PRODUCT LIFECYCLE MANAGEMENT IN THE CONDITIONS OF THE CIRCULAR ECONOMY

[1]Vladimír BARTOŠEK, [2]Marie JUROVÁ

Brno University of Technology, Faculty of Business and Management, Brno, Czech Republic, EU
[1]bartosek@fbm.vutbr.cz, [2]jurova@fbm.vutbr.cz

Abstract

Automotive industry, more specifically manufacture of motor vehicles, trailers and semi-trailers (CZ-NACE 29), is one of the most important sectors of the manufacturing industry both in the European Union and the Czech Republic. In 2014, the total waste generated in the EU-28 by all economic activities and households amounted to 2,503 million tons [1]; 21 % of the annual industrial waste production can be attributed to the manufacturing industry. The article focuses on the proposal for methodology of product lifecycle management based on the principle of logistics management in the contemporary context of the circular economy concept. Analysing documents, the objective is to describe and evaluate logistics spiral of the product lifecycle in such a way that general methodology of precycling will be formulated in the stage of research and development, manufacturing consumption/use (application of preventive approaches and measures enabling and facilitating waste recycling) in the selected part of the manufacturing industry CZ-NACE 29. Application of the general methodology should be in the entire logistics chain, i.e., in all levels of supply chain simultaneously, in all strategies of companies so as to achieve both new forms of business activities and competitive advantage of the entire network organization and, consequently, every company. Meaning of drafted methodological framework is to define an optimal recycling rate from the point of sustainable development, material flow closing and waste recycling optimization. Thus, qualities of sustainability (sustainable supply chain management) and environment (green supply chain management) from the management of the logistics networks integrate into the global society conditions of circular economy.

Keywords: Process management, product, precycling, recycling, Product Lifecycle Management (PLM), circular economy

1. INTRODUCTION

Globalization of industries and markets is a recent trend observed over the past few years. A global organization differs from other organizations not only by its effort to create a larger market for its products, but also by its attempt to purchase materials and components anywhere abroad and manufacture products overseas at the lowest possible cost [2]. The objective, formulated by the global company, is crystal clear: to drive its economic growth through market expansion and, at the same time, reduce costs by savings from volume of production in the area of supply as well as production and rationalization of research and development processes, production processes, processes in the use of the product as well as in the area of reverse flows, which is represented by recycling and waste management [3].

It is evident that these organizations must control far more complex network of material, product, and information flows. Logistics is becoming a cornerstone of global organizations allowing for integration and control over all flows among the supplier, producer, distributor, customer, and the last link of product lifecycle logistics, i.e., waste disposal [4].

In consequence of joint international effort of the UN (such as [5]) or the European Union (such as [6]), logistics, or today rather supply chain management, defines new requirements to accomplish objectives of sustainable development - so called “sustainable supply chain management” (e.g., [7]).

Until recently, the end-customer was the last element in the logistics chain. However, the consumer consumes the product only partially. Packaging and residues of organic and inorganic matters are left, ending their life in

the container (optimistic scenario), and then in landfill sites or waste incineration plants. In any case, humankind misses out on valuable energy resources and irretrievable raw materials. I.e., the need for another method of waste management concept arises, which would ensure its retransformation into raw source commodities using released energy. Therefore, steps towards recycling have been taken, not only in compliance with the Regulation (EC) No. 2150/2002 of the European Parliament and of the Council of 25 November 2002 [8], Decision No. 1386/2013/EU of the European Parliament and of the Council of 20 November 2013 on a General Union Environment Action Programme to 2020 [9].

In harmony with Directive 2008/98/EC of the European Parliament and of the Council, article 4 (1), recycling can be recognized in the waste management hierarchy as the reverse flow channel of distribution - reverse logistics that provides reverse flow of worn-out, dysfunctional or devaluated products, i.e., waste management reverse flow, applying the above mentioned principles, focusing on the product lifecycle [10]. The creator of recycling channel is usually one of the subjects involved in the distribution chain, specialized company or consumers [11].

Recycling achieves several levels and is still evolving. The most advanced strategy so far is manufacture of products with already integrated recyclable components, developed already in the stage of new product development and job engineering.

The article focuses on the automotive industry sector, reaching in macroeconomic values (2017) according to the VDA [12] revenues EUR 334,361 MM. Export of cars to countries outside the EU peaked at EUR 132 bn, with dominant representation (55 %) of German producers. According to the Automotive Industry Association [13], annual car production in the Czech Republic increased by 5.2 % (totally 1,446,543) in 2017 with 9 % share in GDP of the Czech Republic. Since 1.1.2015, Directive 2000/53/EC of the European Parliament and of the Council of 18 September 2000 on End-of-Life-Vehicle (ELV Directive) article 7 (2b) sets out minimum quantified targets for reuse and recovery of vehicles and their components to 95 % by an average weight per vehicle and year [14]. Cars are disassembled for wear and tear or expiration of their life-service; individual components are used to produce new types of vehicles or completely another product [15].

2. METHOD OF SOLUTION, METHODOLOGY APPROACH

2.1. Method of solution

One of the priorities of the European Union and the European Committee for the future of Europe is the environment (for instance, the 7th Environment Action Programme), joint energy policy and measures eliminating climate changes. In 2015, the European Commission approved an action plan entitled “Closing the loop - an EU action plan for the Circular Economy”, defining production (including design and production steps), consumption and waste treatment process as the base for the so-called circular economy. According to the Eurostat [16] (see **Figure 1**), the initial level of recycling in the EU rather varies in the individual member countries.

Based on the quality loop and application of cleaner production principles and life-cycle assessment (LCA, eco-design), precycling methodology demands analysis of basic logistics processes of research and development, production and consumption of the existing products (product modification) as well new products (product development). Hampering and acceleration factors, affecting/facilitating subsequent waste recycling may be identified and quantified in each logistics process; subsequently, a portfolio of general measures (recommendations) may be introduced to eliminate hampering factors and support acceleration factors of recycling.

The result of permanent application of this methodology is the win-win-win project in the areas:

- cost-reduction in manufacturing by cut in the consumption of material;
- reduction in environmental impact in manufacturing and consumption;

- more possibilities of product recycling after the end of its service-life (waste).

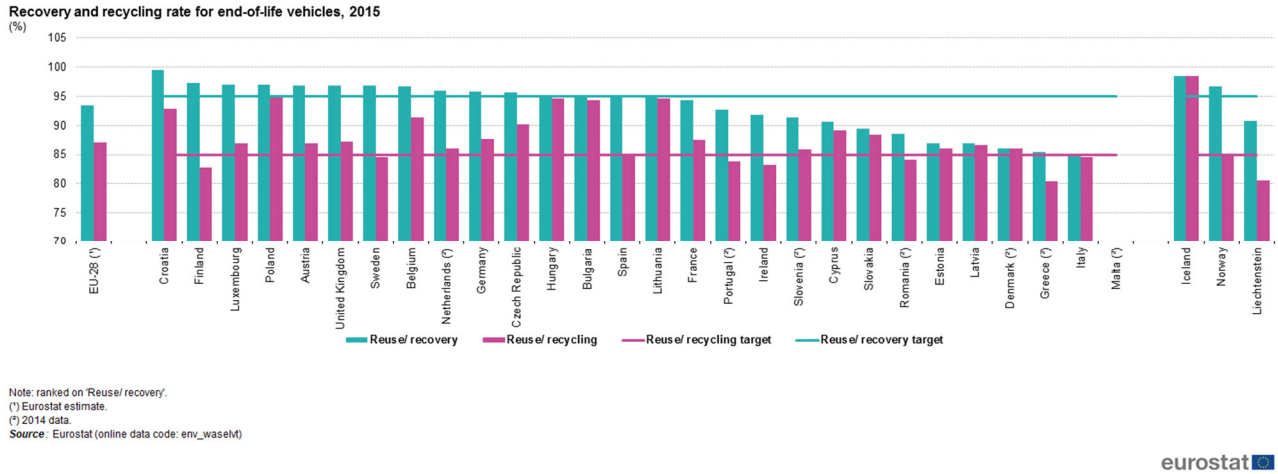

Figure 1 Recovery and recycling rate for end-of-life vehicles [16]

2.2. Methodology of solution to the Product Life Cycle

A general solution package, constituting precycling methodology, will be formulated in close cooperation with professional associations, representing the individual types of production, and will be verified by application of the solution to the product selected from the category CZ-NACE 29.

The solution will compile utilizable terminology for reverse logistics (precycling and recycling) in the area of waste management as the base for environmental policy and new forms of business activities employing PLM strategy.

Evaluation of recycling programs in terms of sustainable development is, in the level “waste”, made on the basis of the set of indicators:

- economic (costs, externalities);
- environmental (power and material consumption, emissions to air and water, waste generation);
- social (increase of employment, acceptability, economic acceptability) of the indicators.

To express analytical approach to the above-mentioned areas, a methodology has been phrased (integrating environmental links) entitled as “SELCA” (Social and Environmental Life Cycle Assessment). Drafted methodology approach “SELCA” will be verified on the products, selected from the categories listed above. The objective of routine application of SELCA methodology is to define an optimum recycling rate in terms of the sustainable development, i.e., to minimize material inputs to production, close material flows and optimize reverse waste utilization.

We must set economic and business system into the environmental framework; nowadays, on one hand oriented to the circular economy in the area of selected elements of direct materials, but in the future certainly expanding with other products and services irrespective of the market segment/company size. Manufacturers and importers must keep closing their material flows; results will be savings of sources and re-use of raw materials, as in the nature. Each designer of a completely new product should think that product, its components and waste products must be disposed over time; thus, the circulation of substances in nature should be imitated as much as possible (see **Figure 2**).

One of the most important areas of the material flow management, often neglected by companies or considered a second-class thing, is disposal of waste, redundant, recyclable, and obsolete materials. Reverse logistics acc. to Klapalová [17] has recently gained major importance, particularly in light of increased attention

paid to the environmental issues, more restrictive national legislation as well as better widespread understanding of possibilities which this area introduces to the circular economy.

Development of IT and information society as well as its global character raise many queries and problems, the impact of which we can hardly predict. We cannot figure out whether we will be able to accept accelerating pace of change, whether we will be able to understand possibilities offered and whether we will be able to seize opportunities in a qualified and correct manner. We do not know how we will deal with offer of enormous information sources available on the world-wide networks or how we will be able to face misuse of information, safety, and new risks of information collapse in the global scope.

Furthermore, a key question is the role, position, and function of human potential. More often than not, ultimate success of the company informatics does not solely depend upon how technical barriers are overcome by new technologies, but mainly how personal, qualification and organizational barriers are tackled.

In spite of these existing and potential problems, electronic (network) business has become a vital factor of strategic development; it is an open-ended question how each of us, each company, each society will cope with such a fact.

All too often happens that large projects are more expensive than first expected. Projects are completed later than initially planned and their benefits are smaller than anticipated. Certainly, it is not going too far to say that one of the causes primarily lies in the first stage of building of approaches, when the first idea of an overall solution is considered, implementation objectives defined, estimated costs calculated, and expected time and capacities scheduled. From the environmental point of view, it stands for the first stage of the product lifecycle logistics spiral - precycling, where financial and capacity resources can be saved or appropriately invested and project time shortened, if well prepared and correctly drafted. At the same time, most mistakes can be made in this stage, which can be hardly eliminated in the subsequent stage - recycling, if underestimated or completely neglected [18].

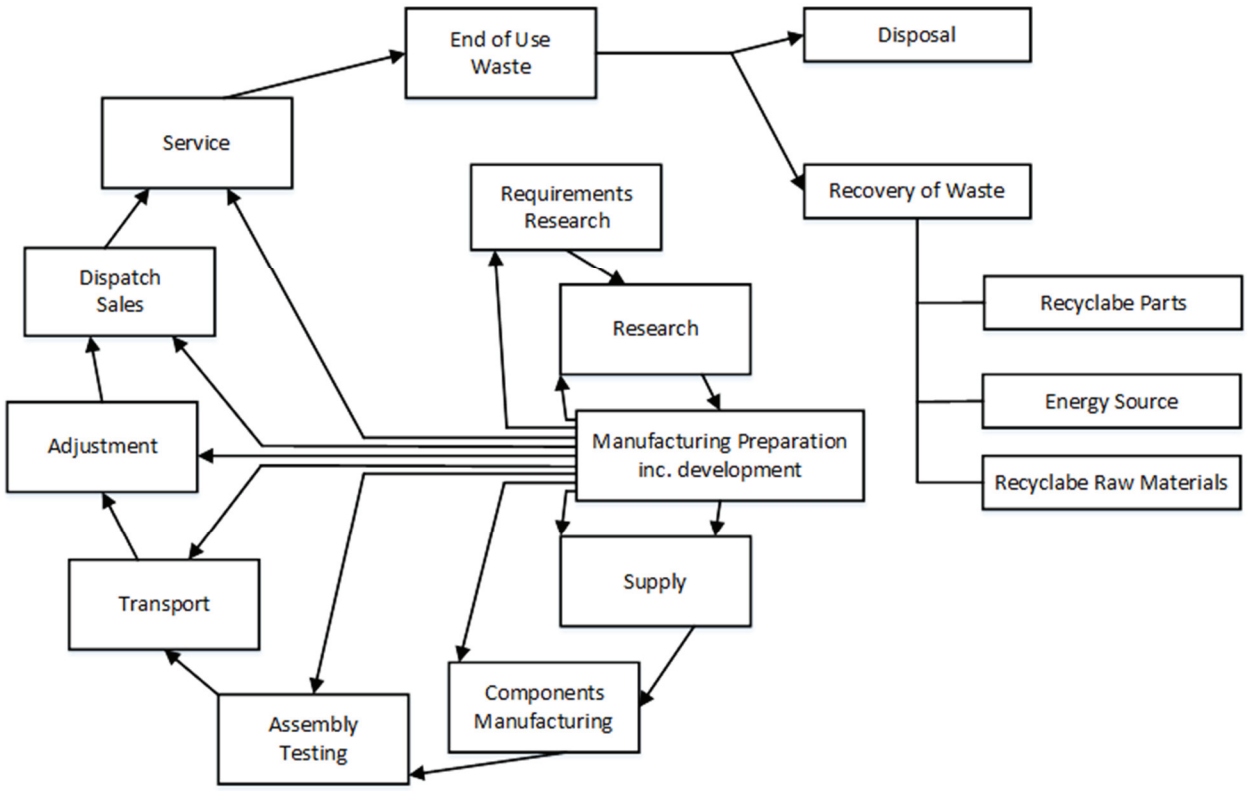

Figure 2 Logistics Spiral of the commodity lifecycle [Authors acc. to [18]]

3. DISCUSSION

The company, launching strategy formulated in Directive 2000/53/EC of the European Parliament and of the Council of 18 September 2000, should follow two basic directions with regard to the environment [14]:

- production of environmentally friendly products [to develop, design (eco-design), and manufacture products which will not exacerbate environmental pollution for the period of their use and after the end of their life-time],
- application of environmentally friendly manufacturing processes [to design and operate such manufacturing, transport, packaging and waste technologies which will not exacerbate environmental pollution-cleaner technologies].

In addition to typical problems, which must be addressed in the stage of product development and designing of manufacturing, transport, storage and packaging systems (such as functionality, low costs, quality, manufacturability, protection of properties in storage and transport etc.), other problems are also faced:

- how to design a product and, at the same time, to minimize waste and optimally use recycled source in the production engineering input for the period of manufacturing, transport, use, and after the end of the product life cycle;
- how to design a product to facilitate or enable subsequent recycling, applying the above-mentioned approach?

Essential principles to be applied include:

- minimization of material consumption - dematerialization in production;
- material unification as a standardization tool;
- minimization of hazardous material consumption;
- optimization of use of renewable materials;
- optimization of use of recycled material elements;
- maximization of lifetime of components (key parts of the product);
- reduction in energy performance of technologies and manufacturing processes;
- minimization of emissions generated by manufacturing and operation;
- hazardous waste minimization;
- collection, evaluation, and provision of objective indicators of recycled materials
    - functional indicators (composition, properties, alternative application areas);
    - environmental indicators (environmental impacts of collection);
    - economic indicators (costs/price, marketing of recycled materials).

It should all be addressed by the analytical concept “SELCA” as the part of supply chain, manufacturing and distribution logistics, especially its specific part - reverse logistics (precycling and recycling). All should be solved throughout the entire logistics chain, i.e., at all supplying levels simultaneously, integrated into all strategies of companies in order to achieve both new forms of business activities and gain competitive advantage of the entire network organization and, thus, every single company [19].

Several last questions should be discussed in the follow-up research, such as:

- vast majority of working methods, organizational structures and introduced company practices date back to the pre-digital era;
- owners and managers gladly disclaim their responsibilities for these areas and assign tasks, related to the environment and electronic commerce introduction, to the hands of creative staff (in the stage of project preparation) and IT staff;
- both engineers and IT staff have knowledge of processes but understand them less in the areas of business and management. Their expert opinion limits itself to description of the status quo as described by managers.

All these aspects must be considered and dealt with for successful accomplishment of proposed procedures.

4. CONCLUSION

On one hand, the future of product lifecycle management depends on application of new technologies and technological development; on the other hand, also on the requirement on sustainable product and general concept of logistics chain management with regard to the key environmental attributes. Nowadays, face of the automotive industry is changing; this issue is reflected in the common action of the Czech government and automotive industry representatives (such as the "Memorandum on the Future of the Automotive Industry in the Czech Republic" [20, 21], which is the first pledge of the analysis of aspects of electrification or change in the current company models. Thus, sustainability (i.e., sustainable supply chain management) and environmental qualities (green supply chain management) push logistics chain management into the circular economy. In spite of partial intersection of green supply chain management with circular economy, as says [22], the realistic way to significant improvement in all company processes and remarkable success is to re-organize company processes; upon completion of introductory changes to further promote, continuously improve, and enhance logistics strategy for the company.

An in-depth systematically analysis as well as radical proposal for all aspects - business processes in the area of environment, logistics as well as use of IT technologies (for example, sustainability and energy management software etc.) lead to easier reporting, change in the business activity, opinion and behaviour in a way that each company may dramatically increase its efficiency and satisfy its present as well as future needs.

The key to success in a dynamically changing world is coherent and flexible company strategy, optimally fostered both by in-house logistics concepts and logistics networks (such as Sustainability Performance Management [23] or their extensions (such as SoFi [24]) in the dawning era of circular economy. Framed logistics concept of the whole network, hand in hand with human resources, is becoming the main tool for competitiveness of both the product and company. The integration itself never ends, as it is a process and not a condition.

REFERENCES

[1] EUROSTAT. *Key figures on Europe*. [online]. Version 3, Last updated: 11 October 2017. [viewed 2018-05-11] Available from: https://ec.europa.eu/eurostat/documents/3217494/8309812/KS-EI-17-001-EN-N.pdf/b7df53f5-4faf-48a6-aca1-c650d40c9239

[2] JUROVÁ, M. *Evropská unie Odvětví a infrastruktura.* 1st ed. Brno: Computer Press, 1999. P. 115.

[3] BERGER, R. *Strategy Consultants: Rightsizing Europe.* [online]. Version 1, Last updated: 28 March 2013. [viewed 2014-02-21]. Available from: http://www.rolandberger.com/media/pdf/Roland_Berger_Automotive_Supplier_Europe_E_20130328.pdf

[4] SANIDAS, E. Manufacturing Sectoral Growth in the USA and Japan: Relevance to SMEs. Organizational Innovations (OIs), and Recent Economic Growth. Working paper. In *Proceedings of the Second Conference on "SMEs in a Global Economy*. Wollongong: University of Wollongong, 2002.

[5] UNITED NATIONS. *Resolution adopted by the General Assembly on 25 September 2015: Transforming our world-the 2030 Agenda for Sustainable Development* [online]. Version 1, Last updated: 21 October 2015. New York: UN. 35 p. [viewed 2018-08-21]. Available from: http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E

[6] EUROPEAN COMMISSION. *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Closing the Loop - An EU Action Plan for the Circular Economy* [online]. Version 1, Last updated: 2 December 2015. Brussels: EC. 21 p. [viewed 2017-7-2]. Available from: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52015DC0614

[7] CARTER, C. R. and ROGERS, D. S.. A framework of sustainable supply chain management: moving toward new theory. *International Journal of Physical Distribution & Logistics Management*. 2008. Vol. 38, no 5, pp. 360-387.

[8] EUROPEAN PARLIAMENT. *Regulation (EC) No. 2150/2002 of the European Parliament and of the Council of 25 November 2002 on Waste Statistics* [online]. Version 1, Last updated: 25 November 2002. Brussels: EP. 54 p. [viewed 2018-07-01]. Available from: https://publications.europa.eu/en/publication-detail/-/publication/c694ef08-6b29-40a6-9124-4b6d3f82883d

[9] EUROPEAN PARLIAMENT. *Decision No. 1386/2013/EU of the European Parliament and of the Council of 20 November 2013 on a General Union Environment Action Programme to 2020* [on-line]. Version 1, Last updated: 20 November 2013. Brussels: EP. 30 p. [viewed 2018-07-02]. Available from: https://publications.europa.eu/en/publication-detail/-/publication/b8e613ef-76de-11e3-b889-01aa75ed71a1

[10] EUROPEAN PARLIAMENT. *Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on Waste and Repealing Certain Directives*. 2008 [online]. Version 1, Last updated: 19 November 2008. Brussels: EP. 28 p. [viewed 2018-05-15]. Available from: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0098

[11] ŠKAPA, R.. Managerial factors of effective reverse logistics. In *JC Spender, Giovanni Schiuma, Vito Albino. IFKAD 2015. 10th International Forum on Knowledge Asset Dynamics. Culture, Innovation and Entrepreneurship: Connecting the Knowledge Dots*. Bari: Institute of Knowledge Asset Management, University of Basilicata, 2015, pp. 2001-2009.

[12] VERBAND DER AUTOMOBILINDUSTRIE. *General* [online]. Version 1, Last updated: 12 April 2018.Berlin: VDA. 1 p. [viewed 2018-05-15]. Available from: https://www.vda.de/en/services/facts-and-figures/annual-figures/general.html

[13] AUTOMOTIVE INDUSTRY ASSOCIATION. *Výsledky autoprůmyslu za rok 2017* [online]. Version 1, Last updated: 20 June 2018. Praha: AIA. 2p. [viewed 2018-07-25]. Available from: http://www.autosap.cz/sfiles/TI16_2018_FIN.pdf

[14] EUROPEAN PARLIAMENT. *Directive 2000/53/EC of the European Parliament and of the Council of 18 September 2000 on End-of Life Vehicles - Commission Statements* [online]. Version 1, Last updated: 21. December 2000. Brussels: EP. 9 p. [viewed 2017-08-20] Available from: https://eur-lex.europa.eu/resource.html?uri=cellar:02fa83cf-bf28-4afc-8f9f-eb201bd61813.0005.02/DOC_1&format=PDF

[15] SEMCON. Future - Trendy, které mění automobilový průmysl [online]. Version 1, Last updated 2013 [quoted 2014-02-18]. Available from: http://www.semcon.com/Global/Docs/Future/FUTen2-2013_webb.pdf

[16] EUROSTAT. *Recovery and Recycling Rate for End-of-Life Cehicles* [online]. Version 1, Lastu updated: 23 April 2018. [viewed 2018-04-02]. Available from: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Recovery_and_recycling_rate_for_end-of-life_vehicles,_2015_(%25).png

[17] KLAPALOVÁ, A. *Řízení zpětných toků jako prostředek tvorby hodnoty*. 1st ed. Brno: Masarykova univerzita, 2017. p. 164.

[18] JUROVÁ, M. et al. *Výrobní a logistické procesy v podnikání.* 1st ed. Praha: Grada Publishing, 2016. P. 264.

[19] CHRISTOPHER, M. *Logistika v marketingu*. 1st ed.. Praha: Management Press 2000, 166 pp.

[20] MINISTERSTVO PRŮMYSLU A OBCHODU. *Memorandum o budoucnosti automobilového průmyslu v České republice "Český automobilový průmysl"* [on-line]. Version 1, Last updated: 11 October 2017a. Praha: MPO. 3 p. [viewed 2018-08-25]. Available from: https://www.mpo.cz/assets/cz/prumysl/2017/10/memorandum-o-budoucnosti-autoprumyslu-v-CR.pdf

[21] MINISTERSTVO PRŮMYSLU A OBCHODU. *Příloha k memorandu o budoucnosti automobilového průmyslu v České republice "Český automobilový průmysl"* [online]. Version 1, Last updated: 11 October 2017b. Praha: MPO. 41 p.[viewed 2018-08-25] Available from: https://www.mpo.cz/assets/cz/prumysl/2017/10/priloha---AP-k-Memorandu-o-budoucnosti-autoprumyslu-v-CR.docx

[22] LIU, J., et al. Green supply chain management and the circular economy: Reviewing theory for advancement of both fields. International *Journal of Physical Distribution & Logistics Management* [online]. 2018. Vol. 48, iss. 8, pp. 794-817 [vieved 2018-07-25]. Available from https://doi.org/10.1108/IJPDLM-01-2017-0049.

[23] SAP. *Whats New in SAP Sustainability Performance Management 4.0* [online]. Version 1, Last updated: 24 October 2016, [viewed 2018-08-25]. Available from https://help.sap.com/doc/PRODUCTION/1995180176754d4d94d55e79f651e788/4.0/en-US/SuPM4ReleaseNotes.pdf

[24] THINKSTEP. *Corporate Sustainability Software* [online]. 2018. Leingelden-Echterdingen: Thinkstep. [viewed 2018-08-25]. Available from: https://www.thinkstep.com/software/corporate-sustainability