NextChem recycling solutions to accelerate waste plastic circularity

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Maire Tecnimont

NextChem
Maire Tecnimont for Energy Transition

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1. Context

Plastics are under pressure due to regulations, social awareness and investors who are posing increasing attention to environmental concerns and in particular on how to reduce waste. While policy makers extend bans on single-use-plastics materials and foster recycled waste plastics usage, consumers and investors increasingly value circularity. Such concerns were at the center of the 2020 World Economic Forum discussions. Solutions to address the plastic waste issue over the long term are urgent.

> *A revolution in the responsible use of plastics has to take place*
>
> P. Folgiero – CEO of Maire Tecnimont and NextChem

Therefore, plastic packaging and components producers need to invest in the redesign of their core products – by converting them into materials easier to reuse, or to shift to biodegradable products as well as increasing the usage of recycled plastic from waste rather than from virgin naphtha. Plastics sustainability is a complex problem that will not only impact packaging and component providers, but the entire plastics value chain, thus also including in different capacities petrochemical companies, Fast Moving Consumer Goods companies (FMCG), and waste management companies. The transition to a new circular plastic economy requires players in the value chain to integrate recycling technologies into their traditional business model. This means exploring different technologies and partner with new players.

Stakeholders are acting with a common purpose

The above transition towards a circular plastic economy is mainly driven by two distinct market approaches: the first being demand-driven and the second supply-driven.

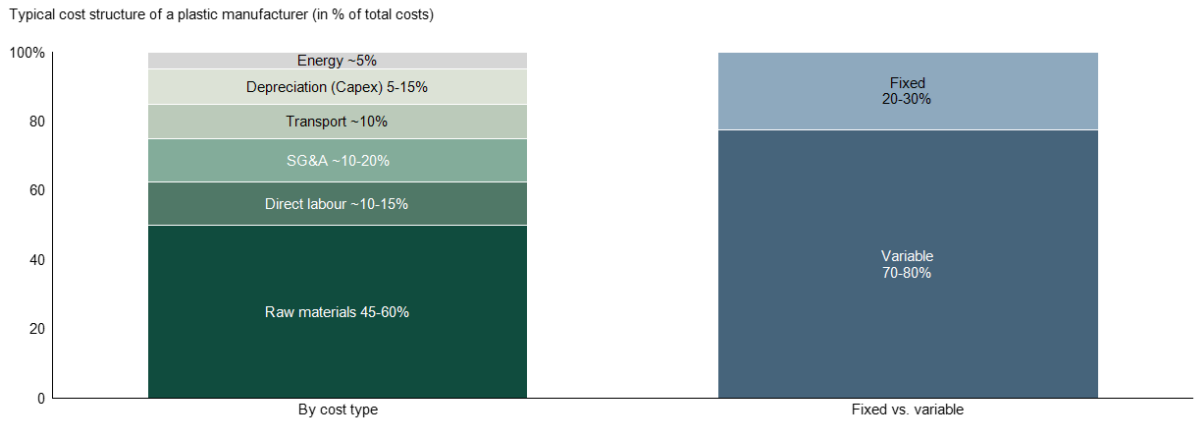
On a demand-driven level, increasing media coverage has extensively exposed consumers and investors to the issue, raising their awareness and attention to the waste plastic theme. At the same time, major regulatory adjustments are rapidly changing the business context. European regulation has banned single-use-plastic (SUP) from 2021[1] onward. In addition, discussions are ongoing to regulate the use of difficult-to-recycle plastics as well as prevent micro-plastics from entering the biosphere. In addition, the US, following the European trend, have been promoting plastics related regulations, albeit in a less restrictive way and limited to some plastic types for food contact packaging only. At state level, nonetheless, California, New York and Washington are aligned – if not more severe – with EU requirements.

[1] Single-Use Plastics Directive (2019) – focusing on single-use plastic cutlery, single-use plastic plates, plastic straws, cotton bud sticks made of plastics, oxo-degradable plastics, food containers and expanded polystyrene cups, plastic balloon sticks

These states have in fact started restricting the usage of selected SUP and PVC (e.g. ban of plastic bags and restriction of rigid plastic containers in California, ban of EPS containers in New York).

To understand the supply-driven motivations, it is worth looking at the cost structure of a typical packaging company (Figure 1). For a packaging company, feedstock typically represents the main cost driver (~45-60% of the total cost structure). Virgin plastics are made from naphtha that is a refined product from fossil oil, thus requiring a complex, multi-step and energy intense production process. Therefore, simplifying the value chain and reducing the cost of plastic feedstock could bring significant potential benefits for plastic packaging and equipment companies.

Figure 1: Typical cost structure of a plastic manufacturer (in % of total costs)



Source: Bain & Company

According to specific studies[2], in 2019, the total production of global virgin plastic amounted to ~300-330 MT. Of this number, a relatively small portion (13-15%) was recycled, resulting in a total of ~40-45 MT of recycled plastics. Assuming a relatively constant business activity (vs. 2019), the total plastic production could potentially increase up to ~400-500MT by 2030. Combined with a substantial raise in recycled plastics – which is expected to make-up ~30% of the total plastics produced - this– it would lead to an annual value of recycling plastics equal to ~120-150 MT.

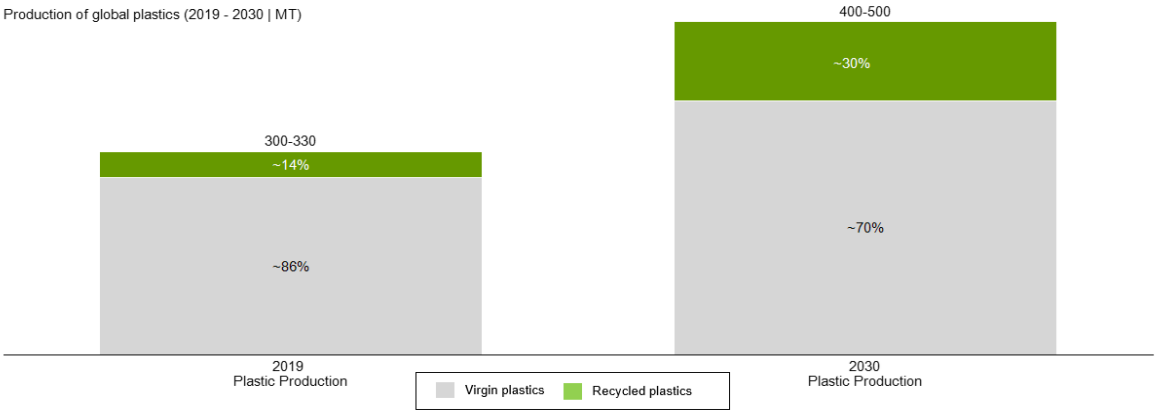
> *Plastic waste is the oil of the third millennium*
>
> P. Folgiero – CEO of Maire Tecnimont and NextChem

Volumes at stake are significant, and regulators, consumers and investors are demanding a higher level of circularity: standing still is no longer an option. Players of the plastics value chain should define solutions to shift to a more circular and sustainable management of both plastic and plastic

[2] Bain analysis based on Grand View Research – Plastics Market (2018)

waste: who will be able to grasp this emerging opportunity will be the winner of the next phase of the plastics business.

Figure 2: Recycling of plastics significantly increasing from 2019 to 2030



Source: Bain & Company

2. Tackling the issue

> *Waste plastic recycling needs to be industrialized*
>
> P. Folgiero – CEO of Maire Tecnimont and NextChem

Several alternatives are available to embrace plastic sustainability, ranging from substitution with other materials (where possible), shifting to biodegradable plastics or plastic waste recycling. We see the latter as a key lever to convert the challenge of plastic circularity into an opportunity to extract value. This implies a process of restoration and regeneration in which materials constantly circulate in a 'closed loop' system, rather than being used once and then discarded, while keeping the value of these elements in the economy and limiting leakage into the natural environment. Eventually, this will allow reducing also the amount of materials currently treated through ‘open loop’ systems, in which recycled materials are converted into both new raw materials and waste products – usable as input for other manufacturing processes. On the downside, this process is associated with degradation of the material as well as an important loss of co-mingled material that cannot be recycled.

Overall, recycling technologies are already available today, with different levels of maturity and applicability. They offer a range of opportunities for players along the plastic value chain to not only address an environmental issue, but also to unlock value from their traditional business.

Different technological solutions according to different needs

As of today, several complementary methods of re-generating plastic waste exist, with different degrees of maturity. The most general differentiation is between mechanical and thermochemical solutions. While the former implies the recycling of recyclable waste into “new” (secondary) plastic raw materials and therefore without changing the basic structure, the second method enables to treat a wider range of non-recyclable plastic waste (e.g. multilayer, mixed-material plastic waste), turning them into valuable chemicals.

Generally, mechanical recycling is nowadays the most common technology and thus by comparison the more mature technology. It implies the recovery of solid plastic waste and the subsequent conversion into re-generated polymers. In the same way, thermochemical recycling – still in a ramp-up phase – allows to convert non-recyclable plastics in new, re-generated monomers. In addition, it addresses de-contamination and to some extents (varying case-by-case) the plastic degradation phenomenon. Therefore, as more restrictive policies are implemented, chemical recycling of plastic waste becomes necessary in achieving these targets.

Within the area of thermochemical recycling, the two main solutions emerging are pyrolysis and gasification. Pyrolysis consists in breaking down the polymer chain in a non-selective way through a pyrolytic process. Therefore, this reaction involves the molecular decomposition of larger molecules into smaller ones in the presence of heat, leading to the generation of a pyrolysis oil. If desired, the resulting product can be further treated through other methods (e.g. steam cracking, polymerization) to close the cycle and turn back to polymers. The main feedstock type for pyrolysis is mixed unrecyclable plastic waste. Gasification, on the other hand involves heating the plastic waste with oxygen, to produce syngas that can be converted to industrially valuable chemicals such as “circular hydrogen”, methane (natural gas), and methanol. These chemicals are the building blocks for the synthesis of practically all other synthetic chemical species, including polymers to produce basic chemicals such as methanol, methane or even downstream (e.g. through methanation/methanol synthesis, methanol to olefins, polymerization).

Case Study – Integrated plastic recycling approach

With the aim of accelerating the technological innovation in the energy transition, Maire Tecnimont, major global EPC contractor for the refining, petrochemical and fertilizers industries, has constituted a dedicated technology vehicle. In early 2019, NextChem was born, consolidating Maire Tecnimont capabilities, technologies, patents and projects in one company, to develop technological solutions with a focus on: (1) Advancing the circular economy through the improved re-utilization of waste; (2) Using biological components as feedstock; (3) Reducing the negative environmental impact of existing industrial processes.

Focusing on the first of these areas, NextChem has developed a portfolio of plastic waste recovery solutions based on the concept of applying the best available technology in function of the recyclability of the plastic waste input. The value of highly recyclable plastics is best extracted through technologies that upgrade them to new raw materials, which in their turn can substitute virgin polymers for the production of plastic goods. Non-recyclable plastics may find their optimal destination in a thermo-chemical process able to re-convert them into their basic molecules and transform them into new chemical feedstock.

The proprietary **MyReplast upcycling technology** combines both mechanical treatment and chemical formulation, to transform rigid plastic waste back into high-quality tailor-made plastic granulates for various plastic conversion industries. The industrial-scale plant – located in Brescia (IT) – has been described as EU's most efficient and economically sustainable mechanical plastic waste upcycling plant. It has an overall capacity of 40kt per annum (corresponding to the average total plastic consumption of 1M people and to 100.000 m^3 of landfill saved per year), shows a 95% efficiency and allows for a total CO_2 reduction of ~8.5KT per annum. Three key pillars characterize the recycling plant: (1) Advanced sorting capabilities: cutting-edge optical sensors, able to sort a range of plastic materials, being PP, HDPE and LDPE, followed by PS, ABS and PA the major polymers of interest; (2) High efficiency process: sequential steps from mechanical sorting to grinding, washing and color separation; (3) Upcycling process: Upgrading plastic flakes into high performance materials of consistent quality with compounding and extrusion technologies – able to meet even the most demanding end-uses (e.g. automotive).

Moving to **thermo-chemical recycling** of plastic waste, NextChem provides two alternative technologies – gasification and pyrolysis – to provide a second life to municipal solid waste, refuse-derived fuel and non-recyclable plastics. Concerning the gasification process, NextChem has developed an economically viable model to transform waste into basic chemical products. NextChem's technology advantage lies specifically in the flexibility and modularity of the different process phases; NextChem can easily integrate methanation, methanol synthesis, methanol to olefins, polymerization and compounding to generate respectively natural gas, methane, monomers, polymers and compounded plastics, according to customer needs

In addition, for the pyrolysis of waste, NextChem is developing a specific solution. Besides achieving high conversion efficiency rates (e.g. minimizing formation of waxes), this technology can be integrated, upon customer request, with additional downstream phases such as steam cracking, polymerization and compounding.

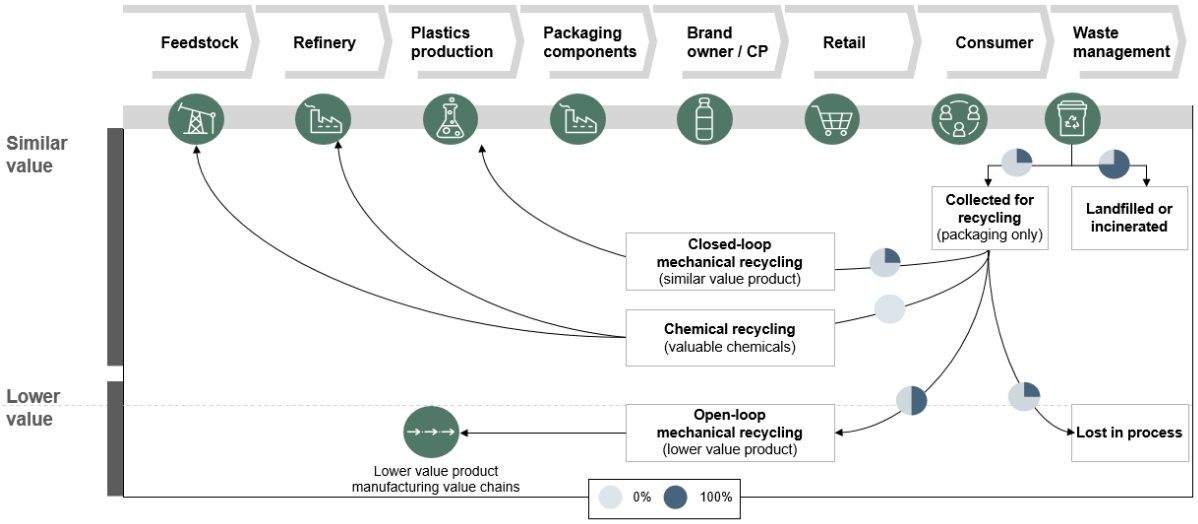
Integration to unlock value from circularity

All players of the value chain have an urgency and an opportunity to address the plastic recycling issue, in different ways:

Petrochemical companies are well positioned to take advantage of plastics recycling. As demand for recycled plastics will increase, by 2030 the naphtha-based polymers are expected to see a downturn in their demand. Therefore, petrochemical and chemical players must be ready to offer a portfolio of products that also integrates recycled feedstock. This will require forward integration into the value chain, by taking stakes into recycling, also benefitting from operational synergies of industrial operations.

Plastic packaging and equipment producers will need to secure a constant and increasing supply chain of new "circular" raw materials with high quality and competitive prices. To facilitate and accelerate the availability of such products, plastic converters will need to co-invest in recycling assets and technology, thus integrating backward in the value chain.

Figure 3: Standard plastics value chain with relative level of plastics recycling (2019)



Source: Bain & Company

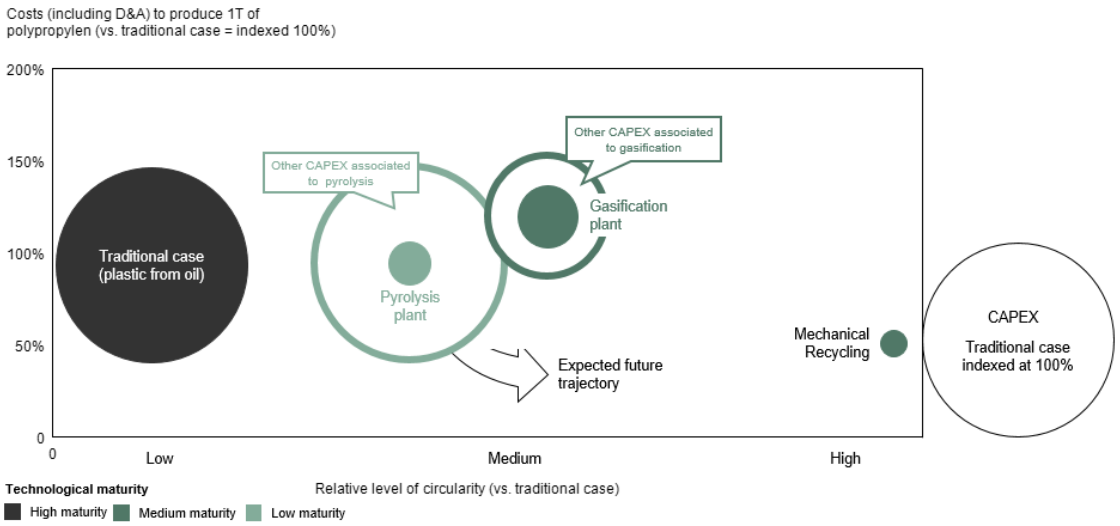
Finally, through a backward integration into plastic waste recycling and investments in innovative technologies, waste management companies also have an opportunity to create additional value to the traditional business. Currently non-recyclable plastics that are directed to landfill could be recycled and reused, thus extracting more value with recycling represents solution to the progressive saturation of incineration capacity.

3. Partnerships and collaborations

There is high value in taking stakes into recycling for all actors of the value chain. However, it will be a complex game. Partnerships and chain collaborations across value chains will be key for different reasons.

Technology in some spaces (e.g. pyrolysis) is not at a mature stage yet. Co-investing in technology development would accelerate the transition from pilots to industrial plants while also lowering the burden associated with running early-maturity technologies. (Figure 4)

Figure 4: Illustrative comparison of mechanical and thermo-chemical processes vs. traditional case of plastic from oil



Note: (1) Assumption on raw materials costs are considered: Naphtha = 534 US$/ton; Methanol: 342 US$/ton. (2) Relative level of circularity (vs. traditional case): qualitative variable, computed as the weighted average of: a) share of circular outputs from process; b) volume of green feedstock. (3) For the case of pyrolysis and gasification plants, the standard capacity of such solutions is much smaller compared to the capacity of subsequent processes plants (e.g. respectively naphtha crackers for pyrolysis and methanol-to-propylene for gasification). Therefore, these processes requires a combined cycles of green feedstock (plastic waste, RDF) & conventional feedstock (naphtha, methanol) to run a full cycle
Source: NextChem

Plastic recycling requires a high level of “chemistry” competences and process know how, to ensure a product that respects high quality standards and is tailored to application needs. Thus, partnering with a technology provider ensures that developed processes and assets meet specific needs.

On the one hand, for packaging and components producers, integration into recycling could ultimately ensure stable supply streams at the quality needed, while reducing complexity related to the management of a heterogeneous panel of recycling players. On the other hand, for waste management companies, integration would secure an end market for different types of waste, while increasing the value of such streams.

To accelerate the transition towards plastic circularity and unlock the most value out of the waste plastic, collaborations and partnerships in recycling are key. Joint development will socialize costs and risks while accelerating the technology development.

NextChem is the partner of choice to accelerate the energy transition and plastic waste circularity. Thanks to our technological background and our leadership in the transformation of natural feedstock, we are the ideal partner for the industrialization and commercialization of sustainable innovation.

Following the principle of low capital intensity, collaborations and scouting, we are able to bridge the gap between laboratory scale ideas and production on an industrial scale. We are industrializers of innovation and we are already collaborating with major players in the plastics industry to develop technology fit for any purpose.

More information on NextChem can be found online: www.nextchem.com

Disclaimer

The above document and all its related analysis have been executed between January and February of 2020. Therefore, possible implications and consequences tied to the spread of COVID-19 are excluded.

As COVID-19 situation, as well as oil price shock, continues to evolve and companies (across industries) are temporary forced to shut down their activities – thus, creating frictions in the overall business environment – estimates might be re-considered.