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Logistics costs estimation in case of industrial waste management

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Abstract

Out of concern for environmental protection is an increasingly common practice. Companies thus have an additional task which is the correct organization of the industrial waste management. This is achieved through the use of logistics processes in industrial waste management, mainly such as warehousing, transport, storage and recovery. These processes involve the formation of logistics costs resulting from waste management. The paper presents a mathematical model for cost of logistics management of industrial waste resulting from the above-mentioned processes. It also shows the interpretation of these costs and the relations between them. The model can increase cost-efficiency in companies managing industrial waste, while increasing attention to the environment.

Keywords: logistics, logistics costs, waste management, industrial waste

1 Introduction

While actively pursuing the process of economic growth and economic development there are all very important improvements used in the management, logistics management and logistics. In connection with the use of ever more advanced automation and information technology in the processes of business management, technical and technological improvement of production, the growing importance of customer service, decreasing the duration of the different manufacturing processes, globalization and integration of considerable

organizational and business computing, began to use logistics solutions on a much larger scale than before. Thanks to this definition, the essence, aims and objectives of logistics continue to evolve and are becoming better and broader dimension. The current sophistication of the market economy imposes on business activities involving not only the traditional logistics - from raw materials to the customer, but also follow-up to the management of products utilized by customers in order to recover resources from them, or from the client to raw materials. Thus was created the concept of logistics management of waste streams. Objects of interest in logistics management of waste streams are returned products and waste generated at any point in the supply chain. These waste products in logistics management of waste streams appear as having recovered the value of inputs. Wastes are no longer only waste, but gain some value as a result of economic changes, which is consistent with the economic development objectives, or long-term process of positive change, to include not only quantitative changes (increase: production, employment, the amount of capital, income, etc.), but also qualitative changes (scientific and technical progress, changes in economic structure in order to modernize, improve the system of internal economic relations and international, increase the skills level of the workforce, etc.).

2 Logistics management of waste streams

The concept of logistics management of waste streams already operates several decades, but the precise time when it was established terminology is not possible. First define conceptually similar to the logistical management of waste streams, which appeared in the scientific literature in the seventies were the *reverse channels* and the *reverse flows* (Gołembska, 2007).

In the early nineties was formulated first formally accepted definition of logistics management of waste streams by Council of Logistics Management, according to which the logistics management of waste streams is *the term often used in relation to the role of logistics in recycling, waste managing and management of hazardous materials,* which in a broader sense applies to *all issues related to logistic activities taken to reduce the use of raw materials, recycling, substitution, reuse of materials and management* (Council of Supply Chain Management). This formula of the definition strongly emphasizes aspects of the recovery and reuse of waste as the action built in the logistics management of waste streams. This definition is general, wide and constructed with a reference point for management (Guiltinan & Nwokoye, 1974).

In the late nineties there was presented another definition in literature, which also stressed the objective of logistics management of waste streams, as well as its internal processes. This definition defines logistics management of waste streams as *the process of planning, implementing and monitoring the effectiveness, cost-flow and raw materials, process, storage, production and finished products, as well as related information from point of consumption to the point of original creation to recover the value or properly disposal* (Nowicka-Skowron & Man, 2010). Modern approach to logistics management of waste streams, presented by Council of Logistics Management, is characterizing it for a second time as *the process of planning, implementing and monitoring the effectiveness, efficiency, cost flow of raw materials, processes involving the accumulation of stocks of finished products and links information on the consumption of starting and ending baseline in order to recover the value or the correct action* (Council of Supply Chain Management). In other words, the logistics management of waste streams is a process of movement of products the typical final destination for them to obtain the correct value or action. This concept of logistics management of waste streams is characterized by a combination of management skills, logistics and activities aimed at reducing and appropriate placement of waste.

When describing in a concise manner logistics management of waste streams, while giving the full nature of this discipline is necessary to cite found that logistics management of waste streams is a *way to maximize the value of waste* (Rogers & Tibben-Lembke, 2001). Under this definition, the determination of waste can also be applied to products in the flow of logistics management of waste streams, which in most cases are treated as defective, or waste products.

3 Waste management and its economic consequences

Logistic management of waste streams focuses its attention on the waste, *the materials arising from any human activities or natural forces, as they are usually unintentionally, though difficult to avoid the effect. In other words, waste is an object or material that cannot be used at all or in full accordance with its original purpose in a given place and at any given time* (Ambrożewicz, 1999). Waste in terms of physical and chemical parameters are divided into solid, liquid and gas. However, in the place of their creation, they are shared on municipal and industrial waste. The Waste Act defines municipal waste as the waste arising from human existence, while industrial waste, as the result of economic activity. In addition, the singled out group is also a hazardous waste, which are mainly industrial waste. Municipal waste is any waste generated by households and the waste does not

contain hazardous waste from other waste, which because of its nature or composition is similar to waste from households (Ustawa o odpadach).

From the perspective of the business scope of the logistics used for waste disposal include (Kopicki, Berg, & Legg, 1993):

- The classification of waste by the possibility of reuse and of the danger they may cause;
- Purchase, storage, sorting, transformation, transport, processing, adaptation, recovery, processing, storage and sale of removed materials;
- Other activities necessary to eliminate waste, such as export of goods or unnecessary scrapping of used equipment.

Logistic management of waste streams is the creation of logistic chains merging of waste disposal sites. It comprises the following steps: sorting of waste, their transport and storage, waste treatment, provision of secondary raw materials.

Analyzing the economic factors should be noted that the logistics management of waste streams is very important and profound impact on businesses, where it is implemented (Rogers & Tibben-Lembke, 1999). If its processes run correctly, it can be a source of large cost savings, and even the possibility of using its actions as a main business, which can generate large profits (Sarkis, 2001). Logistic management of waste streams has a significant impact on costs in all phases of product life cycle, and with good organization of the process can be a big reduction in those costs over the cycle.

The total cost of logistics management system of waste streams can be distinguished (Dima ş.a.):

- waste disposal costs, including costs of purchase and operation of suitable means of transport and the construction and operation of transport facilities, transport costs, loading, landing and cargo handling;
- costs of waste treatment: thermal (combustion), chemical (e.g. pyrolysis) and biological (composting bio-waste) - including the purchase of technology and infrastructure, and the cost of treatment and disposal of residues from the process;
- costs of preparing landfill, landfill disposal costs and landfill gas remediation costs later.

The principles of logistics management of waste streams lead to lower

overall costs in this area, contributing to the elimination of cost barriers in the promotion of waste management processes. This is the purpose of logistics management of waste streams.

Implementation of recycling systems for companies facing also some economic barriers. Often, the costs of acquiring and delivering recyclable materials tend to be higher than the acquisition of raw materials and other sources. In this situation, it is not worth to invest in new green technologies and systems utilization. There is therefore a need to co-finance systems in the field of logistics management of waste from regional and national public funding for the removal of environmental disasters, or for the development of technology-friendly environment. Also, in cooperation with international organizations to set harmonize standards in this field, like for example, in the process of accession to the European Union, often by using foreign funds to support environmental projects. Taking into account the economic conditions of the logistics management processes for waste streams should be noted that their usage can bring direct benefits to the organization by reducing consumption of raw materials for production, adding value to the process of recovery or reduce the cost of disposal. Even if these benefits are not very clear and known, also not achieved in a short time, the organizations involved in the conduct of logistics management of waste streams due to marketing issues, strategic and competitive, which are indirect benefits expected. For example, it can be implemented a strategy to recover value in order to adapt to future changes in legislation. Engaging in recovery, the organization also protects against competition that could not take over the technology and did not reach a better position in the market.

Therefore, the strategy for implementation of recovery processes may also be part of building the image of the organization and improve relationships with customers and suppliers. Thus, the economic impact oscillates around other direct and indirect goals of the organization, streamlining its operations comprehensively and functioning of the market.

4 Model of logistics costs for industrial waste management

Logistic management of waste streams is the creation of logistic chains merging of waste disposal sites. It includes the following processes (Kramer, Brauweiler & Nowak, 2005):

Collection and sorting of waste;

Transportation and storage of waste;

Waste management;

Disposal of recycled materials.

Knowing the processes that make up the logistical management of waste streams, should be paid attention to the cost aspect of these processes. These costs can be represented by a mathematical model developed by the authors of this article, based on previous research models, the costs associated with managing the logistics of waste streams. Using this model it is possible to estimate the costs of logistics management system in enterprises managing industrial waste. The mathematical model consists of four main parts: transport costs, storage costs, recovery costs and landfilling costs. The occurrence of these four components in the model of total logistics cost is justified because at first by analysis of logistics costs associated with managing the logistics of industrial waste streams, and, secondly, by the specificity of activities related to industrial waste management. Since the logistics management of waste streams includes processes related to transport the waste, their storage, transfer to the recovery or disposal, while all of these processes are the basis of enterprises managing industrial waste, hence the existence of the costs of these processes in the model on the total cost of logistics management of waste streams is most appropriate. Additionally, this highlights that the flow of waste streams are similar in specific products and here are the same logistic processes, but the direction of movement is different in nature. It is possible to show the logistics costs by usage of the mathematical formula (1):

$$K_C = K_T + K_M + K_O + K_S \quad (1)$$

Where:

K_C – total logistics costs of industrial waste management;

K_T – transport costs;

K_M – storage costs;

K_O – recovery costs;

K_S – landfill costs.

So by authors' research made in the enterprises managing industrial waste in Poland the above formula will have the extensive form (2) as follows:

$$Kc = \sum_{p=1}^{P} \sum_{n=1}^{N} \left(\frac{i_{pn}^{o}}{\tau} \right) \cdot 2 \cdot S^{T} \cdot t_{m} + \sum_{p=1}^{P} \sum_{n=1}^{N} \left(k_{n}^{m} + k_{n}^{u} \right) \cdot \left(\frac{\tau}{2} \right)$$

$$+ \sum_{p=1}^{P} \sum_{n=1}^{N} \left[\left(\frac{i_{pn}^{o}}{\tau} \right) \cdot 2 \cdot S^{T} \cdot t_{o} \right] + \left(i_{pn}^{o} \cdot k_{o} \right) + \sum_{p=1}^{P} \sum_{n=1}^{N} \left[\left(\frac{i_{pn}^{o}}{\tau} \right) \cdot 2 \cdot S^{T} \cdot t_{s} \right] + \left(i_{pn}^{o} \cdot k_{s} \right) \quad (2)$$

Industrial wastes are a very characteristic group of waste and due to their physical and chemical properties must be considered individually because of these parameters. In calculating the costs of industrial waste, each kind of waste must be considered individually, because due to their high diversity, everyone will have different parameters associated with transport, storage, recovery and disposal at the landfill. Therefore, the total cost of logistics management of waste streams for the company managing industrial waste need to be broken down into individual cost components, calculate for each type of industrial waste received from customers and only at the end calculate the sum (Shear, Speh & Stock, 2002).

In the presented model there are some clear dependencies. Analysing transport costs of waste transportation from customers to the company managing waste, significant are quantities of certain waste types and which types the client forwards to the company, as well as transport distance from the customer to the company. Very important information is transmitted to the mass and density of the waste, since this depends on the truck load. The greater amount of waste can be transported at one time the lower the transport costs. The rate of transport from which also depend on transportation costs is a constant value for the company for which are estimated total cost of reverse logistics.

Storage costs also depend on the quantity of each type of waste sent by the client, but there are characteristic indicators of the unit costs of storage and manipulation. Although in the general formula they are separated, in practice there is often only the unit cost of storage which already includes handling costs. The reason is that the law applies to companies that producers of waste do their segregation, and is often associated with additional handling processes. When receiving such waste from a client, enterprise managing industrial waste stock them in, however, no additional processes are no longer needed. But there is possible for pre-treatment to protect the value of stored waste (e.g. packaging for protection against the weather), or prepare them for storage

and recovery (e.g. baling, shredding), which are included in the cost of storage.

Recovery and landfill costs are interdependent. As the enterprise managing industrial waste receives from customers segregated waste, its sole purpose is to separate them into those that are suitable for recovery and for those that will be lanfilling. In view of the fact that both these costs are dependent on the type of waste, the given type of waste is always either put on the recovery or deposited in full on the landfill. Therefore, analyzing data for a particular type of waste, depending on its further usefulness or recovery cost or landfilling cost is equal to 0, that is, if the waste is suitable for recycling the cost of landfill is zero, and if the waste shall be deposited in the landfill the cost of recovery would be 0. Other parameters in these the two parts of the formula are relating to the distance from the company to the recovery installation or to landfilling place. Here, in practice, sometimes the distance from the company to the installation can be 0, since in some cases, companies have their own processing facilities for certain types of waste, located near the warehouse. The last two variables are the unit costs of recovery or disposal. Both costs are dependent on the type of waste. Cost of recovery depends on regaining the value of the installation used for this type of waste and the technology used. Cost of lanfilling depends on the price list established by this entity. As a rule, the costs of recovery are much higher than the cost of landfill.

5 Final remarks

As a result of industrial development associated with the increasing weight of emerging industrial waste, as well as legal and organizational restrictions on the management of this waste, the market would establish a specialized unit, whose business is to correct and rational managing emerging industrial waste. They are designed to strike a balance between environment and industry, and thanks to the use of logistics management processes, waste streams in their business are more cost-effective for logistics management of industrial waste.

Application of solutions proposed in the article as a mathematical formula which allows estimating the cost of logistics in industrial waste management leads to bring the following conclusions:

Logistics costs associated with the processes of logistics management in enterprises managing industrial waste are the main categories of costs in these business units and are closely related to the types of industrial waste transferred to the management and the existing laws.

Calculation and estimation of logistics cost components: transport,

storage, recovery and landfill and the total cost of logistics management processes of waste streams in the enterprises managing industrial waste allows to request a cost-efficient logistics system for industrial waste management.
Management in enterprises managing industrial waste should be supported by modeling and forecasting of logistics processes costs associated with logistics management of waste streams, as their basis, one can determine the most economically advantageous for those companies with the implementation of logistics management processes of industrial waste streams.
Modelling and forecasting the cost of logistics management processes of industrial waste streams may allow for the economic assessment of these processes of enterprises managing industrial waste, and may indicate the possibility of minimizing costs.
Forecasting, modeling and simulation related to the evolution of logistics costs of logistics management processes of industrial waste streams can be used as a tool in making decisions related to activities of their management in the most efficient way because of the possibility of predicting the effects of cost tasks and objectives.

Logistics management is an important instrument for development costs in enterprises. Comprehensive development of the logistics management processes is possible through the use of the entire acquis theory and practice in information technology, marketing strategies, systems, supply chain, automatic identification and optimization of accounts using computer simulation and the practical implementation of this concept is often conditioned by many different factors and constraints in the form of, inter alia, the scope and nature of the activity, type of products and services offered by the company, market dynamics or distribution and sale of the changing and growing demands of customers.

It can therefore be concluded that the logistics management of waste streams, in the context of waste management issues, it is now, and will be in the future, more and more widespread and readily used by various operators as a result of growing public awareness of environmental issues and some sort of coercion on the part of a competitive market, which should be an ever larger scale appear on products and other goods produced with a focus on re-use or recover the value resulting from their production and use of waste in the future.

6 Conclusion

Logistics costs are not separated from the costs accounting company managing industrial waste. However, it can be seen that the costs of logistics management of waste streams, considered as the sum of the costs of storage, transport and waste management, form the basis of an account in assessing the economic efficiency of the logistics in the enterprises managing industrial waste.

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