A European Plastics Market and Trend Study

Life Cycle Analyses from virgin material until post-consumer waste scenarios

Executed for PTFPlusOne Ltd. by EcoSphere

December 2014

1. Summary

During the second half of the previous century plastics have become one of the most universally used multi-purpose materials in the global and European economy.

In 2013 the European plastic industry, consisting of plastic producers, plastic convertors and the plastic machinery sector, employed 1.45 million people directly: 134,000 of which as plastics manufacturers and 1,267,000 as plastic convertors. The industry achieved a total turnover of over € 320 billion.

Europe is a relatively small net exporter of plastics, responsible for 20% of the global plastics production. But due to growing competition as well as shifting plastic markets to East Asia and especially China this is expected to change in the future.

In line with its general economic development, the European (EU27, plus Norway and Switzerland) plastic production has been fluctuating between 55 and 58 million metric tons (MMT) per annum during the last 4 years.

Plastic consumption within the EU has been relatively stable the last few years as well and reached a level of 46.3 MMT/a in 2013. Biggest consumer Member State by far is Germany, followed at a distance by Italy, France, UK, Spain and the Benelux countries. The top-5 consume two third of the total quantity.

Both plastic manufacturing and plastic conversion is expected to show a very moderate growth in 2014 of around 1%.

PTFPlusOne Ltd is focusing on polyethylene (PE) and polypropylene (PP) as preferred input for its conversion process. These two plastic types combined account for nearly 50% with an annual EU demand of circa 22.4 MMT of the total EU plastic consumption of 46.3 MMT. Both plastics have a wide range of application, including (but not limited to) plastic films, sheets, bags, containers and pipelines.

From the total EU plastic quantity consumed some 54% remains within the EU as post-consumer waste; amounting to 25 MMT in 2013. There is a significant difference between the quantities being (i) recycled (material recycling), (ii) used as secondary fuel including energy recovery (feedstock recycling) and (iii) going to landfill within the different EU member states. Average percentages were 26% material recycling, 35% feedstock recycling and 38% landfill.

Because PE and PP account for nearly 50% of the EU plastic consumption, the expected amount of post-consumer feeding potential available for PTFPlusOne' conversion plants will be in the range of 12.1 MMT: an average 73% (8.8 MMT) of which is going to energy recovery and landfill.

This justifies presuming that 200,000 MT/a of PE and PP not useable for material recycling is available, because this represent only 2.2% of the EU potential.

The environmental impact of plastics' end of life management represents a growing concern. Regulators actively support any improvement and upgrade of the current situation to achieve future environmental improvement. Both *Plastics Europe* (manufacturers) and *EuPC* (convertors) aspire to achieve continuous improvement in recycling rates.

PTFPlusOne' efficient conversion technology clearly demonstrates superior scenarios compared to disposal, combustion, incineration combined with energy recovery and can significantly contribute to growing feed stock recycling quantities by enabling plastic waste to start a complete new (life) cycle as low sulphur marine fuel diesel.

Therefore the commercialization of PTFPlusOne' conversion technology will be duly supported by EU and national regulators, plastic producers and convertors.

Jelle Frölich

ECOSPHERE
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December 2014

Sustainable energy and technologies are key to reducing our environmental impact – *European Commission.*

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2. Introduction

PTFPlusOne Ltd has in house technologies and knowledge to efficiently convert non-mechanically recyclable (re-usable) plastic waste materials to low sulphur marine fuels. The conversion technologies achieve an efficiency of 60% when assessed conservatively. Recent analyses executed by *Core Laboratories* in Rotterdam demonstrated that the produced fuel mix can be easily distilled at 190^0C in to a naphtha fraction (28 vol%) , with the remaining heavier fraction (72 vol%) fulfilling the severe requirements of low sulphur marine fuel as legally mandated for usage by inland waterway vessels and coasters.

PTFPlusOne will build up to three 200,000 MT/a conversion plants which will take non-recyclable polyethylene and polypropylene plastic waste as preferred input material. Each conversion plant will produce a minimum of 120,000 MT of liquid fuel mix, equal to appr. 150 million liters.

Proper offset is guaranteed because *Ensys Energy* forecasts an increase in global marine fuel consumption to a level of 450 MMT in 2020.

Aim of this report is to support PTFPlusOne' management in allocating the required input materials for the commercialisation of the technology and further roll out. The following steps have been covered: analyse and quantify the actual market, trend analyses, analyse and quantify the existing end of life scenarios, check European availability of input material and define potential support.

3. Plastic production

It is obvious that for PTFPlusOne' core business, being conversion of non-reusable PE and PP plastic waste into high quality low sulphur marine diesel, EU plastic consumption and post-consumer waste is of more importance than plastic production. Nevertheless, it is relevant to comprehend the current market and expected trends in order to derive lifecycles and supply schedules.

Where global production of plastics has been showing a moderate growth, uninterrupted by the global financial crisis, to a total of 299 MMT/a in 2013, EU production has stabilized at a level of 57 MMT/a as shown in figure 1. During 2014 a growth of around 1% for the EU is expected because business activities have been picking up.

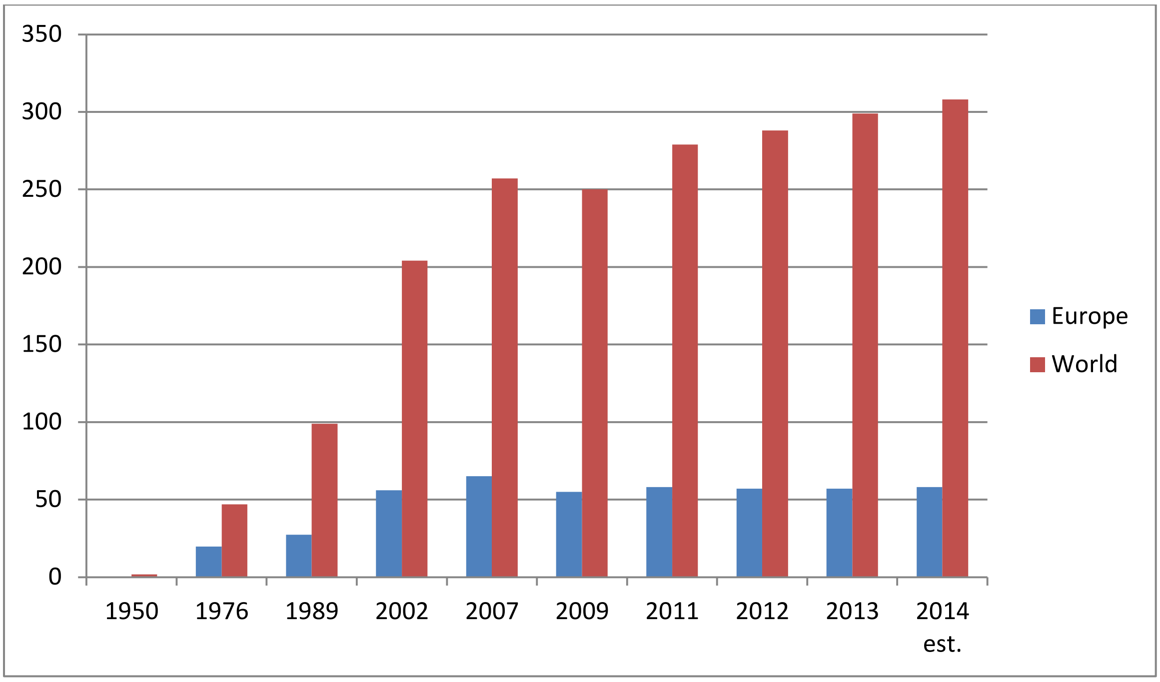


Figure 1: Plastic production in MMT (*PEMRG, EuPC, Consultic,* and *DG ECFIN*)

The European chemical industry, including the plastic market, is immediately and directly reacting to economic developments; upwards and downwards.

The EU, *Directorate General for Economic and Financial Affairs*, analyzed the economic developments in their Autumn Report 2014. As the vast majority of EU economies returned to growth over the course of last year, expectations were raised that Europe's economic recovery was becoming more broadly based and self-sustaining. In the first half of this year, however, GDP growth struggled to gather momentum, leaving the recovery not only subdued but also fragile.
Annual GDP growth in the EU this year is now projected to be 1.3%, while growth in the euro area is expected to be 0.8%.

Economic activity, however, is expected to gradually strengthen over the course of 2015 and accelerate further in 2016. Against this background, growth in the EU is forecast to rise to 1.5% in 2015 and increase modestly to 2.0% in 2016. In addition, the euro area's growth is assessed to reach 1.1% and 1.7% consecutively. Domestic demand is expected to be the driving force of growth over 2015 and 2016. The EU's recovery appears particularly weak, not only in comparison to other advanced economies but to historical examples of post-financial crisis recoveries as well, even though these too were typically slow and fragile. Trend GDP growth, which was already relatively slow before the crisis as a result of low productivity gains, has fallen further due to low investment and high structural unemployment. In the euro area in particular, growth continues to be held back by deleveraging pressures, incomplete adjustment of macroeconomic imbalances as well as disappointment over the pace of structural and institutional reform. The legacy of the crisis is affecting Member States to different degrees but spillover-effect due to trade and (lack of) confidence frequently occur.

Among the largest Member States, Germany's growth has halted, but is expected to gradually pick up again on the back of a robust labour market. Its growth will strengthen external demand, while corporate investment is projected to resume only hesitantly. The French economy is expected to register only very slow growth in 2015 amid a subdued pace of private consumption and still contracting investment. In Italy, GDP growth is projected to turn positive early 2015, as growing external demand is set to drive a still fragile recovery. In Spain, GDP growth is projected to increase, supported in particular by rising employment and easier financing conditions. Growth in the Netherlands is expected to be firm, as private consumption picks up again due to increasing employment and the gradually recovering housing market.
Outside the euro area, the United Kingdom is set to register robust growth, as both investment and consumption expand at a fast pace. Growth in Poland has moderated on the back of weaker external demand, but private consumption is set to support a still healthy expansion. Most of the euro-area Member States that had or have adjustment programs are now catching up.

In Table 2 GDP Trends of the major EU member states and the EU average versus USA, Japan, China and the world average are shown.

GDP Trend	2013	2014	2015	2016
Germany	0.1	1.3	1.1	1.8
UK	1.7	3.1	2.7	2.5
France	0.3	0.3	0.7	1.5
Italy	-1.9	-0.4	0.6	1.1
Poland	1.7	3.0	2.8	3.3
Spain	-1.2	1.2	1.7	2.2
Netherlands	-0.7	0.9	1.4	1.7
EU	**0.0**	**1.3**	**1.5**	**2.0**
US	2.2	2.2	3.1	3.2
Japan	1.5	1.1	1.0	1.0
China	7.6	7.3	7.1	6.9
World	3.1	3.3	3.8	4.1

Table 2: GDP Trend comparison (*DG ECFIN*, European Economic Forecast Autumn Report 2014)

The GDP growth figures of the main EU member states during 2014 are a reliable indicator for plastic market developments and indicate a very moderate growth. The stable consumption of 2013 compared to 2012 exactly fits the 0.0% change of GDP. Figure 1 will be updated with the factual 2014 figures by Plastics Europe next year.

A moderate growth during 2014 of around 1% compared to 2013 has informally been confirmed in talks with *Plastics Europe*, the national chemical industry associations in Germany, UK and the Netherlands as well as the large Polyolefin suppliers in Europe *Lyondell Basell* and *Ineos*.

Europe is a relatively small net exporter of plastics. Nevertheless, due to growing competition as well as shifting plastic markets to Asia and especially China this is expected to change in the future. This change is valid for both the general plastic market as well as for the PE and PP markets.

In 2013 production and demand in the EU plastic market still showed a delta of appr. + 10 MMT. Later in this report expected trends will be analyzed.

The EU is a significant player in the global plastic market covering 20% of total production, but the dominance of the Far East market is clear and expected to increase further. Where Asia currently represents 46% of global production, NAFTA and EU show a similar size. In addition, the Middle East and Africa are expanding. Latin America, on the contrary, remains a relatively small player.

Figure 2 demonstrates the position of EU plastic production in the global market versus the other continents or regions.

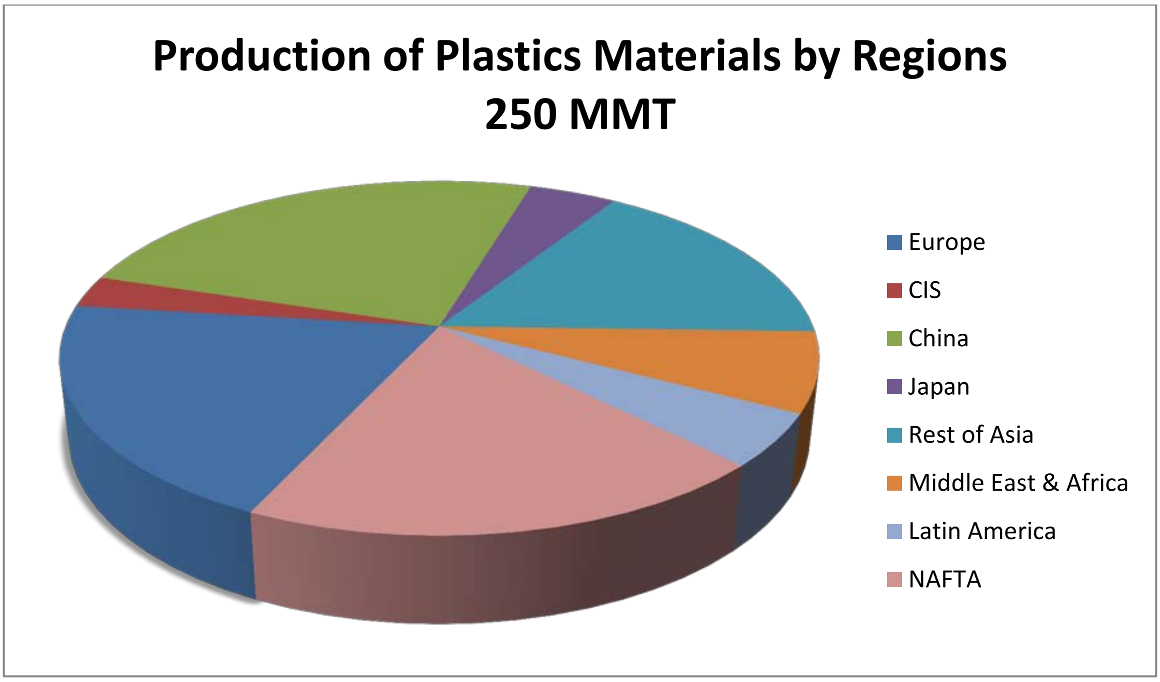


Figure 2: Global plastics production 2013 (*Plastics Europe (PEMRG)* and *Consultic*)
(Does not include thermosets, adhesives, coatings, sealants and PP fibers; total 49 MMT)

Because of expected production expansion in Asia, according to *Platts* the polyolefin rationalization in Europe is going to continue, where they see further expansion in the Middle East. The European rationalization is a result of under-utilization of capacity resulting in poor margins in polyethylene.

Europe consumes around 300,000 MT/a more than it produced in 2013. This deficit is set to grow. Below table 2 shows a list of proposed plant closures.

Company	Location	Product	Capacity (MT/a)	Status
Versalis (ENI)	Gela	LDPE	150,000	Possible close end 2014
Borealis	Burhausen	HDPE	175,000	To close end 2014
Slofnaft	Slovakia	LDPE	180,000	To close 2016
Unipetrol	Litvinov	HDPE	120,000	2017

Table 2: Europe PE proposed plant closures (*Platts*)

Meanwhile, expansion in the Middle East is set to continue. The region will thus continue to be an exporter of polyethylene with a strong focus on growing its business in Asia and Africa and a secondary focus on North West Europe.

Borouge, a joint venture between *Abu Dhabi National Oil* and *Borealis*, plans to increase polyolefin exports to Europe nearly tenfold in the coming years. *Borouge* aims to send around 20% of its output, which is being expanded, to Europe by the end of the decade.

So far, only slightly more than 100,000 MT/a of polyethylene and polypropylene is coming into Europe from the existing *Borouge 1* (Abu Dhabi) and *2* (Singapore).

A $ 4.5 billion *Borouge 3* project will increase annual polyolefin production capacity at the site to 4.5 MMT. *Borouge 1* and *2* have a joint annual production capacity of 1.14 MMT of polyethylene and 0.86 MMT of polypropylene.

Company	Location	Product	Capacity (MT/a)	Status
Borouge 3	Ruwais	LDPE	350,000	2015
Borouge3	Ruwais	HDPE	210,000	2015

Table3: Borouge 3 (*Platts*)

4. Production and usage of PE and PP

The plastic market is globalized where producers are active in different continents. Figure 3 is showing the global top 12 producers of PE and PP. *Lyondell Basell* and *Ineos* are major suppliers in Europe.

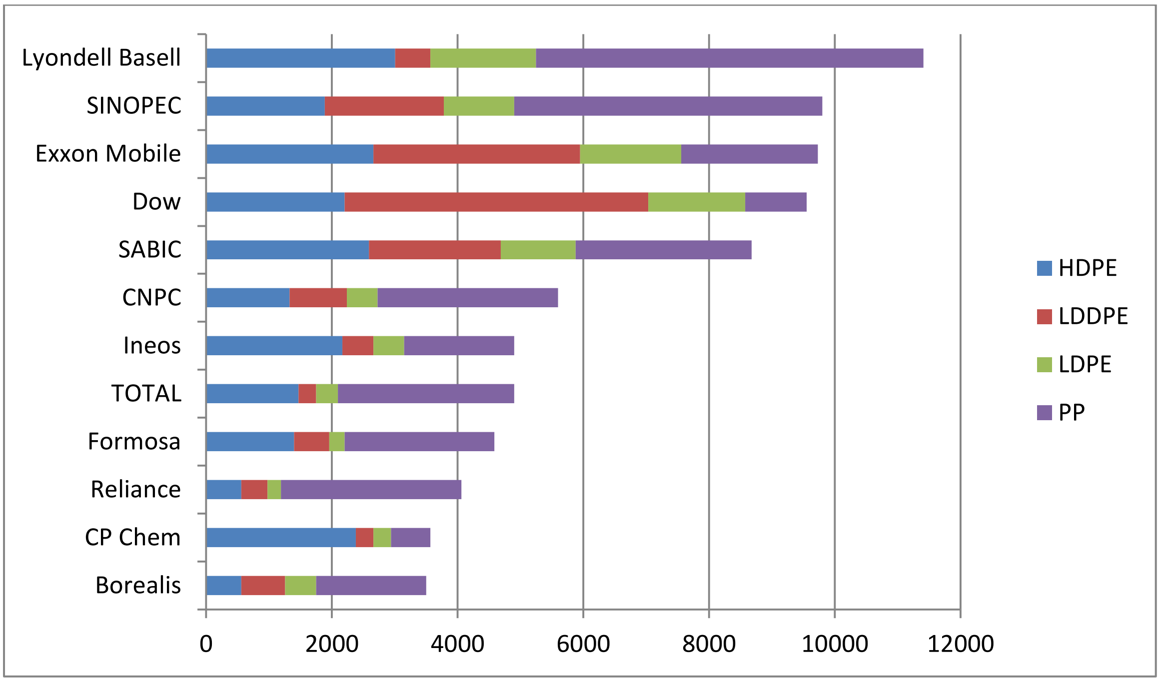


Figure 3: Top 12 global polyolefin producers 2013 in 1000 MT (*Lyondell Basell*).

Figure 4 shows the split up in European demand for the different PP and PE grades.

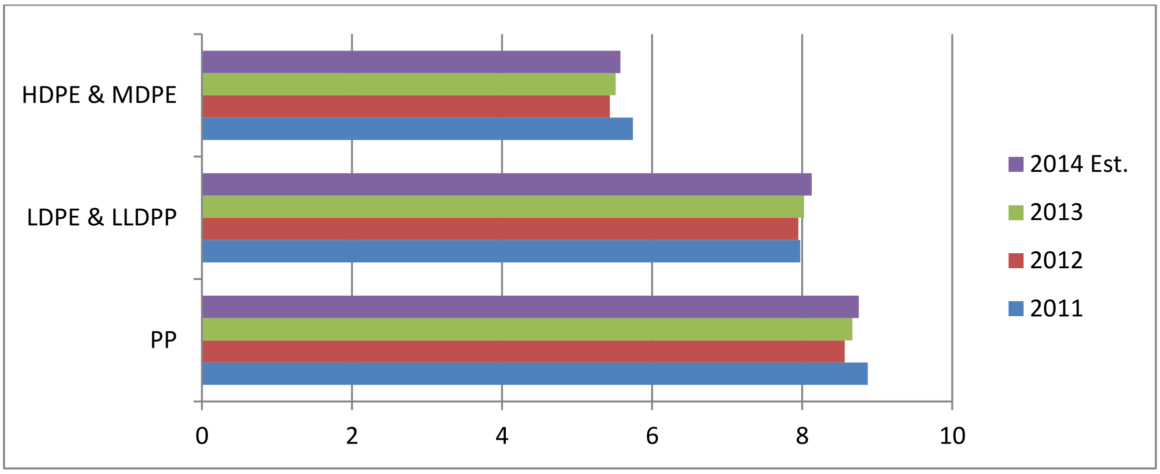


Figure 4: European PE and PP demand in MMT (*PEMRG, Consultic*, and *ECEBD*)

Figure 5 shows the development of total plastics demand in the top 9 EU member states. Note that the top 5 consumes two thirds of the total demand of 46.3 MMT.

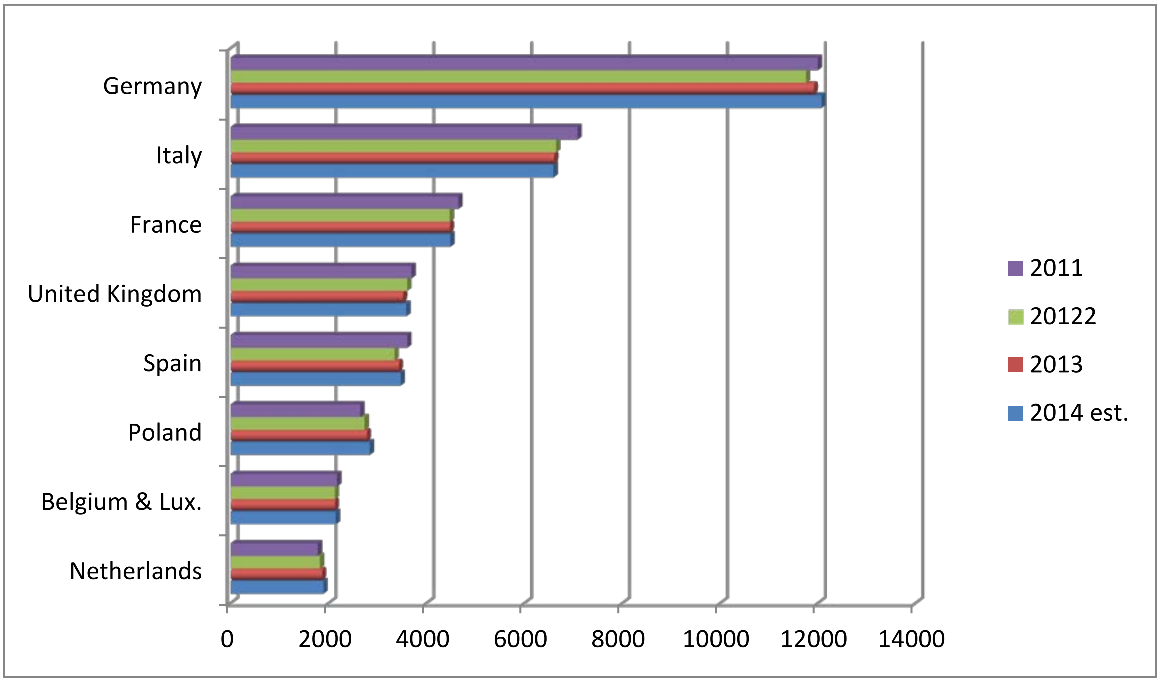


Figure 5: Top 9 plastic consumer EU member states in 1000 MT (*PEMRG, Consultic,* and *ECEBD*)

Main application of high density polyethylene (HDPE) is in the production of blow moulding, injection moulding, film and sheet, which are used in packaging. An additional strong end use sector is construction. HDPE is very flexible and has good chemical resistance; it is also quite inexpensive. These advantages stimulate the high-density polyethylene market.

Today the majority of the HDPE global capacity is concentrated in the Asia Pacific region. In the next few years this region, together with the Middle East, is expected to show rapid growth both in HDPE capacity and in production. At the same time North America and the EU countries will show more moderate growth rates. Figure 6 indicates the split of HDPE consumed by end use sector.

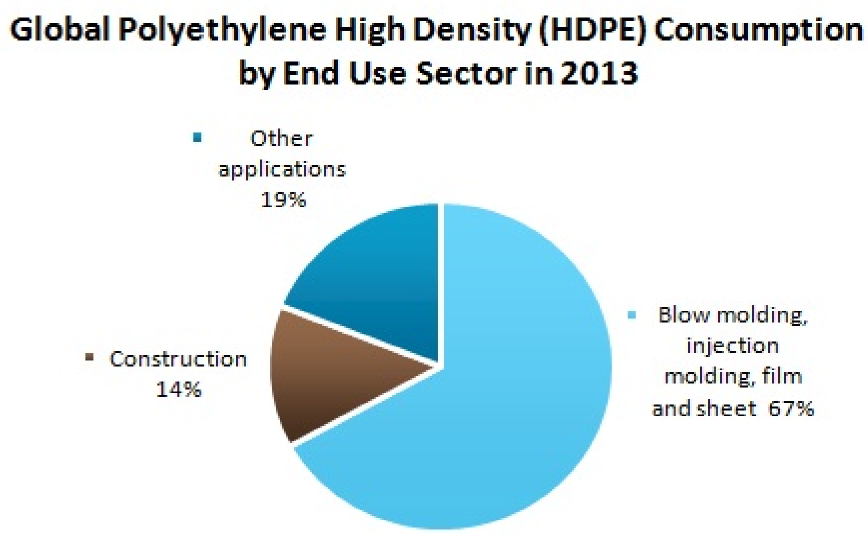


Figure 6: Global HDPE per end use sector in 2013 (*AMI*)

With recession hitting Europe in 2008, the PE film extrusion industry took a downturn. Between 2007 and 2009 PE film production fell by 1 MMT. About half of this lost volume was recovered during 2010 and the industry continued to make steady progress, as per AMI. Inevitably the recession has had an impact on the number of companies operating in Europe. There are some 5% fewer companies listed with France, the UK, Benelux and Scandinavia seeing the greatest decline in numbers. Producers of carrier bags, heavy duty sacks and building films were worst affected. Food packaging suppliers generally performed better due to less contraction in demand from this sector during the downturn.

The PE film industry within Europe has had to adapt to these changing demands. In turn, these demands have seen a shift in the importance of end use applications. Stretch film still remains the largest single application in terms of volume. This is due to stretch film becoming one of the most cost effective means of protecting goods while they are in transit. The market for bags and sacks has seen differing trends between the various sectors. The demand for carrier bags has seen a steady decline due to environmental pressures, incentives for consumers to reuse bags, shops beginning to charge for carrier bags and increasing volumes of imported bags from Asia. In comparison, *AMI* indicates that the market for reusable sacks has continued to grow, driven by the move to more recycling and sorting of domestic waste. A significant change has been the growing demand for more sophisticated multi-layer films and technical co-extrusions, which now account for 9% of PE film production in Europe. The distribution of PE film production in Europe, figure 7, has not radically changed from the figures quoted in *AMI's* previous edition. Italy still has the largest amount of PE film production, with Germany a close second. However, in terms of the number of companies operating, Italy show over a 100 more compared to Germany. This difference reflects the more fragmented structure of Italy's industry. Poland leads the way in Central Europe, accounting for around 50% of film production in the region and the largest number of film extruders. As the industry moves out of recession, AMI forecasts that production will move in line with the underlying GDP growth for Europe. An annual average growth of around 2-3% would result in an industry processing over 8.7 MMT by 2016.

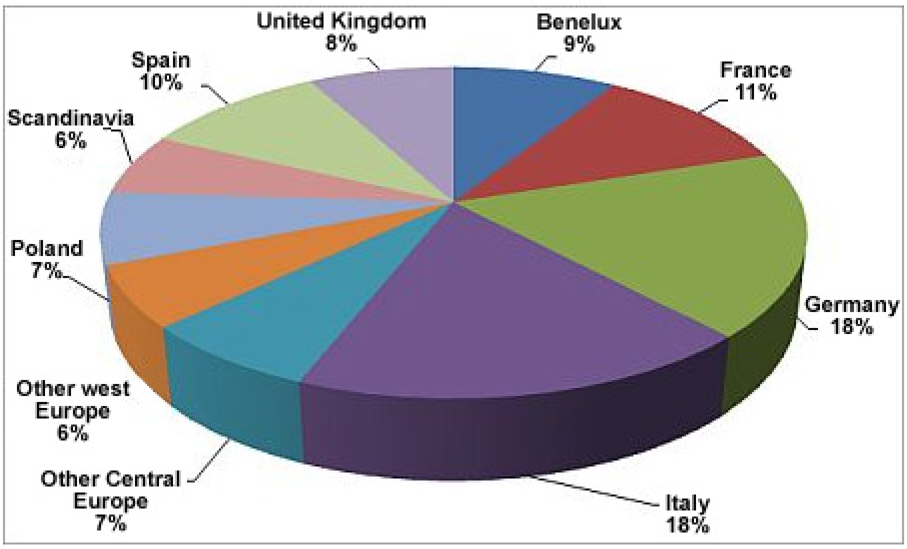


Figure 7: EU distribution of HDPE film production (*AMI*)

The global plastic film and sheets market is predicted to reach 50.7 MMT tons by 2015, driven by globalization, changing food consumption trends, and increasing demand from developing markets in the Asia Pacific region, Latin America, the Middle East and Eastern Europe, as per *Global Industry Analysts*. Low per capita consumption and rapid economic growth combine to propel the plastic film and sheets market in the Asia Pacific, with China and India at the vanguard of growth. North America, Japan and Western Europe represent mature markets with high levels of per capita consumption.

In addition to the Asia Pacific region, global future growth is likely to be driven by Africa, the Middle East, Latin America and Eastern European countries due to rapid industrialization, improvements in the standard of living, and strong construction, food and beverage and consumer packaging sectors in these regions. Over the last decade, the Middle East has emerged as a serious player in the global plastics market, owing to the twin benefits of low raw material and feedstock prices and proximity to the highly lucrative Asian market. This has led plastic players embarking on ambitious capacity enhancements in the region. Furthermore, growing sophistication in the Russian market is paving the way for uninterrupted growth in demand for plastic films in the region.

Plastic films, mostly used for packaging of food as well as non-food items, witnessed slump during the recession, because demand in most end-use markets plummeted. The decline was more visible across the non-food category as compared to the food segment, owing to food being a highly inelastic product. Although the contraction in plastic films market spread across all segments, polypropylene (PP) films fared better compared to other segments due to the relatively better performance of the Biaxially Oriented Polypropylene (BOPP) Films market. Globally, the US, Europe, and the Asia-Pacific region represent the largest markets, collectively accounting for a major share of volume sales in the Plastic Film and Sheets market. Driven by enormous potential in China and India, Asia-Pacific is projected to be the fastest growing regional market with a CAGR of 4% over the analysis period.

Segment-wise, polyethylene (PE) films represent the largest segment of the global demand. The segment is however ceding, due to increasing penetration of polypropylene into its hitherto established end-use markets. Within polyethylene segment, LDPE is losing share to its advanced form, linear low-density polyethylene (LLDPE) films. The market for HDPE film is also expanding at a consistent rate, though not as dynamically as LLDPE. Biaxially oriented polypropylene (BOPP) film, a sub-segment of polypropylene, represents the fastest growing segment in terms of volume. Though the sector witnessed a slowdown in growth during the economic recession, particularly in 2008, the market bounced back quickly with a 3-4% growth rate in 2009. During 2010-2013, worldwide BOPP production capacity expanded by 2.2-2.4 MMT, with the Middle East accounting for the bulk of the capacity expansion.

Since the plastic films industry is characterized by product diversity, competition in the market remains fragmented with the presence of both large-scale manufacturers and small producers. Major players include *Achilles Corporation*, *AEP Industries Inc.*, *Applied Extrusion Technologies (AET)*, *Bemis Company, Inc.*, *Berry Plastics Corporation*, *British Polythene Industries*, *DuPont Teijin Films*, *ExxonMobil Chemicals*, *Futamura Chemical Co. Ltd*, *Foshan Plastics Group Co Ltd*, *Interplast Group Ltd*, *Nylex (Malaysia) Berhad*, *Okura Industrial Co. Ltd*, *Paragon Films*, *Polyplex Corporation Ltd*, *Reynolds Flexible Packaging*, *Rheinische Kunststoffwerke (RKW) AG*, *Quinn Plastics*, *SABIC Innovative*

Plastics, *Sealed Air Corporation*, *SINOPEC Shanghai Petrochemical Co. Ltd*, *Spartech Corporation*, *Sumitomo Bakelite Company Limited*, *Toray Plastics*, *Toyobo Company Ltd*, *Treofan Group*, *Trioplast Industrier AB*, *Unitika Ltd* and *Vibac Group*.

The LDPE or LLDPE form is preferable for film packaging and for electrical insulation. HDPE is blow-moulded to make containers for household chemicals such as washing-up liquids and drums for industrial packaging. It is also extruded as piping. The relevance of the different PE grades in the different application is shown in figure 8.

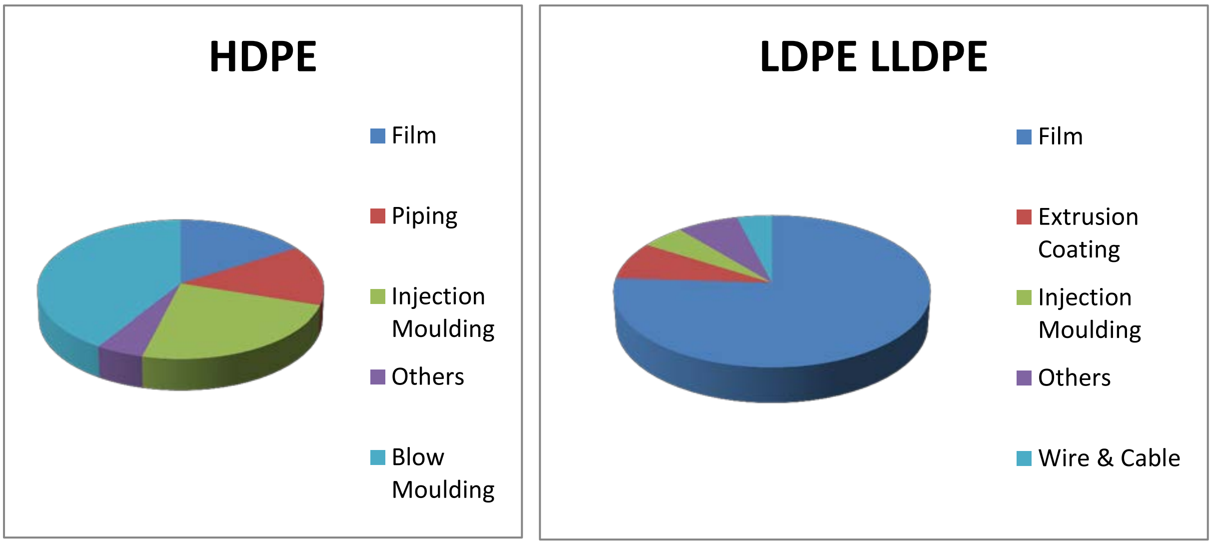


Figure 8: Split up per application (*Plastics Europe*)

All grades can be used for injection-moulded products such as buckets, food boxes and washing-up bowls (Table 4).

Process	HDPE	LDPE	LLDPE
Making film	Food packaging Shopping bags	Cling film Milk carton lining	Stretch film
Injection moulding	Dustbins Crates	Buckets Bowls	Food boxes
Blow moulding	Detergent bottles Drums	Squeezable bottles	
Extrusion	Water pipes	Flexible water pipes Cable jacketing	Cable coating

Table 4: Examples of uses of PE

Polypropylene is used in many spheres of everyday life, such as packaging, textiles, household appliances, consumer products, et cetera. One of the major importers of polypropylene in the world is China. New PP capacity introductions are planned mainly in the Asia Pacific region and CIS countries. Some Middle East polypropylene plants that were closed for reconstruction are to be reopened in the near future.

Next year the global market is expected to grow at 4-4.5% per year, driven mainly by the Asia Pacific, Middle East and Africa regions. The split up per end user sector is shown in figure 9.

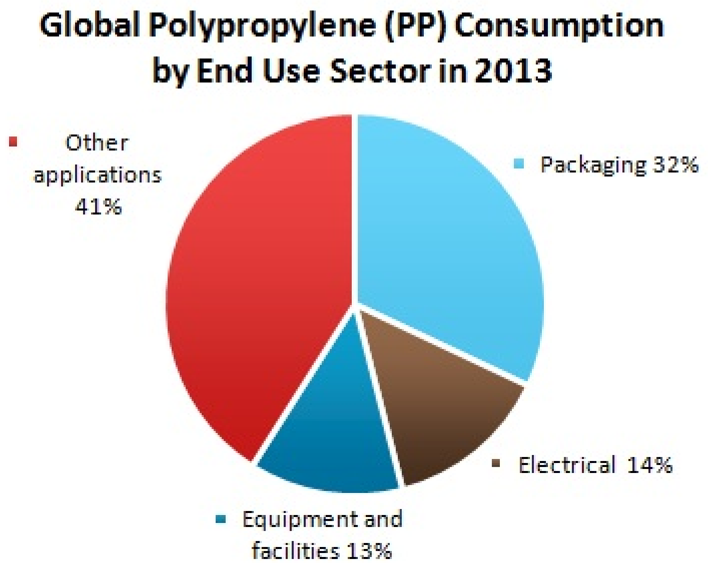


Figure 9: Global PP consumption per end use sector (*AMI*)

5. Different plastic types and market segments.

The plastic production covers different types of plastics with a variety of grades to deliver special properties to the specific applications. The "big five" plastic types, polyethylene (PE), polypropylene (PP), poly vinyl chloride (PVC), polystyrene (PS) and polyethylene terephthalate (PET) represent almost 75% of the total consumption, as shown in figure 10.

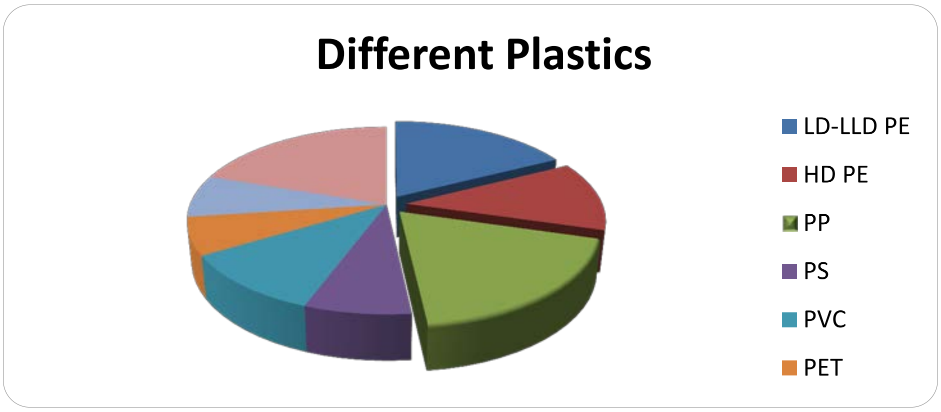


Figure 10: Different types of EU plastics consumed 2013 (*PEMRG*); Total appr. 46.3 MMT

Figure 10 shows that PE is split into different grades. Where LD PE stands for low density PE, LDD for linear low density PE and HD for high density PE. The figure demonstrates that both PE and PP represent almost 50% (LD-LDD PE 17.5%, HD PE 12% and HD PP 18.8%) of the total consumption of 46.3 MMT.

Within the EU, packaging application is the largest sector for the plastic industry, followed by building & construction, automotive, E&E and agriculture. Other applications include household and consumer products, furniture and medical products (figure 11).

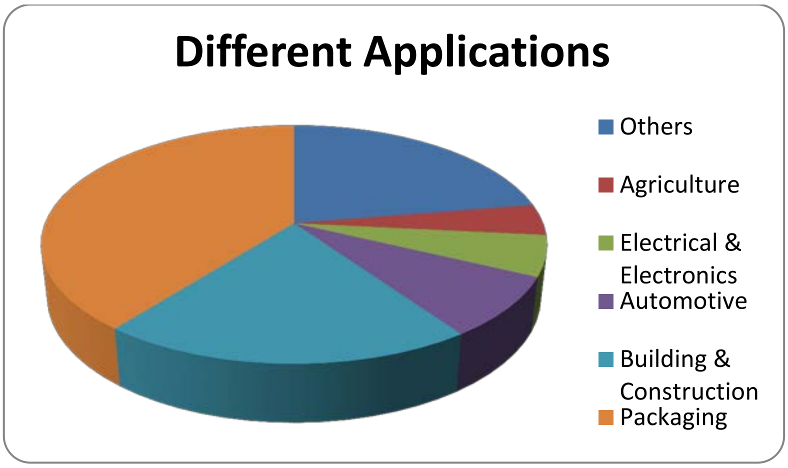


Figure 11: EU plastic demand by segment 2013 (*PEMRG, ECEBD* and *Consultic*)

6. Applications of PE and PP

The fact that the combination of PE and PP represent almost 50% of the total plastic market is a result of its unique properties, characteristics, and processability.

High Density PE (HDPE) is popular because of its versatility, owing to its large range of density, molecular weight and MW distribution, and chemical inertness. HDPE resins can be tailored to be used in many applications, such as film, crates, boxes, caps and closures, bottles and containers for food products, cosmetics, pharmaceuticals, household and industrial chemicals, toys, fuel tanks and other automotive parts, pipelines for gas and water distribution.

Low Density PE (LDPE) is widely used for manufacturing various containers, dispensing bottles, wash bottles, tubing, plastic bags for computer components, and various molded laboratory equipment. Its most common use is in plastic bags. Other manufactured goods include trays and general purpose containers, parts that need to be weldable and machinable, parts that require flexibility, very soft and pliable parts such as snap-on lids, juice and milk cartons made of liquid packaging board, a laminate of paperboard and LDPE (as the waterproof inner and outer layer) and parts of computer hardware, such as hard disk drives, screen cards, and optical disc drives.

Linear low density PE (LLDPE) and LDPE have unique rheological or melt flow properties. LLDPE is less shear sensitive because of its narrower molecular weight distribution and shorter chain branching. During a shearing process, such as extrusion, LLDPE remains more viscous and, therefore, harder to process than an LDPE of an equivalent melt index. The lower shear sensitivity of LLDPE allows for a faster stress relaxation of the polymer chains during extrusion and, therefore, its physical properties are susceptible to changes in blow-up ratios. In melt extension, LLDPE has a lower viscosity at all strain rates. This means if strained it will not harden the way LDPE does when elongated. As the deformation rate of the polyethylene increases, LDPE demonstrates a dramatic rise in viscosity because of chain entanglement. This phenomenon is not observed with LLDPE because the lack of long-chain branching in LLDPE allows the chains to slide by one another upon elongation without becoming entangled. This characteristic is important for film applications, because LLDPE films can be down gauged easily while maintaining high strength and toughness. The rheological properties of LLDPE are summarized as "stiff in shear" and "soft in extension". It is not taken in most curbside pickups in communities.

LLDPE has penetrated almost all traditional markets for polyethylene. It is used for plastic bags and sheets (where it allows using lower thickness than comparable LDPE), plastic wrap, stretch wrap, pouches, toys, covers, lids, pipelines, buckets and containers, covering of cables and, mainly, flexible tubing.

Polypropylene is resistant to fatigue. It is used in the manufacturing piping systems: concerned with both high-purity and designed (specifically) for strength and rigidity (e.g. those intended for use in potable plumbing, hydronic heating and cooling, and reclaimed water).This material is often chosen for its resistance to corrosion and chemical leaching, its resilience against most forms of physical damage (including impact and freezing), its environmental benefits, and its ability to be joined by heat fusion rather than gluing.

Many plastic items for medical or laboratory use can be made from PP, because it can withstand the heat in an autoclave. Its heat resistance also enables it to be used for consumer-grade kettles. Food containers made from it will not melt in the dishwasher, and do not melt during industrial hot filling processes. For this reason, most plastic tubs for dairy products are PP sealed with aluminum foil (both heat-resistant materials). After the product has cooled, the tubs are often given lids made out of a less heat-resistant material, such as LDPE. Such containers provide a good hands-on example of the difference in modulus, since the rubbery (softer, more flexible) feeling of LDPE vis-à-vis PP of the same thickness is readily apparent. Rugged, translucent, reusable plastic containers made in a wide variety of shapes and sizes for consumers are commonly made of PP. The lids, however, are often made of somewhat more flexible LDPE so they can snap on to the container to close it. PP can also be made into disposable bottles to contain liquid or powdered consumer products, in addition to HDPE and polyethylene terephthalate (PET), that are commonly used to make bottles. Plastic pails, car batteries, wastebaskets, pharmacy prescription bottles, cooler containers, dishes and pitchers are often made of PP or HDPE; both of which commonly have a rather similar appearance, feel, and property set at ambient temperature.

PP is highly colorfast. It is widely used in manufacturing carpets, rugs and mats for the private sector.

PP is most commonly used for plastic mouldings. It is injected into a mould while molten, forming complex shapes at relatively low cost and high volume. Examples include bottle tops, bottles, and fittings.

In addition, it can be produced in sheet form and is being widely used for the production of stationery folders, packaging, and storage boxes. Moreover, its wide color range, durability, low cost, and resistance to dirt make it ideal as a protective cover for papers and other materials.

7. Future trends on PE and PP

Polyethylene

Polyethylene is a thermoplastic polymer consisting of long hydrocarbon chains. Depending on the crystallinity and molecular weight, a melting point and glass transition may or may not be observable. Most PE grades have excellent chemical resistance, meaning that it is not attacked by strong acids or strong bases. It is also resistant to gentle oxidants and reducing agents.

The global demand for polyethylene is expected to rise by 4% per year in the build-up to 2018 leading up to almost 99 MMT (figure 12). The gains will be driven by world economic growth, which in turn is expected to be boosted by accelerated consumer spending and an increase in manufacturing activity. Despite the growth, Polyethylene is a highly commoditized and mature product, with large volumes of new applications being unlikely to emerge in the foreseeable future. Additionally, polyethylene (like all plastics) is perceived negatively by many environmentally minded consumers. Consequently, major polyethylene applications such as plastic bags have increasingly become subject to regulations and bans.

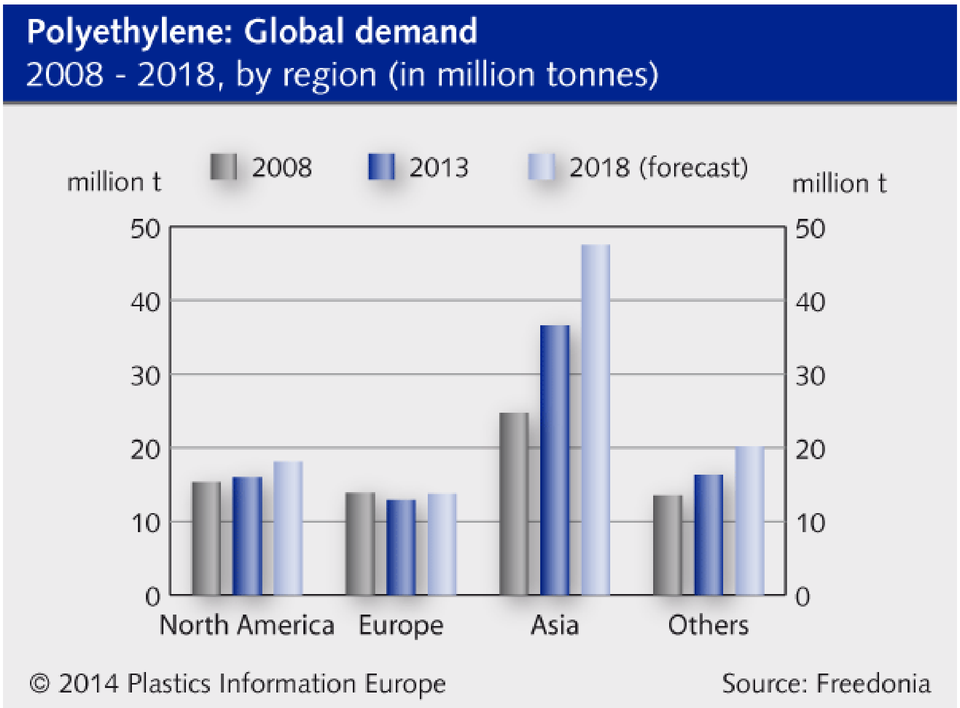


Figure 12: PE global demand 2008-2018 per region (*Freedonia*)

Most of the gains will be driven by new ethylene feedstock, including shale gas, coal and bio-based materials. These will give PE – including HDPE, LDPE and LLDPE – an edge; either in terms of price or sustainability. In addition, ongoing development in catalyst technologies will enhance the performance, customization and yield of PE resins.

In regional terms, growth will continue to be driven mostly by Asia Pacific. PE demand will see the largest and steepest rise. China will prompt this increase significantly and is already accounting for almost one-fourth of total global PE demand in 2013. Other countries boosting demand are India and Vietnam. Nevertheless, the growth momentum in this particular region is losing some of its earlier steam. Whereas demand growth in Asia Pacific averaged 8.1% in the period from 2008-2013; it is expected to slow to 5.4% in the lead-up to 2018.

This decline can partly be explained by the fact that in the decade from 2003 to 2013, global PE production capacity shifted away from North America and Western Europe to Asia Pacific and the Middle East/ Africa. This shift resulted from lower energy and feedstock costs as well as growing demand. The shale gas revolution, however, is changing this allocation of production capacity, with the North American PE industry set to make a resurgence. Following a decade of decline, North America is expected to add more than 9 MMT of polyethylene capacity up until 2023.

Even that estimate could prove to be conservative. Currently 7.5 MMT/a of new PE capacity is already confirmed to commence in North America by 2019. In addition, projects worth another 4 MMT/a are currently being discussed, and could – if approved – commence in 2021-22. *Freedonia* expects North American PE demand to grow by 2.5% in the period 2013-2018, up from just 0.9% in 2008-2013.

The deprived in this equation is Western Europe. Although here, too, things are beginning to look up a bit. Following a decline in PE demand of 1.5% in the course of 2008-2013, the market is expected to pick up again. *Freedonia* predicts that the region's PE demand will amount to 1.3% per year in 2018.

Freedonia's study found that HDPE is the largest of all three PE resins: accounting for just short of half of the total demand in 2013. Thanks to its increasing use in construction projects – including piping – as well as the rise in the use of blow-moulded HDPE containers in emerging markets, this particular resin type is expected to see above average growth leading up to 2018.

LDPE, by contrast, will continue to lose its market share over LLDPE. As the latter is expected to see gains associated with metallocene catalyst technology that improves resin performance.

In application terms, packaging will remain the largest end-market. It is expected to account for the most of the demand in 2018. More specifically, *Freedonia* found that film currently makes up half of the global PE demand, and commands an even greater market share in the developing countries.

Polypropylene

Polypropylene also known as polypropene, is a thermoplastic linear hydrocarbon polymer resin, with little or no unsaturation. A semi rigid and translucent material that does not display stress-cracking problems and offers excellent chemical and electrical resistance at high temperatures. Polypropylene is a versatile product because of which it is used in numerous industries such as toy making, automobile, carpeting, paper, and manufacturing of laboratory equipment. It is easy to customize and can be colored in various ways without degrading the original quality of the plastic. The rising demand of polypropylene from end use industries, such as construction and especially automobile, owing to the increasing demand for light weight vehicles is stimulating the global polypropylene market.

The market of polypropylene regarding end-use is segmented into construction, consumer products, packaging, electrical & electronics, and automotive. The packaging industry is the largest market for polypropylene, due to its unique properties. These include stiffness and twist retention, making it a particularly appropriate material for packaging. In the consumer products segment polypropylene is extensively used in the packaging of soap, detergents and toiletries as well as different perishable food items such as yoghurt. In the electrical and electronics segment, it is used in the production of switchboards, insulation cables, and capacitors because of its high electric shock resistance. The automobile industry uses polypropylene because of its moldability, mechanical properties and lower cost vis-à-vis other plastics.

Regarding regions, the market is segmented into North America, Europe, Asia Pacific and RoW. According to *Grand View Research* the Asia Pacific is the largest market for polypropylene, owing to the high demand from growing end-use industries. Demand in Europe is expected to rise, as manufacturers of this region are gradually upping their use of polypropylene at the expense of the conventional materials (e.g. glass and metal).

8. Material flows and processing technologies

Plastic end products are being produced by plastic convertors. These tend to purchase virgin plastic material indirectly from plastic producers. Before the virgin plastic can be processed, a number of additives like fillers, stabilizers, color agents et cetera have to be mixed in homogeneous depending on the quality specification of the customer.

Most plastic convertors concentrate on their core business and therefore purchase a compound or masterbatch (figure 13).

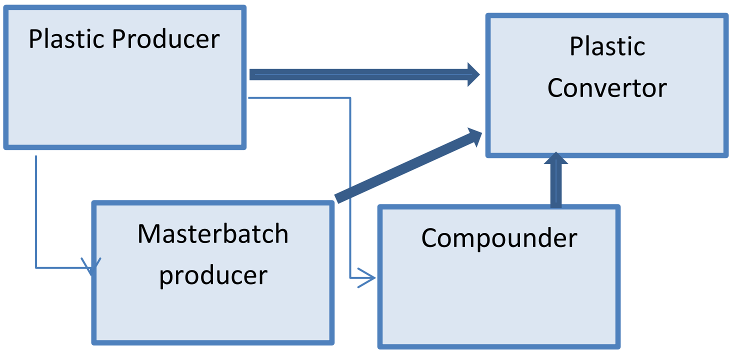


Figure 13: Plastic material flow

1. Compounding consists of preparing plastic formulations by mixing and/or blending PE or PP and additives in a molten state. These blends are automatically dosed with fixed set points, usually through feeders/ hoppers. It is generally a blend of copolymers with additives such as anti-oxidants, UV-stabilizers and other value-adding agents. Sometimes a strengthening component is added, such as glass fibre.
2. A masterbatch is a solid or liquid additive for plastic used for coloring plastics (color masterbatch) or imparting other properties to plastics (additive masterbatch). Masterbatch is a concentrated mixture of pigments and/or additives encapsulated during a heat process into a carrier resin, which is then cooled and cut into a granular shape. A masterbatch allows the processor to color raw polymer economically during the plastics converting process.

Convertors produce their products using different technologies, which are explained below.

1. Blow moulding is a manufacturing process by which hollow plastic parts are formed. In general, there are three main types of blow moulding: extrusion blow moulding, injection blow moulding, and injection stretch blow moulding. The blow moulding process begins with melting down the plastic and forming it into a parison, or – in the case of injection and injection stretch blow moulding (ISB) – a preform. The parison is a tube-like piece of plastic with a hole in one end, where compressed air can pass through.

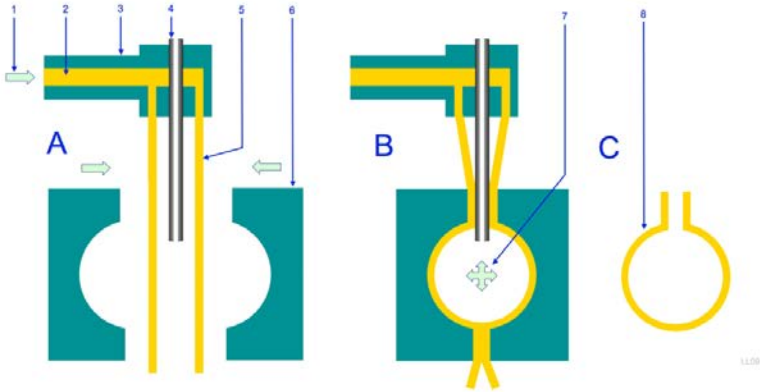


Figure 14: Blow moulding

The parison is then clamped into a mould and air is blown into it. Subsequently, air pressure pushes the plastic outwards, to cover the mould. Once the plastic has cooled and hardened the mould opens up and the part is ejected.

2. Injection moulding consists of a high pressure injection of the raw material into a mould, which shapes the polymer into the desired shape.

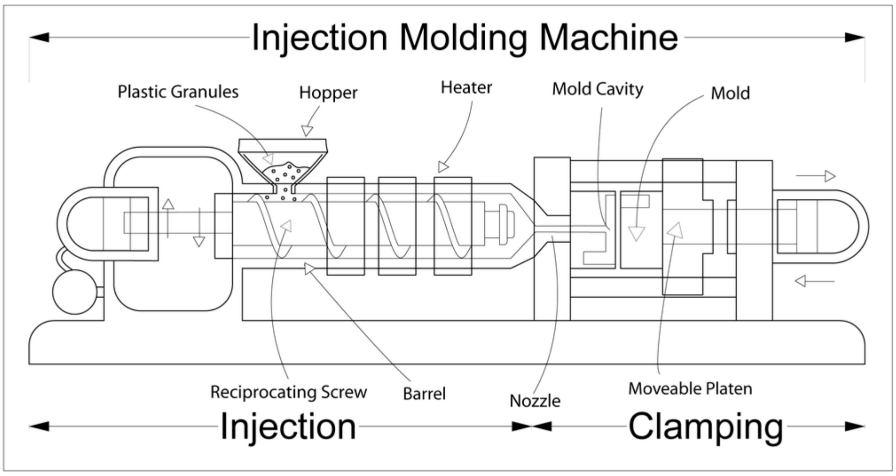
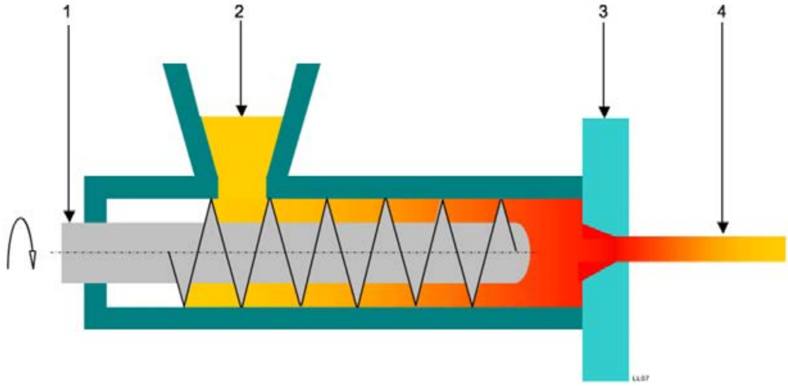


Figure 15: Injection Moulding

3. Plastics extrusion is a high volume manufacturing process that melts and forms raw plastic material is into a continuous profile. Extrusion produces items such as piping/ tubing, weather stripping, fencing, deck railings, window frames, plastic films and sheeting, thermoplastic coatings, and wire insulation.



1 = Extruder, 2 = Plastic material, 3 = Extrusion die, 4 = Extrusion profile

Figure 16: Injection moulding

Inevitably, the recession has had an impact on the number of plastic convertors operating in Europe. There are some 5% fewer companies listed, with France, the UK, the Benelux and Scandinavia seeing the greatest decline in numbers. Producers of carrier bags, heavy-duty sacks and building films were worst affected. Food packaging suppliers generally performed better. This is due to a smaller contraction in demand despite of the economic downturn.

According to the *European Plastic Convertors Association,* around 1.27 million people are employed, in more than 59.000 (plastic converting) companies.

The plastic convertors serve their customers in accordance with the different application as shown in figure 11: packaging, electrical & electronics, automotive, building & construction, agriculture et cetera.

Products arrived at the end of their lifecycle are introduced in different end-of-life management systems: a mix of landfill, energy recovery and recycling. The relating percentage split per EU Member State shows a big difference, as shown in figure 17 of the next chapter.

9. End of life waste management scenario's for plastic waste

The Ladder of Lansink has been the basis for European environmental legislation. Prevention of waste is the optimum regarding minimization of environmental impact. Reuse of material means the reuse of parts. This requires a special product design as well as closed loop recycling. Closed loop recycling is required to guarantee full knowledge of plastic (including additives used) and product characteristics. *Ricoh* was one of the first European players to start collection and partial reuse of their own redundant copiers. Leasing products in stead of buying them contributes to closed loop recycling, because the producer holds ownership during the complete life cycle and is consequently held responsible for re-collection afterwards.

Recycling includes mechanical- as well as feed stock recycling. Both scenarios are explained later in more details. Subsequent is incineration with energy recovery, where produced heat is used to generate power. The efficiency, here, is relatively low; as the primary interest of such an incinerator for municipal solid waste is to reduce waste volumes. Even modern installations only reach efficiencies of less than 30%. Incineration without energy recovery (combustion) is the second least desirable scenario, surpassed only by disposing the waste at landfills.

To further reduce waste going to landfill, the usage of non sustainable raw materials and to further optimize the recycling of plastic materials, policy makers push for zero landfill. A provisional goal is a reduction to 50% for all member states; complemented with a further reduction to zero % in 2020 (recently suspended to 2025). Various Member States have already demonstrated the technical feasibility of approximating the zero plastics to landfill scenario, as shown in figure 17.

Figure 17: Treatment of post-consumer plastics waste 2012 per EU member state (*Consultic*)

Despite the fact figure 17 shows data from 2012 and changes are happening rapidly as a result of EU regulations, it clearly indicates -a- the difference between NW EU and the remainder and -b- the tremendous potential for feedstock as well as mechanical recycling, pertaining to the zero waste to landfill policy (cf. figure 18).

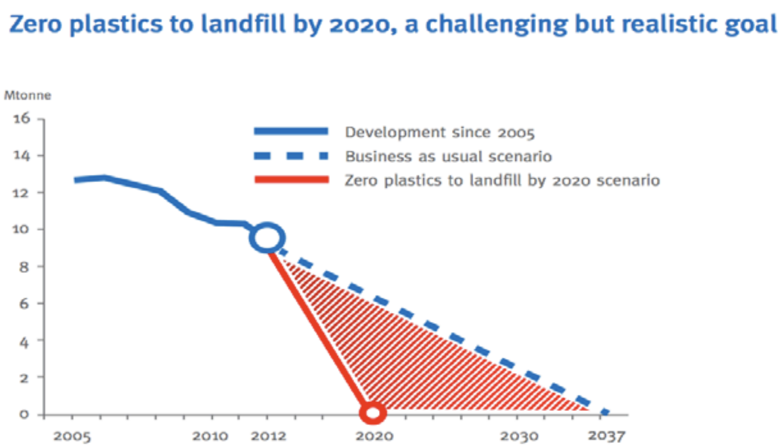


Figure 18: Zero plastics to landfill, a worthwhile goal (*Plastics Europe*)

Where the initial planning for zero plastics to landfill was set at 2020, this time limit has recently been extended to 2025. Therefore, the potential saving of 80 MMT of plastic waste (the equivalent of 1 billion barrels of oil or 70 billion euros) from 2020 to 2037 has changed to 60 MMT of plastic waste; equivalent to over 750 million barrels or 60 billion euros (2025-2037).

Where regulators focus on the environmental impact and expect the market to develop, design, construct and deliver adequate technical solutions, industry is focusing on feasibility along with economic impact. According to *Corporate Europe Observatory*, there are estimated 15-30,000 lobbyists targeting EU decision makers in Brussels, mainly representing the business interests of the industry organizations.

Plastics Europe states:

> *All plastics are recyclable – mechanically or chemically – but not all plastics are beneficial to recycle from an environmental and economic perspective. Such plastics can instead become an important energy source for power and heating. Landfilling used plastics reinforces the perception that plastics have little to no value and can lead to litter on land that may ultimately end up in the marine environment.*
>
> *The plastics industry is committed to diverting all plastics from landfill and will advocate for plastics to either be recycled or used as fuel in efficient energy recovery plants. The comparison between EU Member States is enlightening: wherever legal measures are put in place, e.g. UK's landfill tax or Germany's ban on landfilling combustible waste, the recycling and recovery rates rise.*
>
> *Without such drivers waste owners will continue using the cheapest option and will unlikely pay more for recycling and recovery. Furthermore, such legal measures stimulate investment in state-of-the-art collection, sorting and recycling infrastructure as well as innovations which improve efficiency and create green jobs across Europe.*
>
> *The plastics industry unites behind a policy for a 100% plastics recycling and recovery rate supported by legal and financial restrictions on landfill.*

The reason that *Plastics Europe* is using the widest definition of recycling is because they would like feedstock recycling data to be included in the continuous and increasingly legally mandated recycling percentages. There where PTFPlus is speaking about non-recyclable plastic waste in terms of input material, it is wise to apply *Plastics Europe's* definition instead and speak about feed stock conversion/recycling. This way full support of *Plastics Europe* in allocating feed stock quantities is secured.

Regarding responsible end-of-life management, *Plastics Europe* recommends recycling (whether mechanical or feedstock) as far as economically feasible and environmentally sensible. Where residual streams are concerned, energy recovery can be conducted in special designed plants. For recovered products, demonstrated in LCA studies, *Plastics Europe* would like to see the credits for those quantities rewarded based on substituted virgin materials.

Being the first step of any waste management process*,* collection schemes play a key role in the overall performance. Appropriate waste collection, approved and supported by waste owners, is a prerequisite to solving litter issues. Waste collection determines the composition of waste streams and therefore their suitability for downstream pre-treatment, sorting and recovery operations.

Many successful collection schemes – either capturing plastic waste alone (like *Abakus Serve GmbH*) or together with other materials, including municipal solid waste (*MSW*) (the *Shank's* and the *Sita's*) – are currently available in Europe. These systems share the same objective to maximize recovery of recyclables and recover value from waste by diverting this valuable resource from disposal. Collection schemes are aligned with downstream infrastructure for per-treatment, sorting, and recovery to maximize recovery, improve environmental performance and manage costs.

Today, dedicated commingled collection of dry recyclables (e.g. packaging and other household goods mainly made of plastics or metals, paper, cards and glass), offers an attractive solution to maximize the amount of waste recovered. Subsequent treatment with modern sorting and recycling technologies produces high quality resource streams exhibiting the required market-driven qualities for recycling and recovery.

In addition to municipal waste collection schemes, other product related systems for end-of-life vehicles, electrical and electronic appliances, plastics agricultural films and deposit systems for (plastic) beverage containers also provide a valuable source of resources for recycling and recovery.

The pre-treatment and sorting operations for plastic waste enable this valuable resource to be diverted from landfill and to deliver recyclate of the qualities. A wide range of technologies is currently used for waste pre-treatment and sorting. These range from manual dismantling and picking to automated processes such as shredding, sieving, air, or liquid density separation, magnetic separation and highly sophisticated spectrophotometric sorting technologies, e.g. UV/ VIS, NIR, Laser, et cetera. Modern sorting plants are often complex infrastructures combining several of these technologies that have been custom designed to specific waste streams, in order to reach an optimal output and cost performance.

Both the plastic industry's manufacturers and convertors are fully focusing on mechanical and feedstock recycling.

MECHANICAL RECYCLING is the recovery of materials from waste while maintaining the polymers' molecular structure. In principle all types of (thermo-) plastics can be mechanically recycled with little or no quality impairment.

When available in large amounts, clean and monotype plastic is ideal for mechanical recycling and provides a win-win situation from an environmental and economic perspective. Environmental benefits from substituting virgin material clearly exceed the environmental burden from collection, transport and recycling operations, while the costs of such operations are more than outbalanced by potential revenues from selling recyclates on the market.

The composition of products, the method and efficiency of waste collection schemes, the sorting and recycling technologies, as well as the demand for plastics recyclates play a significant role. The combination is determining what type and how much plastic waste can be mechanically recycled – while ensuring environmental benefits and reasonable costs.

With quality being a major concern, the potential for mechanical recycling is limited. Different plastic types, grades, additives, and colors cannot be mixed without extreme deterioration of the original plastic characteristics and properties. Such recyclate of mixed types, grades and additives ends up being a non-sellable product.

Plastics (containing) waste that cannot be sustainably recycled to the required standard provides a valuable resource for other recovery solutions e.g. feedstock recycling and efficient energy recovery to maximise the recovery of its embedded energy and resources.

FEEDSTOCK RECYCLING is a particularly attractive option for plastics that are ill-suited for recycling. It allows said plastics to be turned into valuable chemical building blocks that can then be used in various applications. Examples of suitable streams for feedstock recycling include laminated and composite plastics, low quality mixed plastics streams and plastics contaminated with food, soil, et cetera. PTFPlusOne' plastic to fuel technology is a perfect example of feedstock recycling.

ENERGY RECOVERY is a necessary, responsible and beneficial addition to recycling plastics-rich waste fractions, when plastics cannot be sustainably recycled. Not all plastics can be recycled as their recyclability is influenced by a number of factors such as:

- The material composition of products;
- The amount, cleanliness and composition of the collected waste streams;
- Market-driven requirements on quality and standards for recyclates that may limit the appropriateness of plastics recycling.

Consequently, some plastics-rich waste fractions, resulting from sorting and recycling operations, cannot be recycled per se (i.e. irrespective of said factors). Energy recovery is the current state-of-the-art solution concerning waste streams that cannot reasonably be recycled. It Involves the most resource efficient approach; far superior to land filling.

Today's modern combined heat and power recovery plants (CHP Plants) use waste plastics together with other high calorific input materials. SRF power plants as well as a number of energy intensive industries (e.g. cement and lime kilns), thereby displacing virgin fossil fuel increasingly use plastics containing solid recovered fuel (SRF). However, collecting, processing, cleaning, drying, shredding, pelletizing and delivery logistics make this a loss-making business for waste companies.

Energy recovery remains inferior, compared to PTFPlusOne' technology to efficiently convert waste plastics in to sustainable liquid fuels.

In 2013 the main steps in the life cycle of plastics from convertor demand to disposal and recovery is shown in figure 19. Set off against 2012, plastics production remained stable at 57 MMT. In addition, the convertor demand increased from 45.9 MMT to 46.3 MMT. Post-consumer plastics waste decreased from 25.2 MMT to 25 MMT, because of improved recovery. Taking into account the non-significant changes in the EU off take of plastics, the post-consumer waste quantities in 2014 will hardly differ from 2013.

The European policy of zero waste to landfill has two clear and significant advantages for PTFPlusOne. Future availability of wind shift fraction ex MSW (as earlier offered by the Dutch waste company *Attero*) will substantially grow the coming decade. Based on the percentage of close to 50% for PE and PP of the total volume, the expected quantities are approximating a potential of up to 4.6 MMT. This is additional to the already available quantities of 4.4 MMT used for energy recovery.

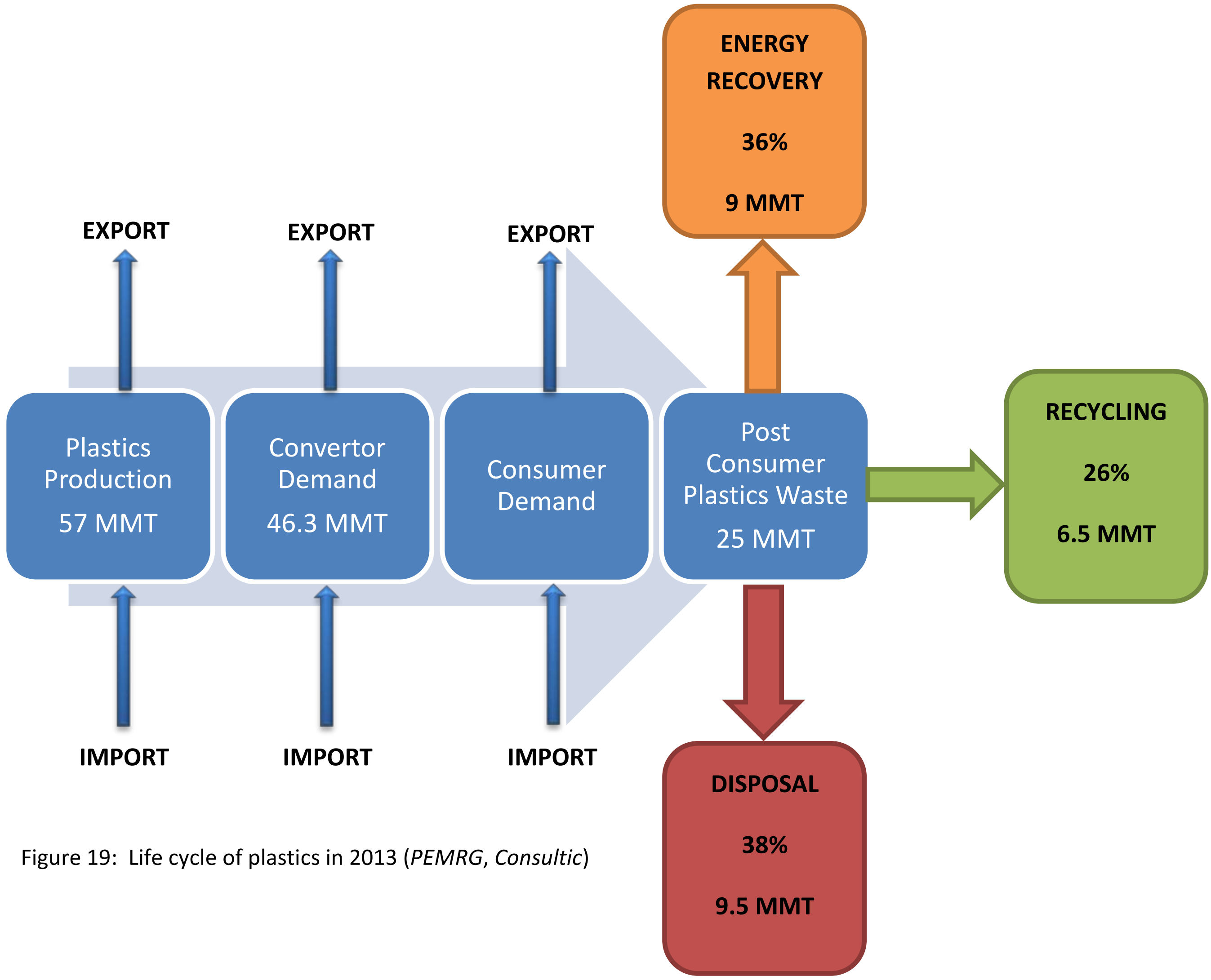


Figure 19: Life cycle of plastics in 2013 (*PEMRG*, *Consultic*)

The CONCLUSION is justified that the required input material for PTFPlusOne' commercialization of their conversion technology is available today, and will further grow significantly because of the zero landfill policy.

10. Conclusion

PTFPlusOne Ltd. has in house technologies as well as knowledge to efficiently convert plastic waste in to sustainable liquid fuels. Test showed that the conversion rates for PE and PP were the highest (> 60%) compared to other plastic materials. The company will commercialize her technology by building up to three 200,000 MT/a conversion plants.

Core Laboratories demonstrated that the produced fuel mix could be easily distilled in to a naphtha fraction and a heavier fraction matching the requirements for low sulphur marine fuel diesel. The total fuel mix produced per plant will be minimal 120,000 MT/a equivalent to 150 million liters.

Total EU plastic production in 2013 reached 57 MMT, identical to the quantity produced in 2012. The EU demand for plastic 2013 reached 46.3 MMT out of which close to 50% has been different PE and PP grades (22.4 MMT). The "top five" countries Germany, Italy, France, UK and Spain represent two third of the total off take. The demand for PE and PP will show an above average growth compared to the total expected plastic market growth of 1.3% until 2018.

Out of total demand of 46.3 MMT 54% remained within the EU as post-consumer waste; a quantity of 25 MMT. Currently three different waste management scenarios are used: landfill (disposal), incineration with energy recovery or use as solid recovered fuel in energy intensive industries (feed stock recycling) and (material) recycling. Although the percentages strongly differ per EU member state the current EU average is 38% landfill disposal (9.5 MMT), 36% feed stock recycling (9 MMT) and 26% material recycling (6.5 MMT).

The environmental impacts of plastics' end of life management represent a growing concern. Regulators actively support any improvement and upgrade of the current situation to achieve future environmental improvement. An EU zero plastics to landfill regulation as of 2025 is being implemented. The plastic industry will therefore face even stronger pressure to significantly increase recycling percentages. The total quantity of 9.5 MMT still going to landfill has to be upgraded and added to the current 9 MMT of energy recovery. Alternatively, even better, as production and off set of plastic containing solid recovered fuel (SRF) is no profitable business, add this to the 6.5 MMT recycling. European front-runner member states, like Germany, Switzerland and Austria, demonstrate that the collection schemes and sorting technologies are available to reach zero plastic to landfill today.

PTFPlusOne' conversion technology is superior to the currently used feedstock recycling techniques as the waste enters a complete new (life) cycle: sustainable fuels. The technology is robust and organic or inert impurities of the input feed do not influence the quality of the produced fuel mix.

The conclusion is justified that the required PE and PP input material for PTFPlusOne' commercialization of their conversion technology is available today (4.4 MMT out of the total plastic quantity of 9 MMT for energy recovery). This availability will further growth significantly as a result of the zero plastic to landfill policy (4.6 MMT out of the total of 9.5 MMT currently being disposed of to landfill). PTFPlusOne' demand per conversion plant represents only 2.2% of the 9 MMT total available quantities of PE and PP.

Both *Plastics Europe* (manufacturers) and *EuPC* (convertors) aspire to achieve continuous improvement in recycling rates. PTFPlusOne’ technology will significantly contribute to increasing feed stock recycling percentages. Therefore the commercialization of the conversion technology will be duly supported by EU and national regulators, plastic producers and convertors.

11. Sources used

Organisation	Name	Address	Country	Phone
AMI	Applied Market Information Ltd.	6 Pritchard Street, Bristol, BS2 8RH	UK	+44 117 924 9442
Borealis	Borealis AG	IZD Tower, Wagramer Str. 17-19, 1220 Vienna	Austria	+43 1 22400 000
BU	Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit	Stresemannstraße 128 - 130 10117 Berlin	Germany	+49 30 18 305-0
CEFIC	European Chemical Industry Council	Avenue E. van Nieuwenhuyse, 4 box 1 - 1160 Brussels	Belgium	+32 2 6767211
CEO	Corporate Europe Observatory	Rue d'Édimbourg 26, 1050 Brussels	Belgium.	+32 2 893 0930
CIA	Chemical Industry Association	Kings Buildings, Smith Square, London SW1P 3JJ	UK	+44 20 7834 3399
Consultic	Consultic Marketing & Industrieberatung GmbH	Röntgenstraße 4, 63755 Alzenau	Germany	+49 6023 9475-0
Defra	Department for Environment Food & Rural Affairs	Nobel House, 17 Smith Square, London SW1P 3JR	UK	+44 20 7238 6951
DG ECFIN	Directorate General for Economical & Financial Affairs	European Commission, Rue de la Loi 200, 1049 Brussels	Belgium	+32 2 2994582
ECEBD	Eastern & Central Europe Business Development Ltd.	University of Miskolc E/7 Office Building 6th floor, PO Box: 28, 3515 Miskolc	Hungary	+36-1-391-6577
EEV	European Environmental Agency	Kongens Nytorv 6, 1050 Copenhagen	Denmark	+45 33 36 71 00
Ensys Energy	Ensys Energy & Systems Inc.	1775 Massachusetts Ave Lexington, Massachusetts 02420	USA	+1 781 274-8454
EPDA	European Plastic Distribution Association	The Old George Brewery, Rollestone Street, Salisbury SP1 1DXTel:	UK	+44 1722 339811
EPRO	European Association of Plastic Recycling & Recovery Organisations	Koningin Astridlaan 59 - 1780 Wemmel	Belgium	+32 2 4568449
EuPC	European Plastic Convertors	Avenue de Cortenbergh 71 – 1000 Brussels	Belgium	+32 2 7324224
Eurostat	European Commission	Commission européenne, L-2920	Luxembourg	+352 4301 35555
Freedonia	Freedonia Group	767 Beta Drive Cleveland, OH 44143	USA	+1 440.684.9600
GIA	Global Industry Analysts Inc.	6150 Hellyer Ave., San Jose, CA 95138 :	USA	+1 408-528-9966
GVR	Grand View Research, Inc	28 2nd Street, Suite 3036, San Francisco, CA 94105	USA	+1-415349-0058
Ineos	Ineos Olefins & Polymers Europe	Building US, Alte Straße 201 (Tor 19) 50769 Köln	Germany	+49 221 3555 1725
Lloyds	Lloyds Register Group Ltd.	71 Fenchurch Street, London, EC3M 4BS.	UK	+44 20 7709 9166
Lucintel	Lucintel	222 Las Colinas Blvd West, Suite 1650, Irving, TX 75039	USA	+1-972-6365056
Lyondell Basell	Lyondell Basell Rotterdam Office	Groot Handelsgebouw – Entrance A Stationsplein 45, 3013 AK Rotterdam The Netherlands	Netherlands	+31 10 275 5500
PEMRG	Plastics Europe's Market Research and Statistics group	Avenue E. van Nieuwenhuyse, 4 box 1 - 1160	Belgium	+32 2 6753297
Plastics Europe	Association of Plastic Manufacturers	Avenue E. van Nieuwenhuyse, 4 box 1 - 1160 Brussels	Belgium	+32 2 6753297
Platts	Platts McGraw Hill Financial	20 Canada Square, 12th Floor, Canary Wharf, London, E14 5LH	UK	+44 20 7176 6111
Recycling.nl	Nijssen Recycling B.V.	Rijnlanderweg 1427, 2153 KE Nieuw Vennep	Netherlands	+31 252674 041
Shanks	Shanks Group plc	Dunedin House, Auckland Park, Mount Farm, Milton Keynes, Buckinghamshire MK1 1BU	UK	+ 44 1908 650580
Sita	Sita UK Ltd (Suez)	SITA House, Grenfell Road, Maidenhead, Berkshire SL6 1ES.	UK	+44 0870 421 1122
VCI	Verband der Chemischen Industrie e.V.	PlasticsEurope Deutschland e.V. Mainzer Landstr. 55, 60329 Frankfurt	Germany	+49 69 25561300
VNCI	Chemical Industry Association	Castellum, ingang C Loire 150, 2491 AK, Den Haag	Netherlands	+31 70 337 87 87
VROM	Ministerie van Infrastructuur en Milieu	Koningskade 4, 2596 AA, Den Haag	Netherlands	+31 70 456 85 55
Wikipedia				