Evaluating potential impact of plastic waste recycling industry on the global energy market

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Abstract. Plastic recycling and “closed-loop” plastics market are among the “hot topics” in the global environmentalist agenda. Secondary plastics are lauded as a way to eliminate demand for fossil hydrocarbon feedstock and solve the polymer pollution crisis. The author has reviewed the potential technological capacity of plastic recycling for affecting the oil and energy markets and the current government legislations for the “circular plastics” development. Even under the “best case” scenario, secondary plastics were found to be able to provide around a third of demand by 2030, and state plans indicate even lower figures.

1 Introduction

In recent years combating plastic waste has become one of the central themes of global environmentalist agenda. Polymer pollution is widely recognized as a threat to both wildlife and human health on a global scale. Many experts, politicians and business representatives are pushing plastic recycling as a solution for both polymer waste utilization, and reducing the consumption of fossil hydrocarbons as plastic industry feedstock. Some even go as far as to suggest a fully “closed loop” plastic system.

The prospects for the development of the plastics recycling segment are relevant not only for environmentalists, but also for specialists in the field of energy markets, in the context of two main aspects of the relationship of this industry with energy: on the one hand, the expansion of the processing of plastics into secondary feedstock can put downward pressure on the demand for liquid hydrocarbons as feedstock for petrochemical synthesis and thus influence the oil market as a whole; on the other hand, the incineration of plastics at specialized enterprises with the production of heat and electricity can offset part of the consumption of other energy carriers from the energy balance of individual countries. In this regard, the study of global plastic waste management systems is an urgent scientific task in the field of system research in the energy sector.

The aim of this work is to assess the potential impact of the plastic waste recycling and disposal industry on energy markets until 2030. This paper examines the current state of the global plastic waste management system: the volume of waste produced and the structure of their disposal; current legislation and plans for improving recycling systems are considered.

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2 Methodology and Data

The study forecasts three main parameters: the volume of polymer waste production; the amount of secondary plastics produced by the recycling industry and the amount of energy produced by energy waste incineration. The methods for calculating each of the parameters are outlined below.

2.1 Plastic waste generation

During the gathering and analysis of data on the plastics markets of more than 50 countries and groups of countries, the author revealed a stable connection between the annual consumption of base polymers and special plastics and the volume of plastic waste produced, which ranges from 0.5 to 0.7 tons of waste per ton of consumption, depending on the country or region. This coefficient demonstrates dependence on the economic characteristics of the country: states with a higher share of industrial goods produced for export (for example, China, Korea, Japan) have lower ratio indicators; while countries where production is more focused on the domestic market or more dependent on imports due to the weak development of their own production, on the contrary, higher (USA, African countries). On the global average, this ratio is about 0.6 t/t. It is worth noting that the correlation coefficients close in values are derived from the data of other studies considered by the authors on the topic of plastic pollution [1], which confirms the validity of the authors' conclusions. This relationship, which the authors have designated as the "turnover of plastics" forms the basis for predicting the amount of waste as a direct function of consumption.

2.2 Plastic waste recycling

In this paper, the material balance of the polymer waste processing industry is considered – how many tons of secondary feedstock (plastic pellets and base monomers) can be produced from a ton of plastic waste.

In general, about 15% of the polymer waste stream cannot be recycled at all, since during heat treatment they decompose with the release of toxic and corrosive substances. These includes primarily PVC, but also other plastics, including some coloring and properties improving additives [2].

According to experts, based on empirical data, about 15% of the material for processing is lost during collection, transportation and sorting. Of the remaining, about half can be processed mechanically, and the rest can only be recycled through pyrolysis. Losses during mechanical recycling average about 10%, while the conversion of polymer raw materials during pyrolysis into ethylene and other monomers is no more than 50% [3-5].

2.3 Plastic waste incineration with energy recovery

The amount of energy generated by the incineration of plastic waste is calculated by multiplying the volumes of plastic disposed of through incineration by the energy density of mixed polymer waste equal to 29 GJ/t and by the average efficiency of the thermal power plant, which fits in the range from 20 to 30% [5].

The author has identified no technological limitations on the types and amounts plastic waste to be incinerated (given the appropriate exhaust gas cleansing), barring the economic feasibility.

2.4 Current state plans for plastic waste utilization industry development

Despite the wide public traction of the issue, on the global scale legislations regarding the plastic recycling industry is mostly undeveloped and most countries still do not formulate comprehensive plans.

The EU is traditionally at the forefront of environmentalist legislative agenda. Plastic recycling strategies of the Union are covered by Circular Economy Action Plan [6]; European Strategy for Plastics in a Circular Economy [7]; Directive "on the reduction of the impact of certain plastic products on the environment" [8]. The main strategic aim is to achieve the level of 10 million tons of recycled plastic per year by 2025, which will increase waste recycling rate up to 30-33% from the current 22%.

The United States are yet to state overall national goals for plastics recycling. The topic should be covered by the National Recycling Strategy [9], which is currently incomplete.

China's 14th Five-Year Plan contains mentions of "circular plastics" [10], however, China mostly focuses on incineration with energy recovery [11].

In Japan polymer waste recycling is covered by the Act on the "Circulation of Plastic Resources" [12] that does not, however, set any concrete indicators.

The Republic of Korea sets a lofty goal of reaching 70% of plastic waste recycling by 2030 in the "Plastic Waste Control Plan" [13]. However, this figure includes waste-to-fuel and energy utilization along with actual recycling into secondary feedstock [14].

3 Scenario Assumptions

For the sake of this research, two scenarios have been considered:

- "Best case scenario" assumes that all of the technically recyclable plastic waste is recycled through conventional mechanical means or pyrolysis. The unrecyclable waste is incinerated with energy recovery. Most technological limitations of current recycling technologies are disregarded in this scenario.
- "Stated policies" scenario assumes that plastic waste processing industry develops in accordance with the current announced government plans and indicators.

Both scenarios assume "inertial" rates of plastic demand growth i.e. unaffected by "plastic bans" and other such regulations, as analyzed in the authors previous work [15]. The average annual growth rates of demand over the forecast period are presented in Fig. 1.

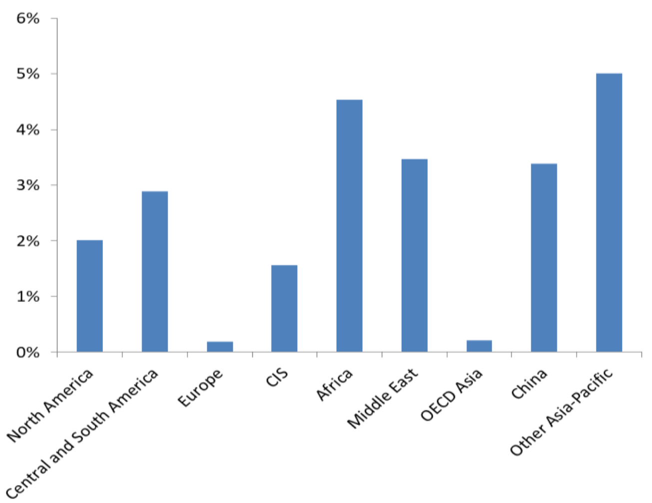

Fig. 1. Annual year-on-year plastic demand growth rates between 2019 and 2030.

4 Results and discussions

Given the fairly reserved demand assumption, by 2030 annual global plastic waste generation will grow by a third and exceed 300 million tonnes (Fig. 2)

In the "Best case" scenario in 2030 close to 220 million tons of waste can be theoretically brought in for recycling, which will yield 160 million tons of "secondary" plastics. To contrast, this will be but a third of demand for plastics projected for that year (Fig. 3). Close to 60 million tons of unrecyclable and unsorted waste is incinerated in this scenario, providing 0.16 TWh*h of energy, roughly equivalent to 2019 level.

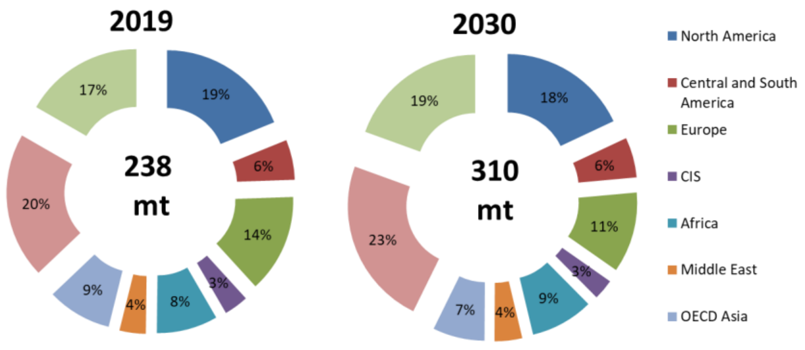

Fig. 2. Plastic waste generation growth in the forecast period by region.

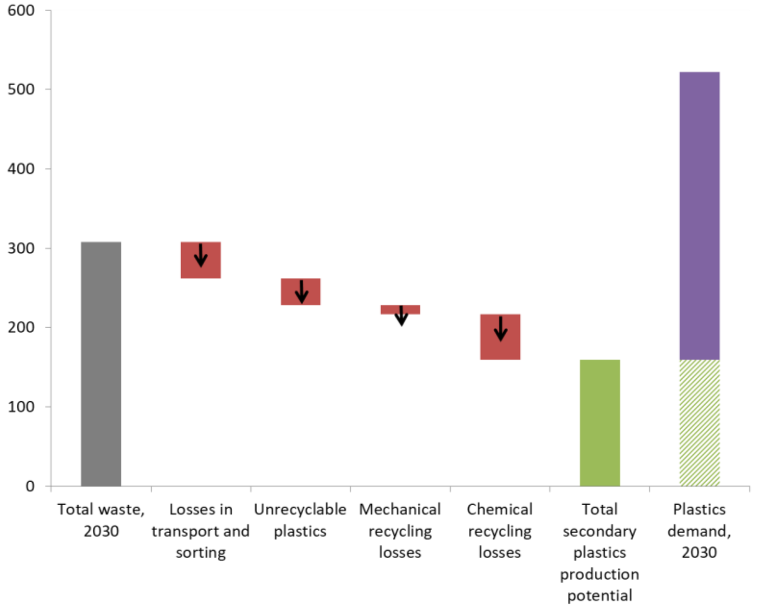

Fig. 3. Maximum technical capabilities for the displacement of "virgin" plastics by "secondary" in 2030, taking into account all losses, million tons.

In "Stated policies" scenario global plastic recycling increases to 68 million tons, producing 54 mt of secondary feedstock. Despite a significant increase on 2019 level, this growth barely outpaces the overall plastic demand growth and the share of secondary plastics increase only to 9% (Fig. 4).

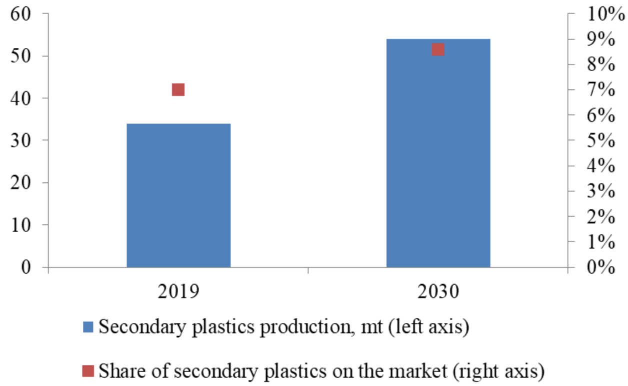

Fig. 4. Secondary plastics industry development in the "Stated policies" scenario.

Energy production from waste also increases in this scenario by over a third in 2030 compared to 2019, to 0.21 TWh*h. However, on a global scale this is a miniscule amount, less than a $1*10^{-3}$% of global energy demand, meaning that converting waste to energy can hardly be considered a factor in energy supply (Fig. 5)

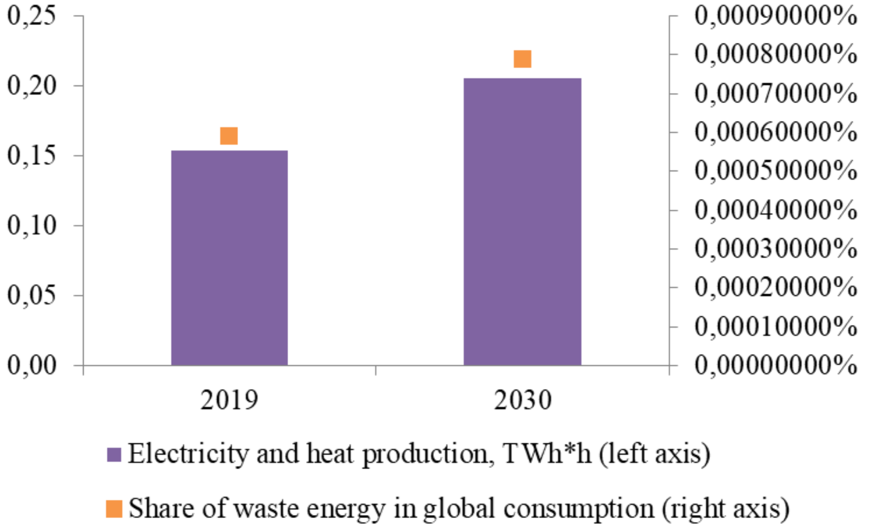

Fig. 5. Plastic waste energy recovery industry development in the "Stated policies" scenario.

5 Conclusions

The author's findings indicate that even without taking into account economic feasibility, under the most optimistic assumptions, "closed loop" circular plastics system is an impossibility, as plastic waste simply cannot provide enough material to cover even half of polymer demand, especially when taking into account all the losses, associated with collection and recycling. This is not to say, that recycling is completely futile, as polymer waste does have potential to become a significant source of feedstock for the plastics industry, but far from the primary one.

The current government plans for efficient plastic waste utilization fall very far short of potential capability for recycling or even incineration with energy recovery even in the developed countries. To properly utilize the energy and material potential of plastic waste an intensification of state work is crucial.

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