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Influence of composition, amount and life span of passenger cars on end-of-life vehicles waste in Belgium: A system dynamics approach

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ABSTRACT

The increasing worldwide production of passenger cars depletes natural resources and increases the number of end-of-life vehicles (ELVs) to be processed. Lack of landfill capacity and a growing scarcity of natural resources have lead to severe ELV reuse and recovery targets in the European Union (EU). This paper examines the main influencing parameters affecting the amount and composition of ELV waste originating from passenger cars to be treated in Authorized Treatment Facilities (ATFs). Moreover the effect of a changing number, composition and life span of passenger cars on the ability to meet the ambitious EU ELV Directive 2000/53/EC targets in 2015 is examined for Belgium. Using system dynamics, the aforementioned changing parameters are studied from 1990 and projected to 2030. The model results show that the total annual weight of ELV waste to be reused and recycled in Belgium is expected to grow over the coming years despite the economic downturn of 2008 and its effect on GDP growth. Moreover it shows that Belgium can sustainably achieve the ambitious EU ELV Directive 2000/53/EC targets in 2015 and thereafter if it continues to invest in waste treatment of ELV plastics. The availability of higher amounts of ELV plastics proves to be favourable to trigger investments in their reusing and recycling. We demonstrate that this can be realized by reducing export of discarded passenger cars, shortening the life span of passenger cars or shortening the time for investing in additional plastic recovery.

1. Introduction

The worldwide production of passenger cars has been increasing over the last decade fuelled by an emerging Chinese market (ACEA, 2013; Poudenx, 2008). In 2005, the disposal of passenger cars and light commercial vehicles at the end of their operational life was estimated to generate more than 10 million tonnes of material requiring treatment and disposal, within the EU. Due to an increase in the number and average weight of vehicles, this volume was projected to reach 14 million tonnes in 2015 (Zorpas and Inglezakis, 2012). The increase in the number of End of Life Vehicles (ELVs) generated in the EU, as

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well as the associated Automotive Shredder Residue (ASR) impact on the environment by land filling, have been the driving force for EU legislation on ELV (Smink, 2007) resulting in the ELV Directive 2000/53/EC (European Parliament, 2000).

ELV waste-performance figures (Eurostat, 2014) indicate that a significant number of EU countries are still struggling to meet the two 2015 ELV targets—at least 95% *reuse and recovery* and at least 85% *reuse and recycling*. These 2015 ELV targets have been challenging for all EU member states since they were introduced for a few reasons: insufficient availability of post-shredder capacity, high treatment costs for the reuse of components and recycling of the Shredder Light Fraction, (SLF), and a lack of economically viable markets for secondary materials, with the exception of metals (Duncan, 2005). Currently Germany, Finland, Austria and the Netherlands have been able to meet the 2015 target of 95% reuse and recovery of ELV (Eurostat, 2014).

Belgium has not yet succeeded in meeting the 2015 ELV *reuse and recovery* target, but has been one of the first EU member states to comply with the 2015 *reuse and recycling* target (Bio Intelligence Service, 2012).

This paper aims to identify how Belgium was able to meet at least 85% of ELV *reuse and recovery target*, and at least 80% *reuse and recycling* target by 2015 and how it may contribute to meeting the 2015 ELV targets. Our aim is not to develop an exact forecasting model but to build a framework for examining which factors influence materials management and how they specifically affect ELV in the passenger car supply chain. The contribution of this paper is the establishment of a comprehensive closed-loop material supply-chain model for ELVs that will enable decision makers to assess various policy scenarios for meeting the EU ELV targets. Moreover, it brings forward ways for Belgium Authorized Treatment Facilities (ATFs) to reach and maintain the EU 2015 ELV targets. The framework discussed can be applied to other EU countries taking the country-specific peculiarities into account. All EU countries are subjected to the same ELV Directive; and the change in the number of passenger cars in their national car stocks are all influenced by GDP, population, and average life span of passenger cars. Differences from the Belgian case are found in data gathering (which varies by country), by the manner in which reuse, recycling, and recovery are organized (European Parliament, 2010) and in the average life span of passenger cars (which can e.g. vary from 13 years for Ireland to 22 years for Finland) (Oguchi and Fuse, 2015). For more details on the differences in ELV performance between various EU countries we refer the interested reader to Zorpas and Inglezakis (2012) and European Parliament (2010).

This paper is structured as follows: Section 2 presents the closed-loop passenger-car supply chain and discusses the ELV reuse and recovery system. Section 3 presents a literature review focused on how the EU ELV Directive 2000/53/EC targets can be met and how system dynamics can be used as a modelling tool for analysing ELV waste performance. Section 4 introduces the methodology of system dynamics models. Section 5, discusses the parameters of the closed-loop passenger-car supply chain that most influence ELV performance and formulates quantitative as well as qualitative relationships. Section 6 discusses the system dynamics model validation. Section 7 reports on scenarios for evaluating the effect of policy measures on increasing ELV reusability and recyclability. Finally, Section 8 formulates conclusions and offers directions for further research.

2. Reuse and recovery system for ELV waste of passenger cars

2.1. Closed-loop passenger-car supply chain

In this section we describe the closed-loop passenger-car supply chain with an emphasis on the material reuse and recovery performance of discarded passenger cars. In general only those economic, environmental and societal aspects that have a significant impact on the material composition of cars are considered. Fig. 1 represents the closed material loop of the passenger-car supply chain from the perspective described above. It is drafted based on the input of several sources discussed hereafter. The boundaries of the system studied in this paper are described in more detail in Section 5.

The forward loop of the closed-loop passenger-car supply chain, depicted in Fig. 1, starts with the production of new passenger cars from virgin raw material and recycled secondary raw material. The reverse, vehicle-recovery loop starts with the collection of discarded passenger cars. Original Equipment Manufacturers (OEMs) assemble parts made from primary and secondary raw materials, while taking into account both current legal obligations and profitability related to the use of such primary and secondary materials. New passenger cars are distributed via dealers. Reused parts may be used during maintenance and repair. When a used car is still in a good working condition, it can be sold as a second-hand car (Zorpas and Inglezakis, 2012).

After an average lifespan of 12–15 years, passenger cars reach the end of their useful life (Kanari et al., 2003; Statbel, 2009) and cease to be roadworthy due to age, wear-and-tear, or damage from a car accident. The demand for new cars replacing discarded ones is influenced by legislation that, amongst other factors, can allocate subsidies for less polluting cars or assign more favourable taxes for cleaner engines. Such legislation has an influence on the recyclability and material composition of new cars (Stevens, 2010; Kibira et al., 2009; IPTS, 2003).

Because of the Extended Producer's Responsibility (EPR) principle, as outlined in the EU ELV Directive 2000/53/EC, the car manufacturer has a take-back obligation when the last owner decides to get rid of his car and this is, in practice, organized by the Authorized Treatment Facility (ATF) sector in Belgium. However, vehicles may be sold for export either before reaching the end of their life, or at the moment of deregistration. Each year, large numbers of used cars are exported inside and outside the EU, resulting in a reduction in the number of ELVs requiring waste treatment within their originating country. In 2004,