***	***66%***

Annex II

The environmental, economic and social impacts of increased plastic recycling according to EU targets (Chapter 5) are presented in the table below, broken down by Member State. The allocation of the impacts to each MS is done by taking into account the amount of plastic waste generated in each individual MS in 2012. Data on plastic waste generation by MS was provided by PlasticsEurope.

Member State (plus Norway and Switzerland)	**Environmental Impacts** (Mtonnes CO2e)		**Economic Impacts** (million EUR)		**Social Impact** (number of direct jobs)	
	2020	**2025**	**2020**	**2025**	**2020**	**2025**
Austria	0.14	0.23	20.1	25.9	895	1 424
Belgium	0.17	0.27	23.4	30.2	1 045	1 661
Bulgaria	0.06	0.10	8.6	11.1	384	611
Cyprus	0.01	0.02	1.6	2.1	74	117
Czech	0.12	0.20	17.4	22.5	778	1237
Denmark	0.10	0.17	14.2	18.3	633	1006
Estonia	0.02	0.03	2.3	3.0	103	165
Finland	0.07	0.12	9.9	12.8	444	705
France	1.04	1.70	146.1	188.6	6 524	10 373
Germany	1.41	2.31	197.8	255.3	8 831	14 040
Greece	0.15	0.24	20.6	26.6	919	1462
Hungary	0.11	0.17	14.8	19.1	661	1050
Ireland	0.09	0.14	12.0	15.5	535	851
Italy	1.06	1.74	149.1	192.5	6 658	10 585
Latvia	0.02	0.03	2.9	3.7	127	202
Lithuania	0.03	0.05	4.5	5.8	199	316
Luxembourg	0.01	0.01	1.2	1.6	54	85
Malta	0.01	0.01	0.8	1.0	36	57
Netherlands	0.27	0.44	37.4	48.3	1 669	2 654
Norway	0.08	0.13	11.3	14.6	503	800
Poland	0.46	0.76	65.3	84.3	2 915	4 635
Portugal	0.17	0.28	24.2	31.2	1 078	1 715
Romania	0.15	0.24	21.0	27.1	937	1490
Slovakia	0.06	0.10	8.4	10.9	376	598
Slovenia	0.03	0.04	3.7	4.8	167	266
Spain	0.69	1.12	96.4	124.4	4 304	6 843
Sweden	0.12	0.20	17.2	22.3	770	1224
Switzerland	0.13	0.21	17.7	22.9	792	1259
UK	1.21	1.98	169.9	219.3	7 587	12 062

Annex III

Excerpts from EC Directives describing the existing and prospective targets related to waste streams containing plastic waste:

Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment (WEEE) (recast)

From 2019, the minimum collection rate to be achieved annually shall be 65 % of the average weight of EEE placed on the market in the three preceding years in the Member State concerned, or alternatively 85 % of WEEE generated on the territory of that Member State.

Minimum targets applicable by category from 15 August 2018:

(a) for WEEE falling within category 1 or 4 of Annex III,

— 85 % shall be recovered, and

— 80 % shall be prepared for re-use and recycled;

(b) for WEEE falling within category 2 of Annex III,

— 80 % shall be recovered, and

— 70 % shall be prepared for re-use and recycled;

(c) for WEEE falling within category 5 or 6 of Annex III,

— 75 % shall be recovered, and

— 55 % shall be prepared for re-use and recycled;

(d) for WEEE falling within category 3 of Annex III, 80 % shall be recycled.

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(f) by the end of 2020, a minimum of 60% by weight of all packaging waste will be prepared for re-use and recycled;

(g) by the end of 2020, the following minimum targets for preparing for re-use and recycling will be met regarding the following specific materials contained in packaging waste:

(i) 45% of plastic;

(ii) 50% of wood;

(iii) 70% of ferrous metal;

(iv) 70% of aluminium;

(v) 70% of glass;

(vi) 85% of paper and cardboard;

(h) by the end of 2025, a minimum of 70% by weight of all packaging waste will be prepared for re-use and recycled;

(i) by the end of 2025, the following minimum targets for preparing for re-use and recycling will be met regarding the following specific materials contained in packaging waste:

(i) 60% of plastic;

(ii) 65% of wood;

(iii) 80% of ferrous metal;

(iv) 80% of aluminium;

(v) 80% of glass;

(vi) 90% of paper and cardboard;

(j) by the end of 2030, a minimum of 80% by weight of all packaging waste will be prepared for re-use and recycled;

(k) by the end of 2030, the following minimum targets for preparing for re-use and recycling will be met regarding the following specific materials contained in packaging waste:

(i) 80% of wood;

(ii) 90% of ferrous metal;

(iii) 90% of aluminium;

(iv) 90% of glass;

For the purpose of calculating whether the targets laid down in Article 6(1) (a) to (k) have been achieved, the weight of waste prepared for re-use and recycled shall be understood as the weight of the waste put into a final preparing for re-use or recycling process less the weight of any materials which were discarded in the course of that process due to presence which need to be disposed of or undergo other recovery operations.

However, where the discarded materials constitute 2% or less of the weight of the waste put into that process, the weight of the waste prepared for re-use and recycled shall be understood as the weight of the waste which was put into a final preparing for re-use or recycling process.

Landfilling:

2a. Member States shall not accept the following waste in landfills for non-hazardous waste by 1 January 2025, recyclable waste including plastics, metals, glass, paper and cardboard, and other biodegradable waste.

2b. Member States shall not accept a quantity of waste in landfills for non-hazardous waste in a given year exceeding 25% of the total amount of municipal waste generated in the previous year, from 1 January 2025.

2c. Member States shall endeavour to accept only residual waste in landfills for non-hazardous waste by 1 January 2030, with the result that the total amount going to such landfills does not exceed 5% of the total amount of municipal waste generated in the previous year. The Commission shall review this objective by 2025 and, if appropriate, submit a legislative proposal for a legally-binding 2030 landfill reduction target.

<u>Waste Framework Directive (2008/98/EC)</u>

2020: target for preparing for re-use and recycling of municipal solid waste: 50%

target for preparing for re-use, recycling and other recovery operations of construction and demolition (C&D) waste: 70%

<u>Directive on end-of life vehicles - ELV (2000/53/EC)</u>

By 2015, re-use and recycling by an average weight per vehicle: 85%