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CONCEPT FOR MANAGEMENT OF END OF LIFE VEHICLES RECYCLING SYSTEM *

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Abstract: *This paper presents a concept for management of End-of-Life Vehicles (ELV) recycling system based on hierarchy of goals in waste management which sets up the following sequence of importance: prevention; reduction; re-use; recycling; energy recovery; permanent storage. The potential model of material, funds and information flow management was shown so that targets of current legal regulations, primarily EU Directives for ELV, can be accomplished including the maximum possible application of market principles.*
Key words: *Management, End-of-Life Vehicles, Recycling Sistem*

1. INTRODUCTION

The system concept which has been presented in this paper is based on the hierarchy of goals in the management of waste, which establishes the following order of significance: prevention, reduction, reuse; recycling; energy recovery; lasting storage. The management is conceptualized so that the system can satisfy the requirements of the EU Directive for End-of-Life Vehicles. The Directive 2000/53/EC [1] has banned utilization of certain hazardous materials on vehicles and defined the procedure of handling ELV. It has anticipated successive accomplishment of set requirements, whereas the final target is to be reached on 1.01.2015, which is in comparison to total mass of ELV:

- Reuse + Recycling ≥ 85%
- Reuse + Recovery ≥ 95%

The decisive factors to be taken into consideration for the creation of the system are acquaintance with the flow of materials, energy, money and information. It is only possible to manage the complete system by following these flows. This management entails maximum possible implementation of market principles, but also implementation of legal regulations which provide for the achievement of the general social goals in the sustainable development. This paper presents the management role of the subjects of the system and defines the models of positive impact on its functioning. A large number of subjects participate in the ELV recycling system – with partial of full engagement, as has been presented in figure 1. Competent government institutions (SI) have the global management role, and they define systematically the conduct of all subjects and monitor the achievement of goals.

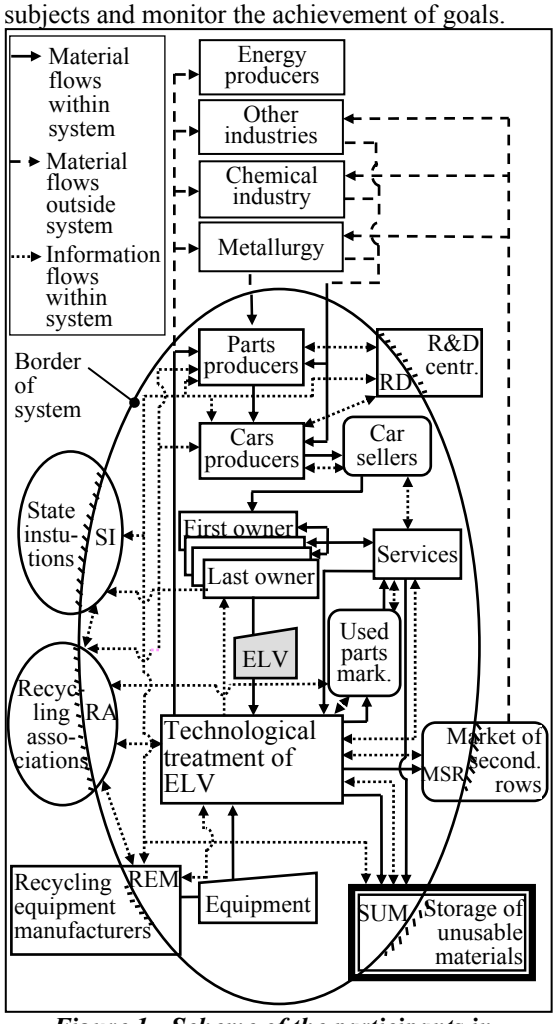

Figure 1 - Scheme of the participants in the system for ELV recycling

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The following have been identified as subjects of the technological part of the system: Centers for dismantling (CD), Centers for Repair (CR), Shredders (S), Centers for mechanical treatment of automotive shredder residue – AASR (MTASR), Centers for thermal treatment ASR (TTASR) and Centers for material treatment (TM).

2. POSSIBLE MANAGEMENT SOLUTIONS

The management system entails maximum possible implementation of market principles, but also implementation of legal regulations which provide for the achievement of general social goals in sustainable development.

2. 1 Decision Making Model

It is extremely important to establish an appropriate system of decision making and implement it at the phase of solution selection and in the continuous management of the subsystem for technological treatment. Therefore, the model of decision making, which takes into consideration all regulations, has first been created and this meaning in the order of priorities defined by the EU Directive for ELV: Reuse, Recycling, Energy recovery (figure 2).

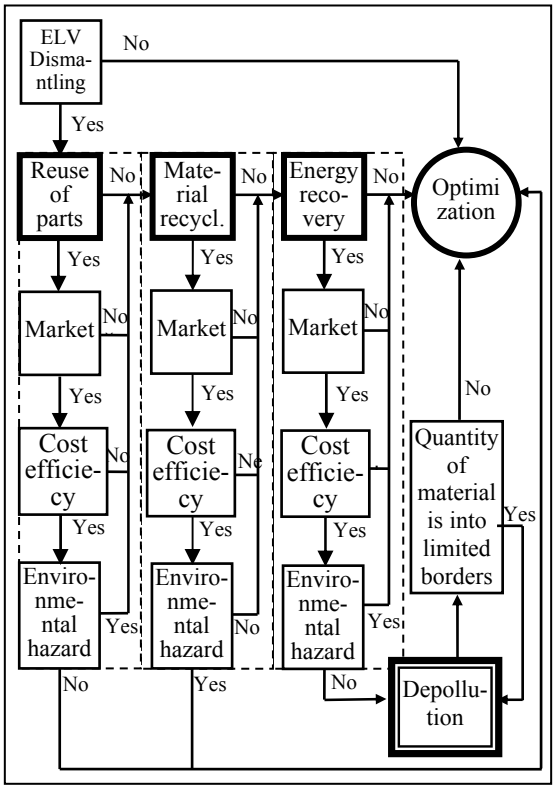

Figure 2 - Scheme of the decision making model in the selection of operations with ELV

It is possible to conclude from the presented scheme that the dismantling of ELVshould be done provided that it is possible to return its parts into exploitation, i.e. that such have their functional (usage) value. The dismantling of ELV is rational only if there is market which can absorb such parts under economically acceptable conditions. If not, ELV should be sent to shredders (after the removal of hasardous materials – decontamination) and thus eliminate in this way the dismantling costs. If the dismantling of parts from ELV is dangerous for the environment, they should be sent to further treatment by specialized procedures in recycling. If it is concluded that the parts cannot be used at all, that is a clear sign that the technological treatment concept should be looked into and optimized. The optimization of the solution of the subsystem must be performed also if big amounts of unusable waste are generated in the dismantling, regardless of the fact that it is not dangerous for the environment.

2.2 The role of State Recycling Agency in the Management of the System

Should the system be based only on market conditions, then a conflict of interest would be unavoidable of the subjects of the system with general interests. This shows that the system must be globally managed from one place. If the government is competent for taking care of the general social goals, then it is also authorized to take over the responsibility for the global management of the system. The presented research results in the previous chapters deal with the significance of the role of the government institutions for the management of the system and its functioning.

In order to provide the process of management in a specially established government institution, herein referred to as the Recycling Agency", it is necessary to establish a special data base for ELV. The basic tasks which the Agency should materialize can be classified into the following fields: Infrastructure for ELV Recycling; Financial Management; Licensing (issuance of certificates) to subjects for the performance of activities related to ELV recycling; Permanent Supervision Related to the Respect of Regulations by the Subjects; Analyses of Effects and Finding Solutions for their Optimization; Promotive-Propaganda activities in the aim of inciting ELV recycling.

In its work, the Agency for Recycling should rely on independent experts, which means that a network of competent experts should be established instead of a team of officers. The term "Independent Expert" entails a person who has been given a licence by the Agency for the

performance of his tasks based on his expert qualifications. Experts are independent of the Agency as they are not employed by it, nor by any other subject in the system. The Agency may also engage independent experts and independent competent institutions for the purpose of data analysis and completion of system optimization projects. In continuation consideration has been made of the possibilities for monitoring and management of the flows in the system.

2.3 Material flow management

Material flow management has been provided in accordance with the prescribed activities of the centers for technological treatment, by forwarding data about materials and parts from the subjects of the technological subsystem, as has been presented in figure 3, to the data base of the State Recycling Agency. If a check is made of the taken over, i.e. handed over material masses at the entrance and exit of the subjects, then it is possible to conclude by their comparison whether the materials have been forwarded to the set destination. This is a very significant indicator considering that it enables fast follow up of the respect of regulations in the management of waste.

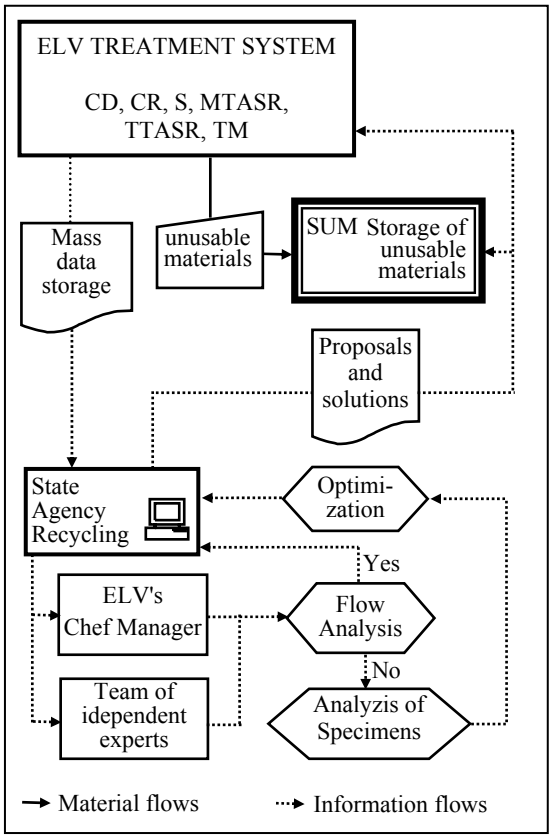

***Figure 3*- Scheme for the management of material flows**

The Agency organizes, through its chief manager for ELV, a team of independent experts, who make detailed analysis of the material flows based on the data in the base and check particularly the total quantities of stored unusable waste and material used for getting energy.

The following total quantities of unusable materials (letters "*UM*" in the subscript sign) and materials for energy recovery by subjects of technological treatment are generated (letters "*ER*" in the subscript sign): Centers for dismantling: m_D^{UM}, m_D^{ER}; Centers for repair: m_R^{UM}, m_R^{ER}; Shredders: m_S^{UM}, m_S^{ER}; Centers for mechanical treatmentASR: $m_{mtASR}^{UM}, m_{mtASR}^{ER}$; Centers for thermal treatment ASR: $m_{ttASR}^{UM}, m_{ttASR}^{ER}$; Centers for material treatment: m_{tm}^{UM}, m_{tm}^{ER} [2].

The given masses represent the sum of all masses which occur in all centers of the same operation. For example, the mass of unusable waste from all centers for repair on a certain territory is:

$$m_R^{UM} = \sum_i^{N_R} m_{Ri}^{UM}$$

It follows that the following condition must be fulfilled according to the EU Directive (2000/53/EC) for ELV:

$$m_R^{UM} + m_S^{UM} + m_{mtASR}^{UM} + m_{ttASR}^{UM} + m_{tm}^{UM} \le 0{,}05 \cdot \overline{m}_{ELV}$$

$$m_D^{ER} + m_R^{ER} + m_S^{ER} + m_{mtASR}^{ER} + m_{ttASR}^{ER} + m_{tm}^{ER} \le 0{,}10 \cdot \overline{m}_{ELV}$$

In the previous expressions $\overline{m}_{ELV}$ is the average mass of the average ELV per vehicle and year.

U slučaju da nije zadovoljen bilo koji od navedenih uslova, potrebno je postupiti po redosledu aktivnosti prikazanih na figure 3. Tim eksperata će izvršiti analizu tokova materijala, a zatim predložiti aktivnosti kojima će se izvršiti njihova optimizacija, tako da se obezbede mase materijala za skladištenje i povraćaj energije u okviru propisanih limita. Ukoliko se na teritoriji nalazi veći broj subjekata koji vrše tehnološki tretnman, analize i optimizacije zahtevaju više vremena, pa je u tom slučaju potrebno uraditi plan realizacije po rangovima prioriteta. Izbor centara koji će biti prioritetno analizirani i optimizirani zavisi od njihovog učešća u overrun of regular limits. Overrun of limits (m_o^{UM}, m_o^{ER}) represents the difference between the generated unusable material in each center "i" and the maximum allowed mass for such a center. Analogously, it is necessary to determine for each center the overrun in the material for energy recovery.

$$m_{o_i}^{UM} = m_i^{UM} - m_{max_i}^{UM}$$

$$m_{o_i}^{ER} = m_i^{ER} - m_{max_i}^{ER}$$

It is then necessary to determine the coefficients of share for each center, i.e. the relation between the respective overrun and the generated material, as is presented in the expressions:

$$K_{o_i}^{UM} = \frac{m_{p_i}^{UM}}{m_i^{UM}} \; ; \; K_{o_i}^{ER} = \frac{m_{o_i}^{ER}}{m_i^{ER}}$$

Obviously "*i*" has different maximum values, depending on the total number of centers, i.e. Dismantling centers $i = 1$ *to* N^D**;** Repair centers: $i = 1$ *to* N^R; Shredding centers: $i = 1$ *to* N^S; Centers for mechanical treatment ASR: $i = 1$ *to* N^{MTASR}; Centers for thermal treatment ASR: $i = 1$ *to* N^{TTASR} Centers for treatment of material : $i = 1$ *to* N^{TM}.

The generation of big quantities of unusable material i.e. material for energy recovery by a center may mean that it is a question of a subject with a large materialized scope of treatment. This indicator does not speak with sufficient certainty as to how the center was conceived and organized. It is therefore important to determine for each subject, the ratio between the mass of the resulting unusable waste and the mass of received material i.e. the mass of received material for energy recovery:

$$Q_i^{UM} = \frac{m_i^{UM}}{m_{rm_i}} ; \quad Q_i^{ER} = \frac{m_i^{ER}}{m_{rm_i}}$$

It is now possible to determine the priority ranks for all kinds of centers. For example, for the center for repair, ranks will be determined in the following manner:

$$R_i^{UM} = K_{o_i}^{UM} \cdot Q_i^{UM} \; ; \; R_i^{ER} = K_{o_i}^{ER} \cdot Q_i^{ER}$$

The priority ranks should be put in the order of growing index values (from the smallest to the biggest, i.e.

$$R_1^{UM} = \left(R_i^{UM}\right)_{max} \; ; \; R_{max}^{UM} = \left(R_i^{UM}\right)_{min}$$

$$R_1^{ER} = \left(R_i^{ER}\right)_{max} \; ; \; R_{max}^{ER} = \left(R_i^{ER}\right)_{min}$$

The rank of the first (greatest) priority is R_1, then R_2, etc. The team of experts will make an analysis of the operation of the selected centers based on the determined priorities starting from the first rank onwards. In agreement with the findings resulting from the insight, it will suggest i.e. adopt respective measures, as has been presented in table 1.

As has been presented, the optimization of the technological concept (O) has meaning only if such a center has apositive marks in all categories of verification. In case that part of the equipment is not in function, it is necessary to give instructions for it to be purchased or repaired (R). Unskilled workers are also an irregularity in the operation, thus instructions will be issued for their education (E). In all other cases the operation of centers (T_s) will be prohibited temporarily.

Kind of Audit	Evaluation						
The center disposes with all requied and good order equipment	+	-	+	+	-	+	-
The employees are trained for the operations they are doing	+	+	-	+	-	-	+
The treatment of materials is in accordance with the regulations and procedures	+	+	+	-	-	-	-
Activity	O	R	E	T_S	T_S	T_S	T_S

Table 1- Audit and activities

2.4 Management of Currency

The cost efficiency of the technological treatment of ELV depends on several different factors, which points out to the necessity of appropriate supervision and management of financial courses. All subjects of the system, except for the state recycling agency (SAR) and storage of unusuable materials should operate in accordance with the market principles, i.e. to make profit from their operation. The government agency for recycling is advised by the operator about the technological treatment of ELV. All money transactions between subjects should be free. The role of the government is in the creation of the ambient for market operating conditions. The last owner of the vehicle cannot have any financial costs related to handing over the ELV for recycling, which means that he must also be compensated for the transport costs to the collection center, i.e. center for dismantling. In order to achieve the goals for the protection of the environment, as well as for the purpose of managing the material and energy flows, the recycling agency should carry out the respective control of the subjects and can prohibit them operation temporarily or permanently if they do not satisfy the regulations and goals. The Agency may also engage independent experts and/or research-development institutions so as to help the subjects in the optimization of operation. The optimization costs should be borne by the subjects for which they are done, except in cases when the manner of operation is a consequence of system disorders within the competence of the government administration. The costs of restoring good order in the operation, i.e. removal of illegally left ELV should be borne by the local administration, which can contract in this sense cooperation with

authorized subjects for technological treatment. The car manufacturers and parts manufacturers should bear themselves the costs of designing and vehicle production processes following the recycling requirements. The owners of vehicles which are on the road should pay an annual tax on account of ELV recycling, whereby a budget would be established for the operation of the part of the government recycling agency which is in charge of the treatment of ELV.

It is necessary to form a separate budget, managed by the government agency for recycling for financing the activities related to the management of the system for ELV recycling and for financing the non-profitable subjects, such as the storages of unusable waste (SUM). The flows of budget funds are presented in figure 4. Following this proposal, the users of vehicles (except for the last one) pay special taxes, which altogether comprise the budget for ELV recycling (F_{BELFV}). The budget is intended for financing the operation of the Agency, i.e. for the organization and maintenance of the storage of unusable waste (F_{BSUM}), engagement of R & D centers on the optimization projects (F_{BRO}), engagement of indpendent experts (F_{BIE}) and for the materialization of the activities which promote ELV recycling.

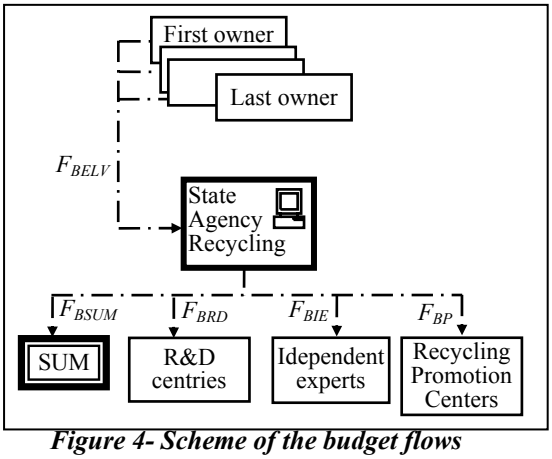

Figure 4- Scheme of the budget flows

The proposal for the budget is formed based on an operation plan and forecast costs for its materialization. The manager for ELV is responsible for making the plan, and for the forecast of costs the finance manager in the government Recycling Agency. The adoption of the budget for the ELV recycling is done following the procedure foreseen by the Law.

3. CONCLUSIONS

- The management of the system entails maximum possible implementation of principles with strict respect and implementation of the legal regulations which enable achievement of general social goals in sustainable development.
- The decision making model must be conceived so as to take into consideration all regulations and this means following the priority order defined by the EU Directive for ELV: Reuse, Recycling, Energy Recovery.
- The key issue in managing the material flows is to provide a mechanism for following up the mass balance, particularly of unusuable materials and of the material for energy recovery. It is necessary in this sense to make analyses and optimisations in several iterations. In case of a large number of technological subjects, one should follow the priority order, as has been presented.
- The money flows analysis points out to the necessity of establishing a separate budget for the implementation, optimization and promotion of ELV recycling.

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