MODERN TECHNOLOGIES AND TRENDS IN THE SECONDARY POLYMER MARKET

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Over the past five years a significant number of technologies to conversion processes to yield new products high-value added petrochemical products have appeared: plastic waste can be returned for processing into value-added petrochemical products, including aromatic hydrocarbons, hydrogen, syngas, and bio feedstock using a variety of technologies including thermochemical, catalytic conversion, and chemolysis. The article discusses the market prospects for the processing of polymer waste and the production of secondary polymers and the regulation and incentive issues and presents the experience of LINK on the treatment of polymer waste and assessment of the carbon footprint.
Keywords: polymer waste, recycled plastics, life cycle assessment, carbon footprint, circular economy, recycling, polymer processing.

International studies have shown that the production, use, and disposal of plastics pollute the land, water, and atmosphere. Plastics derived from the products of oil refning do not decompose and remain within the environment for a long time and can also contaminate human and accumulate in tissues. The annual plastic consumption has reached 200 million tons. For this reason the problem of environmental pollution with plastic waste has become a high-priority issue. The interest in recycled plastics is gaining momentum with more than 80 of the world's largest in volume companies engaged in the production of consumer goods, packaging, and retail trade committed to increasing the recycled volume of packaging from 15 to 50% by 2025. Under this commitment in the European Union market up to 10 million tons of recycled plastic will be used in new products, and by 2030 more than 50% of the plastic waste produced in the EU will have to be recycled, and all packaging will have to be made from recycled polymers. The approach to assessment of the life cycle is inherently an iterative process with each phase or stage dependent on the results and principles used in a corresponding one. The concept to which all the progressive companies strive: Cradle-to-cradle (from source to source) goes beyond cradle-to-grave approach and is more consistent with the circular economy model. In the "cradle-to-cradle" model the products are designed so that at the end of their useful life they can be easily reused or recycled, avoiding landfll waste, e.g., as in plastic reprocessing and recycling.

Experts from LINK assessed and calculated the carbon footprint of the products from the LUKOIL Group petrochemical enterprise, carried out primary benchmarking in terms of emission levels, and developed recommendations for reducing the carbon content of the enterprise's technology processes, as well as producing low-carbon products that will in future sustain the competitiveness of goods in export markets. It is planned to carry out external verifcation of the carbon footprint assessment methodology and further extension to other enterprises. One of the most important aspects of inventory analysis in LCA researches is accurate and consistent modeling of the waste and recycled materials and also the distribution of the environmental burdens and credits between the consumers and producers. Contemporary researches suggest an approach that has been developed through a dedicated consensus process for this specifc purpose: the circular footprint formula (CFF). All waste fows formed during the production, distribution, use, and end-oflife stages as well as all the recycled or recyclable materials entering or leaving the system (i.e., the recycled materials used at the stage of production and recycling of the materials obtained at the end of the product's life) were modelled according to this formula. The CFF formula consists of three parts: formulas for material, energy, and usage. Integration of its results gives the total number of emissions and resources present in the system's inventory as a result of the recycling, application, and energy recovery processes. The material part of the formula applies to all stages of the value creation chain, where the recycled materials replace the initial raw material. In 2020 Saudi Arabia introduced the concept of a "circular carbon economy" (CCE) using the country as an example. The CCE is based on the idea of a circular economy, but instead of material fows it focuses on energy and carbon dioxide or greenhouse gas emissions in general. Proponents of the concept emphasize that the CCE concept focuses deliberately on a wide range of policy areas but at the same time emphasizes particularly the potential of capture, utilization, and storage (CCUS) of carbon and hydrogen, which are regarded as increasingly relevant for countries that use fossil fuels as they help decarbonize their economies. The scaling up of CCE solutions and technologies across organizations and industries requires the involvement of various factors at the organizational and industrial levels. Such factors include (KAPSARC): – investments in new technologies and energy sources, including research and development (R&D) and implementation; – collaboration between governments, businesses, and scientifc circles to conduct R&D and pilot projects; – information and ideas exhange to support the necessary changes; – demonstration of how the CCE approach can unlock cost-effective emission reductions through practical application; – creation of measurement and accounting systems to track progress. The CCE concept is aimed at reducing the consumption of resources while maintaining the output volume of the goods and services; it involves reuse and recycling as well as recycling of what cannot be reused. The main principles of this approach are the "four Rs": reduce, reuse, recycle, remove. In terms of this concept most of the decarbonization methods belong to the reduce section since they only focus on reducing the emissions of CO_2 . There are very few technologies that combine multiple approaches, such as reuse of CO2 , recycling of CO_2 , and removal of CO_2, that can be applied to the oil and gas sector. Solutions where the three Rs are being developed in related felds such as the chemical industry, the production of synthetic fuel, construction and materials production, and environmental management. Although the share of bioplastics currently produced is quite small – almost 1% compared to petrochemical-based plastics, it is bound to increase signifcantly in the near future due to of strong legislation recently passed by the European Union and other governments – such as the EU Framework Program Circular Economy Monitoring (European Commission), which aims to measure the progress and assess the effectiveness of actions toward a circular economy in the EU and its member states. The program consists of ten indicators that cover four subject areas: production and demand, waste control, secondary raw material, and also competitiveness and innovation. Plastics are the least recycled materials in industry and account for about 9% of the world's total, compared with 85% for steel, 75% for aluminum, 60% for paper, and 50% for glass (Figure 1). At present Russia produces 70-80 million tons of municipal solid waste (MSW) every year, but only 6–7% goes to recycling. Of the total volume of solid waste in large cities plastics only account for about 10%.

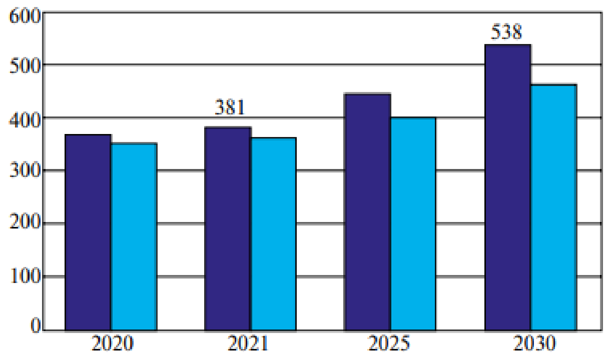

Fig. 1. The volume (■) and growth rate of global polymer waste generation and polymer production (■) in 2020-2030, million tons

The largest volume of plastic waste is produced in the packaging industry. The observed increase in the volume of polymer waste collected is due to increased public awareness and to measures that the state is taking to improve waste collection and create a recycling infrastructure. It is expected that the volume of polymers collected and processed will increase in the future as a result of the adoption state actions to reduce the allowance of plastic waste into the environment, increase of the processing capacity, and the development of the secondary raw materials applications. Russia still lags critically behind developed countries in terms of the collection and recycling of plastic waste: waste collection level of the most common source of polymer recyclables – PET bottles – is still around 20%. On average the collection of plastics from waste does not exceed 10%. However, there have been clear positive trends in the last few years. First, the level of collection is increasing. Second, the system for collecting and sorting plastic waste is changing: whereas more than 75% of waste for recycling in 2012 was the result of "manual labor" (low productivity and ineffective), in 2016 more than half of the raw materials were delivered by waste sorting plants. The proportion of industrial waste sent for recycling has also increased (primarily due to the development of the manufacturers' own processing capacities but also due to increasing cooperation with independent recyclers). Separate collection, which is the main source of the raw materials in developed countries and can signifcantly improve the economics of the business, has so far had virtually no effect on the market in Russia. It is mainly homogeneous industrial waste that is recycled. At present a number of projects are being proposed to improve the situation in this market. Concerning pricing in the secondary polymers market is possible to visualise a chain of typical added value according to the processing levels. The price of the waste materials and of the products after treatment varies markedly depending on the quality of the feedstock, its type or brand composition, and the degree of processing. In particular, clean and homogeneous wastes are the most valuable. For example, polyethylene landfll waste is approximately 1.5 times cheaper than the industrial materials and differs signifcantly in price depending on the brand. If we are talking about polyethylene terephthalate (PET), then the colorless/ blue PET is in greatest demand due to its versatility, and its price is higher compared with the dark, blue, and green fractions. Mixed fractions are the least valuable. From the standpoint of the level of processing: granules are more expensive than fakes or crushed grains (due to less issues with caking, transportation, feeding into an extruder, etc.). Cost analysis shows that the cost of 1 kg of waste at landfll is 3-6 times lower than the cost of recyclable materials and 7-10 times lower than the cost of the primary raw materials. A slightly smaller difference in cost is typical of polypropylene, polystyrene, ABS plastic, and polyvinyl chloride (PVC). As for PET, the landfll price differs from the price of the recycled materials by only 2-3 times, which is explained by a special feature of the processing process for this polymer: the recycled material consists of fakes obtained by grinding. The produced recyclable materials are most often processed directly – in house or put out for sale. If the line has equipment for the fnal extrusion stage it is possible to produce plastic products from 100% recycled materials. However, such production is not always feasible economically since it is necessary constantly to to take care of the sale of such products that have additional limitations on their use. One of the services being developed on the market is third-party processing of polymer waste: the recycling company receives the waste and, after recycling, returns it to the original owner. Essentially, the owner of the waste pays for its processing, and the cost of the service is 8-10 rubles/kg. In terms of recycling the volume of recycled plastic exceeded 6 million tons. The recycling rate is less than 50%. About 92% of the polymer waste is practically non-hazardous (hazard class V).

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