CURRENT STATE OF USE OF THE CONCEPT OF CIRCULAR ECONOMY IN THE AUTOMOTIVE INDUSTRY IN SLOVAKIA

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PRELIMINARY COMMUNICATION

ISSN 2637-2150
e-ISSN 2637-2614
UDK 662.75/.76:621.43(437)
DOI 10.7251/STED2102083P

Paper received: 22.08.2021.
Paper accepted: 16.11.2021.
Published: 29.11.2021.
http://stedj-univerzitetpim.com

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ABSTRACT

We understand circular economy as an economic system that aims to eliminate waste throughout an entire value chain – including manufacturing, production and use. Circular economy is also a way of rethinking our approach to waste and to every single stage of a products´ life cycle. Slovakia has been challenged recently to keep up with the changes the automotive industry is undergoing, including the green and digital transformation. The automotive industry producers have to accelerate innovations based on the required transition towards circular economy, an alternative to the unsustainable linear model of economy. The paper focuses on the principles of circular economy, demonstrated by the example of the Slovak automotive industry. The aim of this paper is to evaluate the current state of use of circular economy aspects in the automotive industry in Slovakia. We found out practical approaches of circular economy incorporated by Slovak automotive producers. In context of circular economy, Slovakia perceives prospective transition to automotive electrics industry, the introduction of new progressive technologies and sophisticated production.

Keywords: circular economy, automotive industry, value chain, green transformation.

INTRODUCTION

For cities and regions, the circular economy represents an opportunity to rethink production and consumption models, services and infrastructure. The circular economy (CE) is based on three following principles: i) design out waste and pollution; ii) keep products and materials in use; and iii) regenerate natural systems (MacArthur, 2019).

Although there are many conceptions of the circular economy, they all describe a new way of creating value, and ultimately prosperity, through extending product lifespan and relocating waste from the end of the supply chain to the beginning – in effect, using resources more efficiently by using them more than once (United Nations Industrial Development Organization [UNIDO], 2021).

By and large, today's manufacturing takes raw materials from the environment and turns them into new products, which are then disposed into the environment after

use. It's a linear process with a beginning and an end. In this system, limited raw materials eventually run out. Waste accumulates, either incurring expenses related to disposal or else polluting. In a circular economy, however, products are designed for durability, reuse and recyclability, and materials for new products come from old products (Figure 1). As much as possible, everything is reused, remanufactured, recycled back into a raw material, used as a source of energy, or as a last resort, disposed of (UNIDO, 2021).

According to Stephan Sicars, Director of UNIDO's Department of Environment: "A circular economy creates economic benefits through systemic innovations by designing to avoid waste later; keeping products and materials in use as long as possible; and using renewable energy, while regenerating natural capital. It foresees a transformation from consuming to safeguarding the finite resources of the Earth, as we continue to create jobs and income through inclusive and sustainable industrialization." (UNIDO, 2017).

Figure 1. Circular economy (UNIDO, 2021).

Circular economy aims to maintain the value of products, materials and resources for as long as possible by returning them into the product cycle at the end of their use, while minimizing the generation of waste. The fewer products are discarded, the less materials are extracted, the better for the environment.

This process starts at the very beginning of a product's lifecycle: smart product design and production processes can help save resources, avoid inefficient waste management and create new business opportunities (European Commission [EC], 2020).

For citizens, the circular economy will provide high-quality, functional and safe products, which are efficient and affordable, last longer and are designed for reuse, repair, and high-quality recycling. A whole new range of sustainable services, product-as-service models and digital solutions will bring about a better quality of life, innovative jobs and upgraded knowledge and skills (EC, 2020).

MATERIALS AND METHODS OF WORK

Looking on research dimensions of a circular economy, authors from different

disciplines view circular economy differently. In rare cases, the focus on circular economy was mono-dimensional, whereas we often found a link to the three pillars of sustainability: economy, environment, and society. Building on the literature, we however believe that at least three more defining elements are missing from the triple bottom line view: the role of governments, the role of matter (e.g. design, technology, and materials), and the role of individuals (i.e. behavioural) (Pomponi, & Moncaster, 2017).

There is a need to define which design features are most desirable for a circular economy; as these may vary by individual product. Bovea, Ibáñez-Forés, Pérez-Belis, & Quemades-Beltrán, (2018) have developed a methodology to guide designers on the most important circular-economy design features for specific types of products.

The method gives designers 33 possible circular-economy design guidelines to work with. The researchers identified these by analysing existing research on eco-design principles, and then categorising guidelines into five groups:

- Extending lifespan. These promote longer life and durability of products through adaptability, upgradeability, and 'timelessness'. These guidelines could be met by using features such as modular design and standardised components.
- Disassembling. These relate to connection and enabling easy access to parts.
- Product re-use. These promote easy maintenance and cleaning of products and their parts to encourage re-use.
- Component re-use. These suggest design features such as standardised parts and minimal variation in product design.
- Material recycling. These promote features that enable materials to be easily identified, separated, and recycled, such as labels or avoiding complex mixtures of materials (EC, 2019).

In our paper we are providing initial mapping of circular economy perception in Slovak automotive industry. The aim of this paper is to evaluate the current state of use of circular economy aspects in the automotive industry in Slovakia.

Ways the automotive industry can benefit from the circular economy and innovations that can be triggered within the automotive supply chain in this respect are the focus of this paper.

Our data are carried out from annual reports of main Slovak automotive producers (Volkswagen Slovakia, PSA Group - Peugeot Citroen Slovakia, KIA Motors Slovakia, Jaguar Land Rover), as well as other industries across value chain (textile, plastics, etc.).

Other data are coming from Ministry of Environment of the Slovak Republic (MESR), Slovak Investment and Trade Development Agency (SARIO); Institute of Circular Economy (INCIEN), 2018; Chambers of Commerce in Slovakia active in the area of circular economy (AmCham, 2021), Automotive Industry Association of the Slovak Republic (AIASR, 2021), etc.

RESULTS AND DISCUSSION

The Circular Economy in Automotive Industry

The auto industry has driven technological and manufacturing revolutions. With the shift to electric vehicles and the circular economy, automakers are poised to once again create a template for the global economy. Transitioning away from the 'linear economy' means systems-wide changes, including decarbonizing production and designing products for recyclability at 'end of life'. For the automotive industry, it means achieving transformation at the scale of Henry Ford's legendary assembly line, or Toyota's famous 'Just in Time' production system, one that timed manufacturing to dealer orders to minimize parts inventory (World Economic Forum [WEF], 2020).

The automotive industry does not only contribute to the circular economy by remanufacturing components or reducing waste, but also by prolonging the service life of the vehicles it produces. Manufactures believe that they have a responsibility to their customers to support the longevity of vehicles by ensuring that they can be serviced, repaired and maintained. Extending the lifetime of a vehicle is essential to reducing costs for consumers, as well as conserving natural resources and energy. Besides industry-led initiatives, automobile manufacturers also have to adhere to a wide range of existing legislation promoting sustainable production, more efficient vehicles and their proper dismantling. The End-of-Life Vehicles Directive, for example, already sets a target of 95% recyclability per vehicle per year. As a result of economic incentives, as well as existing legislation, the automotive industry has made the circular economy an integral part of its DNA (European Automobile Manufacturers' Association [ACEA], 2018).

Automotive manufacturers have already set ambitious targets towards carbon neutrality in the next three decades and aligned their business strategies with an ever-accelerating push for electrifying the product portfolio. As we move towards a tipping point for electric vehicle adoption, it becomes clear that it will take more than getting rid of the combustion engine to get the job done: leveraging circular economy strategies for transforming the product, as well as the way it is used, will be the second piece of the puzzle towards net zero. To kick-start the transformation, a common language is needed along the value chain to guide a gauge progress. Thus, Accenture and the World Economic Forum are proposing a five-level taxonomy towards a circular car (Figure 2).

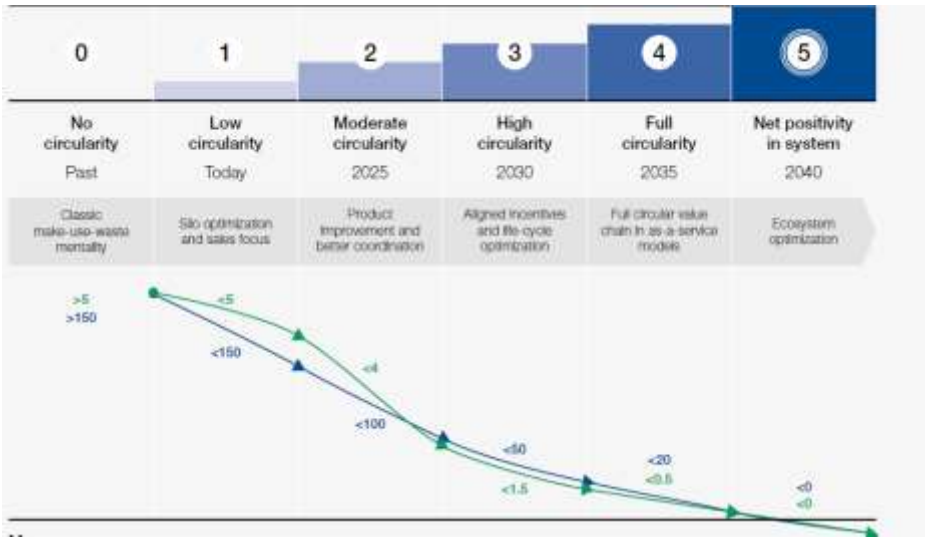

Figure 2. 5 Levels of automotive circularity (Accenture, 2021).

To be sure, a circular future is not guaranteed for the automobile industry. It depends on the rise of three simultaneous trends: high vehicle utilization models (such as ride hailing, car sharing, and mobility-as-a-service – MaaS); the conversion of the distribution and maintenance network into collection, re-manufacturing and recycling centres; and the adoption of modular designs and low carbon circular materials during vehicle design (WEF, 2020).

Overview of the Automotive Industry in Slovakia

The impact of the automotive industry on the Slovak economy has been substantial, helping boost growth in output, exports, and employment. The emergence of domestic car suppliers that have also begun supplying companies in the neighbouring countries (Czech Republic, Hungary, and Poland) has been a welcome second-round effect, as has been the impact of stronger productivity growth than the average for the economy. Further, providing the education needed for the labour force of the 21st century, and creating the right incentives for more robust research and development activity, are becoming key priorities for the government and will have a positive effect on the broader economy in the years to come (Jakubiak, Kolesar, Izvorski, & Kurekova, 2008).

The automotive industry became the most important sector and driving force of the Slovak economy, with 50% share on total industrial production and 13% share on the GDP of Slovakia (Slovak Investment and Trade Development Agency [SARIO], 2021). Over the past 20 years it has been also an important source of foreign direct investment as well as industrial innovation.

The production of cars increased very rapidly at the beginning of 21st century. The development of automotive industry in Slovakia started with the entrance of Volkswagen in 1991. In this period, the production of cars was lower than 300.000 cars per year while it was characterized by underdeveloped network of subcontractors and suppliers. In 2006, two new automotive companies established their plants in Slovakia, KIA and PSA Group, and the number of employees in supplying industries and number of subcontractors started to rise. From 2012 on, these three car producers produce more than 900.000 cars per year in Slovakia (Luptáčik, Habrman, Lábaj, & Rehák, 2013). Looking on the development of car production in Slovakia during period 2005 – 2020 (Figure 3), we have observed gradual increase since 2005.

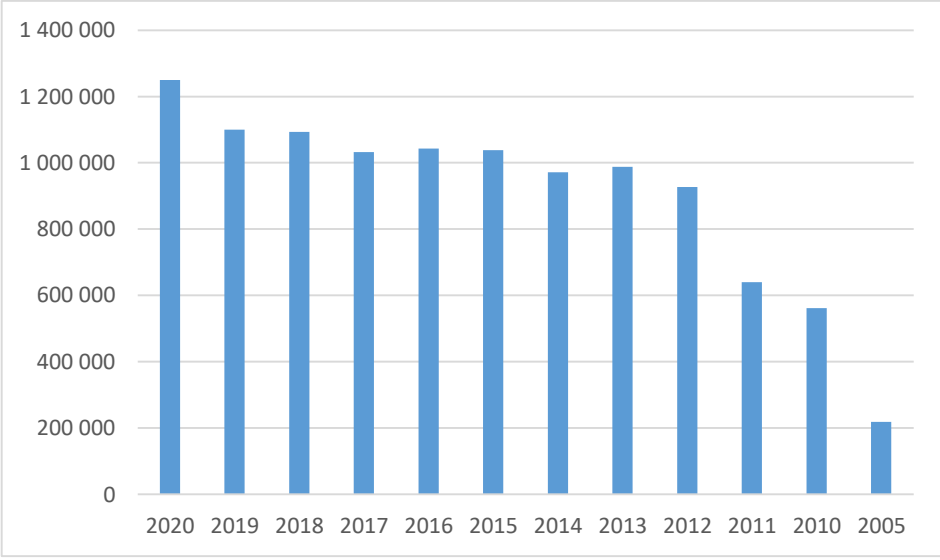

Figure 3. Car production in Slovakia (SARIO, 2021).

Slovakia belongs to the key players of the global automotive industry. Already 9 global brands are producing their flagship models in Slovakia. Its position will be further strengthened by the facility of Jaguar Land Rover (SARIO, 2021).

According to revised data from Automotive Industry Association of the

Slovak Republic (AIASR), in 2020, 990.598 cars were produced in Slovakia, which was 10,6% less year-on-year, in 2019 it was almost 1,08 million cars. The number of cars produced in 2020 was affected by the pandemic of the coronavirus. In 2021, more than 1 million cars should be produced in Slovakia (TREND Slovakia, 2021).

When recalculated to the number of inhabitants, we can see that Slovakia remains the leader in the number of manufactured passenger cars per 1.000 inhabitants among the EU countries. While in Slovakia almost 173 passenger cars per 1.000 people were produced, in Czech Republic, ranked second, it was 105 (Slovenská sporiteľňa, 2021).

Due to high and steadily increasing productivity in the Slovak automotive sector, the production in this industry is not categorized as low cost anymore. Nevertheless, it remains cost–competitive on a regional as well as European level. The Slovak labour force is known for its flexibility, excellent qualification and high productivity (SARIO, 2021).

Car Producers in Slovakia

In medium term all main Slovak automotive producers have suitable product portfolio, as Volkswagen Slovakia belongs to the most innovative in frame of the whole Volkswagen Group, PSA in Trnava is focused on growing segment of smaller cars and electric vehicles (EV) and KIA in Žilina is the single manufacturer of KIA in Europe and Land Rover in Nitra as the newest manufacturing facility has an advantageous position thanks to the new model.

Volkswagen Slovakia

Volkswagen Slovakia (VWSK) seated in Bratislava was established in 1991. VWSK continued in a successful course, in 2015 produced 397.458 cars, in 2018 already 408.208 (VWSK, 2018), in 2019 with 14.000 employees has produced 400.000 cars (Hospodárske noviny Daily, 2020).

Year 2018 was marked by the achievement and evaluation of the environmental protection strategy Think Blue. Factory. Think Blue. Factory is a strategy for the sustainable production of automobiles and components. VWSK uses resources more efficiently through the implementation of organizational measures and projects employing the latest equipment and technologies. At the same time, it relies on permanent product quality, the use of state- of-the-art technology and, last but not least, qualified and committed employees. The company measures the reduction of environmental impact through the Think Blue. Factory strategy by means of five basic indicators: energy and water consumption, waste production, and emissions of CO_2 and volatile organic compounds (VOCs). The strategy Think Blue. Factory does not end with the achieved goals. It will continue with new challenges to year 2025, where the goal is to reduce this burden by up to 45% per vehicle produced compared to 2010. In Volkswagen Slovakia, environmental protection is an essential element that is transmitted over the entire production spectrum. An ecological approach is the mainstay of processes and decisions, which are constantly looking for ways to reduce the environmental burden. Sustainability and continuity are essential attributes for meeting the set goals, with employees actively contributing as well. They continually participate in saving natural resources and energy. To be a permanently ecologically sustainable company is the primary goal at the end of the road to Think Blue. Factory. In this respect, VWSK systematically and in keeping with the latest scientific knowledge, is modifying existing operations and building new ones (VWSK, 2018). We can see the comparison of setting goals in Table 1.

Head of Environmental Department, VWSK Ms. Ploszeková, has presented three main production challenges of electrification: The first was the question of the new body, which needs to be more lightweight, given the CO_2 emissions regulations. At VWSK, this means shifting

from steel to aluminium – which is lighter – and glued rather than welded bodies. The second challenge is how to dispose of the battery. This is particularly the case of lithium-ion batteries, which create new types of waste.

Finally, regulations pose a challenge, as they are often contradictory, and simply create a feedback loop. VWSK is committed to cover the entire life cycle of a vehicle, and added that by 2025, the company aims to reduce the environmental burden by 45% per vehicle, compared with 2010 (Ministry of Environment of the Slovak Republic [MESR], 2017).

Table 1. The goal by 2018 to reduce the environmental burden on the vehicle produced by 25% compared to 2010 (VWSK, 2018).

Indicator	Amount per vehicle	2010	2018
Energy	kWh/vehicle	3 080	1490,26
Water	m^3/vehicle	5,97	2,63
CO_2	t/vehicle	0,68	0,15
VOC	kg/vehicle	3,71	2,07
Waste sent to dups	kg/vehicle	27,33	2,63

PSA Group Slovakia

PSA Group Slovakia was established in Trnava in 2006, when started mass production. With 3.500 employees has produced 370.000 cars in 2019 (Hospodárske noviny Daily, 2020), in 2020 with 4.400 employees has produced 338.050 (PSAG, 2021).

PSA Group in Trnava is focused on the growing segment of smaller vehicles, including e-cars. Groupe PSA Slovakia is leader in production of small vehicles of segment B-mainstream, so-called platform 1. Actually, the product portfolio is represented by models Citroën C3 a Peugeot 208 (PSAG, 2021).

KIA Slovakia

Kia Slovakia in Žilina was established in 2006 and started mass production. With 3.800 employees has produced 370.000 cars in 2019 (Hospodárske noviny Daily, 2020).

New strategy of Kia reacted and formed a change with the expected development products and services that meet the needs of customers all over the world. This will give a better approach to a wider range of environmentally friendly products, to meet the growing demand from customers around the world. In addition to this effort at the same time, Kia will support sustainable production through the use of clean energy and recyclable materials (Kia Motors Slovakia [KMS], 2018).

Kia and SK Innovation knuckle down to achieve a circular economy principle in production of electric vehicle (EV) batteries. This aims to attain the virtuous cycle of the materials of high-voltage batteries for EV and reduce CO_2 through reuse or recycling batteries after use. Kia and SK Innovation announced on the April 29, 2021 that they had secured the possibility of building an industrial ecosystem that enables eco-friendly handling of EV batteries and technological basis thereof by re-collecting metals such as lithium from used batteries (SK innovation News Channel, 2021).

Jaguar Land Rover

Jaguar Land Rover in Nitra was established in 2018, with 2.800 employees has produced 150.000 cars in 2019 (Hospodárske noviny Daily, 2020). It is first Industry 4.0 manufacturing plant of the group in continental Europe (Land Rover, 2018).

The plant is equipped with state-of-the-art technologies and is the first in Europe to use the Kuka brand pulse transport system, which offers 30% faster

transport time than conventional conveyor systems. It will also include a highly automated painting process, which guarantees the highest quality and minimal impact on the environment. From an established network of suppliers nearby, Jaguar Land Rover acquired several components, such as seats and wheels, which supported the production of the Land Rover Discovery in Nitra and created several thousand additional jobs within the automotive supply chain in Slovakia (Land Rover, 2018).

In the following part we would like to discuss examples of best practices how Slovak automotive companies and companies across value chain are adopting circular economy methods.

Examples of best practices of circular economy in Slovak automotive industry and supply industry

One indicator of a favourable development in the area of circular economy in Slovakia is growing environmental awareness in private sector and the consequent willingness to accept relevant measures. However, companies are becoming increasingly aware that environmental protection and economic growth they are not mutually exclusive, so they try to reduce themselves its negative impact on the environment (ACEA, 2018).

Volkswagen Slovakia

The Volkswagen Group is bundling all its measures in environmental protection under the new "goTOzero" environmental mission statement. In its "goTOzero" mission statement, the Volkswagen Group concentrates on four main fields of action:

- Climate change: Volkswagen is committed to complying with the United Nations' Paris climate protection agreement. The goal is to become a balance-sheet CO_2 neutral company by 2050. By 2025, the company plans to reduce its total life cycle Greenhouse Gas Emissions of passenger cars and light duty vehicles by 30% compared to 2015. The company actively contributes to the transition towards renewable energies along the entire life cycle.
- Resources: Volkswagen intends to maximize resource efficiency and promote circular economy approaches in the areas of materials, energy and water. By 2025, the company plans to have reduced the production related environmental externalities (CO_2, energy, water, waste, volatile organic compounds) by 45% per vehicle compared to 2010.
- Air quality: Volkswagen is driving e-mobility forward to improve the local air quality. By 2025, the share of battery electric vehicles in the Group's model portfolio will be between 20 and 25%. The share of electric vehicles in the Group fleet is to rise to at least 40% by 2030.
- Environmental compliance: In terms of integrity, Volkswagen aims to set an example for a modern, transparent and successful company by installing and monitoring effective management systems that cover the environmental impact of its mobility solutions across all life cycle phases (Volkswagen, 2019).

PSA Slovakia

The main aims for PSA Slovakia in the area of circular economy are as follows: (1) Waste treatment at the plant; (2) Reducing the amount of waste and slowing down the emergence of new; (3) Waste disposal; (4) Increasing of environmental awareness of employees and external companies; (5) Communication with departments (PSAG, 2018).

By waste sorting at source – with introducing of operational audits after Operations Company has reached improvement in sorting, in 2018 the sorting success was 96%. By decreasing the amount of waste and preventing the emergence of a new one – the produced waste was decreased on 14,7 kg per car; priority has the material and energy recovery – 91% of whole waste produced in the company was material and energy

elaborated. PSA is increasing environmental awareness of employees – with system of education and training and by environmental cooperation with external companies, as well as by intensive cooperation with service suppliers in the area of waste treatment and by exchange of experiences with French manufacturers inside the PSA Groupe (PSAG, 2018).

PSA Slovakia is taking circular economy and sustainability seriously. Mr. Peter Švec, Head of External Relations, PSA Groupe Slovakia noted that PSA is firmly committed to sustainability and is the European automotive industry leader in reducing CO_2 emissions. Already 42% of PSA cars sold in Europe emitted less than 100 grams per kilometre of CO_2 in 2016, considerably less than the market average. PSA has ambitious goals for materials, waste materials, hybrid and electric vehicles, mobility services and autonomous cars too (MESR, 2018).

KIA Slovakia

Kia Motors and SK Innovation join forces to achieve a certain level of circular economy of electric vehicle (EV) batteries. This aims to attain the virtuous cycle of the materials of high-voltage batteries for EV and reduce CO_2 through reuse or recycling of batteries after use. Kia Motors and SK Innovation announced on the April 29, 2021 that they had secured the possibility of building an industrial ecosystem that enables eco-friendly handling of EV batteries and technological basis thereof by re-collecting metals such as lithium from used batteries (KMS, 2018). As part of the endeavour to reinforce their ESG management, the two companies signed a memorandum of understanding to establish an industrial ecosystem for electric vehicle batteries in March 2020. They have conducted empirical testing of the used battery recycling and subsequently evaluated the possibility of collecting metal within the battery, its effects and efficiency, etc. Under the umbrella of Hyundai Motor Group, Kia Motors evaluates used batteries with a battery performance testing system and reuses those that exhibit good residual battery performance as energy storage systems (ESS) by classifying them into modules or packs. If the residual performance is low, the battery will be decomposed into cell units and the metal is recovered through recycling. After use, the battery contains a lithium electrolyte inside, so it requires a technology that is more difficult than recovering lithium from waste cathode material generated during battery manufacturing. SK Innovation uses its own technology to recover metal resources such as lithium hydroxide, nickel, and cobalt from the battery after use, and then re-use it to manufacture the cathode material (*) for batteries (Battery Industry, 2021).

PR Krajné

PR Krajné, LTD. was established in 2006 with the aim to re-use mixed synthetic textile waste particularly from the automotive industry. Thanks to developing a unique technology, Stered, a comprehensive technological line was assembled, first of its kind not only in EU countries, which is processing the textile material and use it in the production of new products. In PR Krajné, they were looking for an answer to where the border is between real waste and waste as source of secondary raw material. The aim was to turn textile waste into material for new products. Technical textile in a car meets demanding needs of the automotive industry and its life highly exceeds the life of the car itself. When used in a car it is 10 years on average. Company has focused on a production process in which they transferred as many specific features required by car manufacturers as possible into new product. The period 2007 – 2009 was focused on research and development and production of the product as well as its marketing. A comprehensive processing line is a result of research, development and production of Slovak authors and production companies and it is able to process technological waste from primary production of 1.000.000 new cars or separated waste from 100.000 vehicles after the end of their life. Input waste is supplied by authorized processors of vehicles after

the end of their operating life and producers of individual textile parts. A prudent approach to the environment is also proved by the fact that company is revitalized and unused production area for the purpose of construction Mechanical processing with low energy intensity during production of STERED boards is typical for the technological line. Eventually, the technological process has been designed so that not more than 5% of additional waste is generated from processing waste – a raw material (MESR, 2016).

ELEKTRO RECYCLING

The company deals with processing of plastics originating from discarded electrical equipment, technological waste and plastics from the automotive industry. The product is crumbs or granules made of the named plastics. Company is equipment for plastics processing, which is divided into 3 parts: 1. crushing, material preparation and cleaning of material from non-plastic admixtures, 2. washing and sorting of individual types of polymers, 3. homogenization crushes before extrusion, extrusion and homogenization of output material. Output quality, but also inputs are regularly tested in a modern laboratory. Products are crumbs or granules. Typical examples are plastics from refrigerators or televisions, crushed or moulded, as well as technological wastes from the production of new electrical equipment and the automotive industry.

More sustainable plastic production methods and better management of plastic waste – in particular higher recycling rates – offer significant potential for improving resource efficiency. At the same time, they help reduce raw material imports as well as greenhouse gas emissions (Zelené hospodárstvo, 2021).

CONCLUSIONS

Over the past 20 years the automotive industry in Slovakia became the most important sector and driving force of the Slovak economy. It has been also an important source of foreign direct investment as well as industrial innovation.

The paper develops the concept of circular economy and shows that circular economy principles are very relevant to automotive industry in Slovakia, with different roles in value chains, including manufacturing.

In case of the current state of use of circular economy aspects in the automotive industry in Slovakia, our initial findings are as follows: (1) In the area of the circular economy in Slovakia we have observed growing environmental awareness in private sector and the consequent willingness to accept relevant measures. The perception of the circular economy between Slovak automotive producers has increased with necessary transition to sustainable economy; (2) In case of practical approaches of circular economy incorporated by Slovak automotive producers, we have selected examples of main automotive producers (Volkswagen Slovakia, PSA Slovakia, KIA Slovakia), as well as companies across value chain (PR Krajné and ELEKTRO RECYCLING). VWSK is committed to cover the entire life cycle of a vehicle, and added that by 2025, the company aims to reduce the environmental burden by 45% per vehicle, compared with 2010. Kia Motors join forces to achieve a circular economy of electric vehicle (EV) batteries and reduce CO_2 through reuse or recycling of batteries after use. Also, PSA Slovakia is taking circular economy and sustainability seriously, the main aims in the area of circular economy are: waste treatment at the plant, reducing the amount of waste, waste disposal and increasing of environmental awareness of employees. The circular economy is perceived not only by main automotive producers in Slovakia, but also by small and medium enterprises that have developed innovative products or offer innovative solutions based on circular economy principles. Companies across value chain, have developed a unique and innovative technologies, as for processing the textile material and use it in the production of new products (PR Krajné), as

well have processed of plastics originating from discarded electrical equipment, technological waste and plastics from the automotive industry (ELEKTRO RECYCLING).

In context of circular economy, we found out, Slovakia perceives prospective transition to automotive electrics industry, the introduction of new ones progressive technologies and sophisticated production.

ACKNOWLEDGEMENTS

This paper was elaborated within project DRIVEN in frame of Erasmus+ Programme.

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