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Dynamic Optimization of the Investment Portfolio in the Contemporary Business Conditions

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Abstract

Making an optimal investment decision is the necessity in the contemporary business conditions, especially having in mind the risk/return characteristics of the investments. The subject of the research is to test and analyse the performance of the investment portfolio and the possibility of return maximization, while recognizing the acceptable measure of risk in the investment processes. The main objective of the research is to determine the significance of the dynamic optimization application in the process of the investment portfolio creation and to assess the effects from the investment activities. The methodology used in the research comprises usage of appropriate dynamic optimization methods enabling adequate portfolio selection. The research results are useful both to the academic and investment community regarding acquiring the concrete knowledge about the volatile nature of the investment portfolio returns.

Key words: *dynamic optimization, investments, portfolio, return, risk*

1. INTRODUCTION

The possibility of the investment portfolio optimization is even more considered having in mind the dynamic nature of the investment data. Frequent occurrence of both external and internal shocks requires adaptive approach to the evaluation of adequate investment risk/return characteristics.

While evaluating the performances of the observed investment portfolio it is necessary to adequately solve the problem of the expected utility, which has to be maximized.

Regarding the above mentioned, the application of the appropriate method, that is, dynamic optimization, is the necessity, especially while acquiring and maintaining the competitive advantage.

The usage of dynamic optimization of the investment portfolio is considered by many authors (Bardhan et al, 2004, Gabih et al, 2005, Hibiki, N., 2006, Oh et al, 2005, Chacko et al, 2005, Brandt, 2006, DeMiguel, 2009, Krokhmal, 2002, etc.).

The research is significant both for the academic and investment community because it gives a comprehensive approach to the dynamic optimization of the investment portfolio with special attention to the Republic of Serbia.

2. METHODOLOGY

Let the portfolio consist of several different securities, that is of *n* assets $\{S_1,...,S_n\}$. Each asset S_i, for *i = 1,…,n* has the yield r_i, the expected yield $\bar{r}_i$, and the standard deviation σ_i .

The portfolio is calculated as the sum of individual weight coefficients times assets, i.e.

$$\pi = \omega_1 S_1 + ... + \omega_n S_n = \sum_{i=1}^{n} \omega_i S_i \tag{1}$$

where ω_i are the weight coefficients (weights) for which it is valid

$$\sum_{i=1}^{n} \omega_i = 1. \tag{2}$$

The portfolio yield r_π is considered as random variable, since an uncertain outcome is at the end, and its expected value is

$$E(r_\pi) = \bar{r}_\pi = \omega_1 \bar{r}_1 + ... + \omega_n \bar{r}_n = \sum_{i=1}^{n} \omega_i \bar{r}_i \quad (3)$$

The variance (standard deviation) of the portfolio σ_π^2 can be calculated as the sum of weight coefficients and covariances

$$\sigma_\pi^2 = E(r_\pi - \bar{r}_\pi)^2 = \sum_{i,j=1}^{n} \omega_i \omega_j \sigma_{ij} = \omega^T G \omega \quad (4)$$

where G is covariance of matrices, and ω vector of weight coefficients.

Markowitz considered that the relationship between realized return and risk can be expressed numerically and in that way the level of risk required for different levels of realized return can be determined. The conclusion is that the surplus profit cannot be achieved without taking over excess risk. In order to explain that conclusion, the notion of the efficiency is introduced, which represents a line at which each point defines an intersection of the potential reward and an appropriate level of risk. The most efficient portfolio is the one that generates the highest returns for a given level of risk, and an inefficient portfolio involves risk exposure without achieving an appropriate level of return. In 1959, Markowitz published his first book, "Portfolio Selection - Effective Investment Diversification", in which he explained his ideas in detail, used standard deviation as a measure of risk, a variance as a deviation from the average, and considered that the greater the deviation from the average, the greater the risk. The notion of covariance is introduced, so that the portfolio risk is not a deviation of individual security, but a covariance of securities of the total portfolio. [8]

Optimal conditions – let that the expected returns $\bar{r}_1, \bar{r}_2, ..., \bar{r}_n$ are known and consisted of *n* assets, covariance σ_{ij}, *i, j = 1,2,..,n,* weight coefficients ω_i, *i = 1,2,n,* $\sum_{i=1}^{n} \omega_i = 1$. The following problem is solved:

$$\min \frac{1}{2} \sum_{i,j=1}^{n} \omega_i \omega_j \sigma_{ij} \quad (5)$$

$$\sum_{i=1}^{n} \omega_i \bar{r}_i = \bar{r}_\pi \quad (6)$$

$$\sum_{i=1}^{n} \omega_i = 1 \quad (7)$$

The above stated optimization problem is solved by the method of Lagrange multipliers for the Lagrange function

$$L(\omega, \lambda_1, \lambda_2) = \frac{1}{2} \sum_{i,j=1}^{n} \omega_i \omega_j \sigma_{ij} - \lambda_1 \left(\sum_{i=1}^{n} \omega_i \bar{r}_i^{\,p} - \bar{r}_\pi^{\,p} \right) - \lambda_2 \left(\sum_{i=1}^{n} \omega_i - 1 \right). \quad (8)$$

The portfolio consisted of *n* assets, with weight coefficients ω_i, *i = 1, 2,…, n* and Lagrange multipliers λ_1 and λ_2 for the efficient portfolio satisfies the optimal conditions (which are obtained by partial derivatives by all unknowns equals zero):

$$\sum_{j=1}^{n} \sigma_{ij} \omega_j - \lambda_1 \bar{r}_i - \lambda_2 = 0, \quad i = 1,2,...,n \quad (9)$$

$$\sum_{i=1}^{n} \omega_i \bar{r}_i^{\,p} = \bar{r}_\pi^{\,p} \quad (10)$$

$$\sum_{i=1}^{n} \omega_i = 1 \quad (11)$$

3. RESULTS AND DISCUSION

The research sample is consisted of the data obtained by the official Belgrade Stock Exchange Internet site.

The observed portfolio is consisted of the following stocks: AERO - Aerodrom Nikola Tesla a.d., Belgrade, ENHL - Energoprojekt holding a.d., Belgrade, NIIS - NIS a.d., Novi Sad and SJPT - Sojaprotein a.d., Bečej.

The historical data used comprise the period from 01.01.2016 to 31.12.2016 (Figure 1).

The example of the calculation of the returns for the January 2016 is presented in the Table 1.

Table 1. Returns calculation

	AERO	**ENHL**	**NIIS**	**SJPT**
Returns for January 2016	0.0216	0.0617	0.0428	-0.0503
	0.0232	0.0151	0.0346	0.0000
	-0.0044	0.0176	0.0216	0.0000
	0.0055	0.0000	-0.0020	0.0617
	-0.0011	-0.0011	0.0079	-0.0024
	-0.0152	0.0145	0.0060	-0.0024
	-0.0305	0.0000	-0.0118	0.0000
	-0.0246	0.0000	-0.0097	-0.0309
	-0.0081	0.0000	-0.0172	-0.0124
	-0.0131	-0.0344	-0.0525	-0.0167
	-0.0129	0.0000	-0.0230	0.0000
	-0.0761	-0.0096	-0.0191	0.0000
	-0.0259	-0.0467	-0.0137	0.0011
	0.0045	0.0000	-0.0068	0.0000
	-0.0062	-0.0140	-0.0134	-0.0011
	-0.0097	0.0000	-0.0067	0.0000
	0.0143	-0.0010	0.0067	-0.0217
	0.0036	-0.0357	-0.0033	0.0337

Source: the authors' calculations

The expected returns of the observed stocks on a year basis are shown in Table 2.

Table 2. Returns calculation on the year basis

0.38%	AERO
2.16%	ENHL
1.72%	NIIS
-2.49%	SJPT

Source: the authors' calculations

Corresponding standard deviations are presented in Table 3.

Table 3. Standard deviation on the year basis

	N	Std. Deviation
AERO	253	.01627
ENHL	253	.01455
NIIS	253	.01209
SJPT	253	.02009

Source: the authors' calculations

Covariance matrix is presented below.

$$\begin{bmatrix} 0.000265 & 0.000237 & 0.000197 & 0.000327 \\ 0.000237 & 0.000212 & 0.000176 & 0.000292 \\ 0.000197 & 0.000176 & 0.000146 & 0.000243 \\ 0.000327 & 0.000292 & 0.000243 & 0.000404 \end{bmatrix}$$

If the Markowitz procedure i.e. case is applied:

$p=1$ for $n=4$, the optimal conditions (9), (10) and (11) are the following:

$$\begin{bmatrix} 0.000265 & 0.000237 & 0.000197 & 0.000327 \\ 0.000237 & 0.000212 & 0.000176 & 0.000292 \\ 0.000197 & 0.000176 & 0.000146 & 0.000243 \\ 0.000327 & 0.000292 & 0.000243 & 0.000404 \end{bmatrix} \begin{bmatrix} \omega_1 \\ \omega_2 \\ \omega_3 \\ \omega_4 \end{bmatrix} - \lambda_1 \begin{bmatrix} 0.0038 \\ 0.0216 \\ 0.0172 \\ -0.0249 \end{bmatrix} - \lambda_2 \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} = 0$$

$$\begin{bmatrix} \omega_1 & \omega_2 & \omega_3 & \omega_4 \end{bmatrix} \begin{bmatrix} 0.0038 \\ 0.0216 \\ 0.0172 \\ -0.0249 \end{bmatrix} = \overline{r_\pi}$$

$$\begin{bmatrix} \omega_1 & \omega_2 & \omega_3 & \omega_4 \end{bmatrix} \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} = 1$$

From the first system:

$$\begin{bmatrix} \omega_1 \\ \omega_2 \\ \omega_3 \\ \omega_4 \end{bmatrix} = \lambda_1 \begin{bmatrix} -43490000 \\ -173860000 \\ 18240000 \\ 150140000 \end{bmatrix} + \lambda_2 \begin{bmatrix} -481700000 \\ -971400000 \\ 32900000 \\ 1073700000 \end{bmatrix}$$

By incorporating the remaining two equations of the solution, they are expressed as a function of the expected return $\overline{r_\pi}$.

Having in mind that the portfolio risk is

$$\sigma_\pi = \sqrt{\sum_{i=1}^{4} \omega_i^{\,2}} \qquad (12)$$

based on a derivative of the portfolio risk and its equalization with 0, the expected return of the portfolio is:

$$\overline{r_\pi} = 0.14136244,$$

while weight coefficients are the following:

$$\begin{bmatrix} \omega_1 \\ \omega_2 \\ \omega_3 \\ \omega_4 \end{bmatrix} = \begin{bmatrix} -1.15 \\ -7.36 \\ 1.83 \\ 6.68 \end{bmatrix}$$

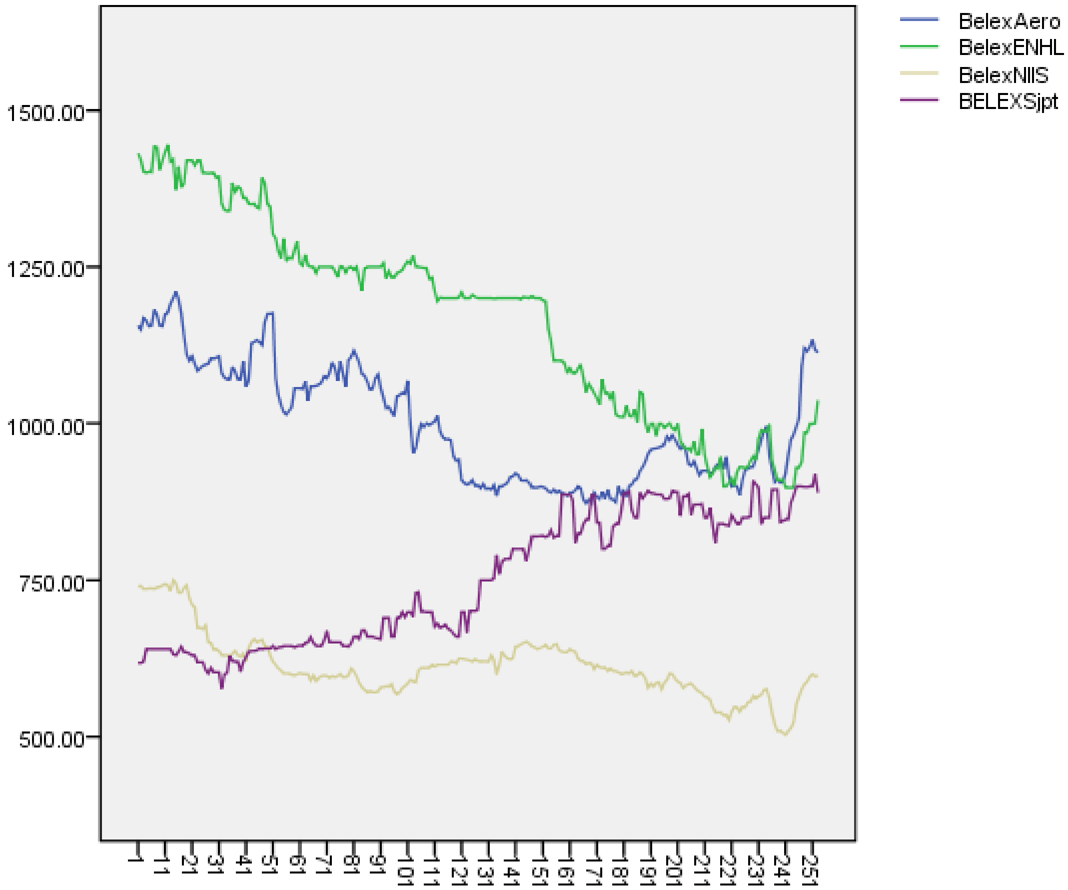

Figure 1. AERO, ENHL, NIIS and SJPT data – 01.01.2016-31.12.2016.

4. CONCLUSION

The results of the research stress the necessity of the dynamic optimization of the investment portfolio, especially having in mind the expected utility maximization.

Having in mind the characteristics of the AERO, ENHL, NIIS and SJPT it is required to further test the possibility of making an optimal investment portfolio, while adequately asses the level of risk.

Further research in the subject field understands widening of the research sample in order to overcome the market and companies specificities, which requires additional modifications of the investment portfolio.

5. ACKNOWLEDGMENT

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Energy analysis of waste management system *"Ponikve eko otok Krk"*

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Abstract

Solid waste causes endangering human health, harming the environment, increasing greenhouse gas emissions, climate changes, depletion of ozone layer, nuisance through noise and odors and overmuch wasting of the natural resources. Therefore, the European policy encourages waste prevention, sustainable use of natural resources, protection of ecosystem and circular economy. Published studies based on LCA (Life cycle assessment) analysis are primarily concentrated in Europe with little application in developing countries, such as Croatia. This article is an introductory part of the research that will include an analysis of the economic, environmental and energy aspects of the various waste management systems in Croatia. This research will provide a detailed and comprehensive energy analysis and waste structure of system „Ponikve eko otok Krk", Croatia. "Ponikve eko otok Krk" is system in which dominates recycling and re-use of products. Specific data per ton of material are obtained and shown in tables and diagrams. Some of these data are electricity consumption in the sorting expressed through mass of sorted material.

Key words: *energy analysis, recycling, solid waste, waste management system*

1. INTRODUCTION

Waste management is defined by all the activities including collection, transport handling, treatment, material and energy recovery and disposal of waste [1].
The traditional "waste management hierarchy" (Fig 1.) is a preferential order of waste treatment options that aims to reduce environmental impacts by prioritizing prevention, reuse, recycling, and recovery over landfill. Unfortunately, landfill is most commonly used and accounts for approximately 95 % of the total collected municipal solid waste (MSW) worldwide [2]. One environmental problem deriving from landfills is groundwater pollution from leachates. Moreover, there are over 10 toxic gases released from landfills, of the most serious of which is methane [3]. Besides, solid waste causes endangering human health, harming the environment, increasing greenhouse gas emissions, climate changes, depletion of ozone layer, nuisance through noise and odors and overmuch wasting of the natural resources.

Therefore, the European policy encourages waste prevention, sustainable use of natural resources, protection of ecosystem and circular economy. One of those waste management systems is "*Ponikve eko otok Krk*", Croatia. This is a system in which dominates recycling and re-use of products.

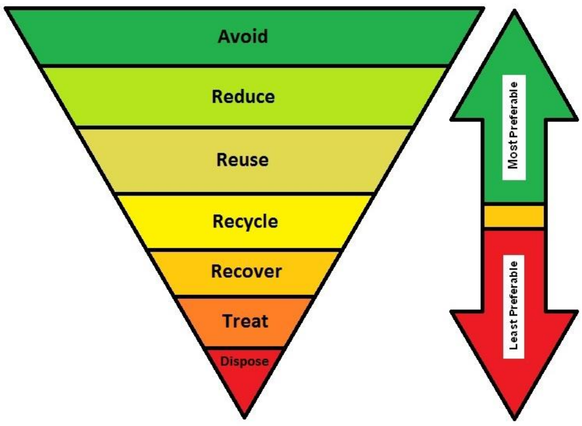

Figure 1. Waste management hierarchy [I]

2. "PONIKVE EKO OTOK KRK"

"*Ponikve eko otok Krk*" is waste management system that refers to the area of Croatian island of Krk. It is popular tourist destination in summer period of the year.

The present waste management system can be divided into two main categories (Fig 2.):

- collection and transport of waste
- treatment of waste and disposal (sorting plant, compost plant and landfill).

The percentage of separated waste in 2016 was about 54 % (Fig 4.). In 2016 started "*door-to-door*" waste collection when additional bins for bio waste were distributed to households.

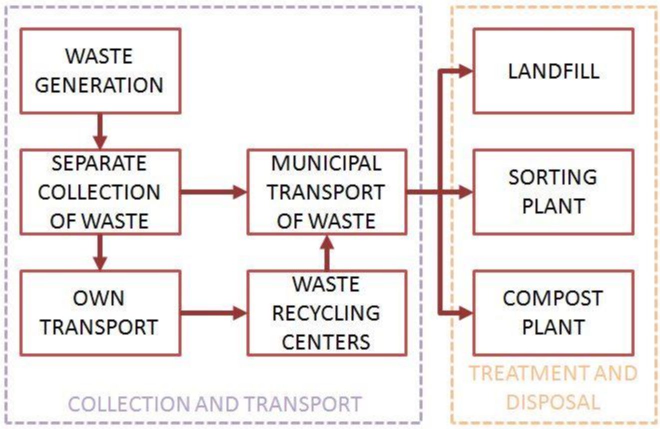

Figure 2. Scheme of waste management system "*Ponikve eko otok Krk*"

3. SYSTEM ANALYSIS

3.1 *Mass analysis*

In Figure 6. overall mass of waste in period 2006-2016 is shown. It is obviously that through years overall mass of waste increases. The cause of that change is not researched yet. Still, it is assumed that one of the reasons is bigger amount of people and another is reduced number of wild landfill. In Figure 7. mass of different waste types in period 2006-2016 is shown. It can be noticed that through years mass of mixed municipal waste decreases when mass of bio waste, paper and cardboard increases. The reason of that is progressively implementing of waste recycling and re-using. It is a slow and complex process in which main role has society and their adaptation.

After all, a minimization of the increase of waste is essential for a more sustainable development of the society [4].

3.2 *Structure of waste*

Waste collection structure is observed from the beginning of transformation of waste management system from period in which disposal of mixed municipal waste was dominated to current state where recycling and reuse of separately collected waste dominates.

Separate waste collection started in 2010 by opening of redemption station for metals and by collecting of olive pomace for the purpose of obtaining high-quality humus. Further activity was the installation of larger containers for different waste types at more frequent locations.

By comparing of figure 3. and figure 4. the change of waste structure in last six years can be observed. It can be noticed increasing of collected bio waste from 12 % in 2010 to 26 % in 2016. The cause of that is implementation "*door-to-door*" collecting system of bio waste. Other values have not been changed during a period 2010-2016.

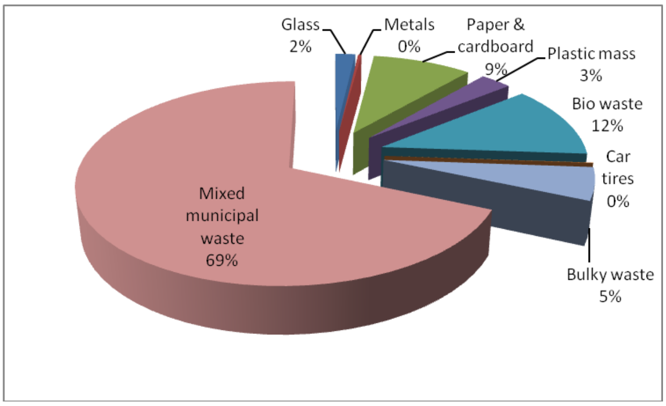

Figure 3. Structure of waste in 2010

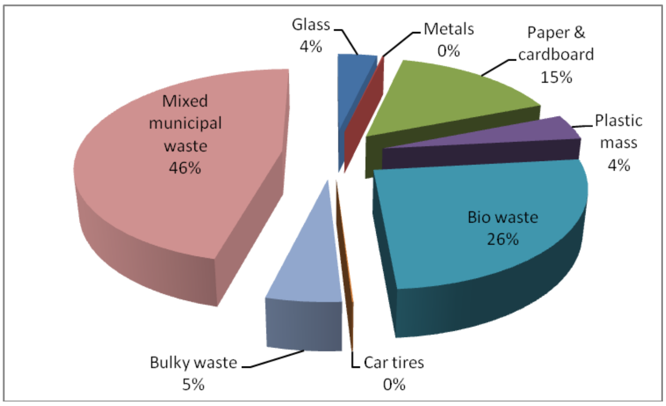

Figure 4. Structure of waste in 2016

In Figure 5. it can be seen that amount of waste significantly increases in summer months (June, July, August and September). This is caused by bigger amount of tourists.

4. ENERGY CONSUMPTION

Energy consumption of this solid waste management system can be divided into three main categories:

- waste sorting plant
- transport of waste
- compost plant.

In this paper electric consumption of waste sorting plant is observed.

4.1 *Waste sorting plant*

Waste sorting plant has an area of 1407 square meters. Over the years the structure of waste sorting plant has been changed. In 2015 the capacity of sorting plant was increased compared to 2012 year (Fig 8. and 9.). Since then two baling presses work at the same time. The reason for change is bigger amount of separated waste (Fig 7).

The consequence of implementation of new sorting structure is increased energy consumption (in kWh per ton of waste) for sorting sector (Fig 10. and 11.). This is because working hours were decreased and nominal power of baling presses was increased.

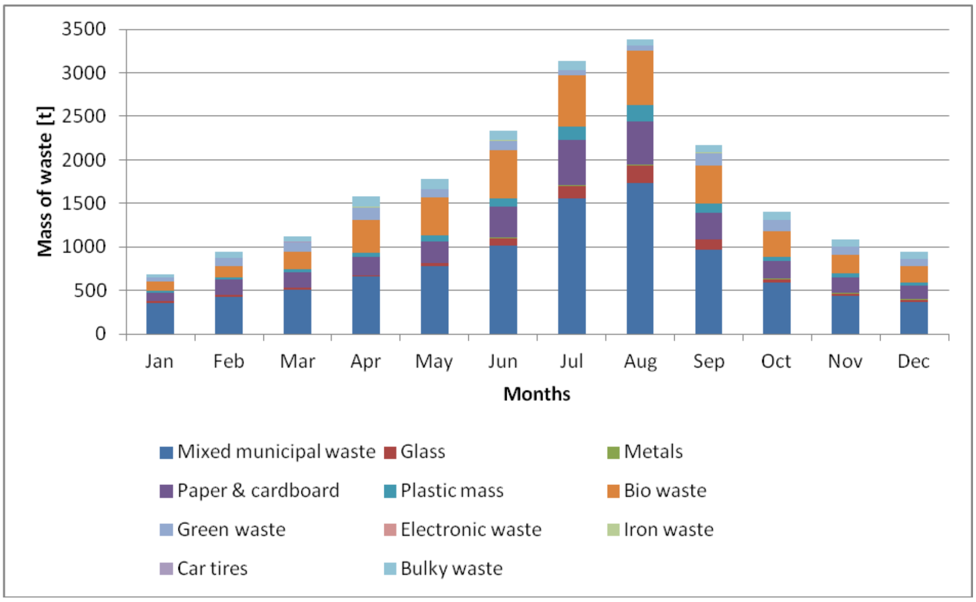

Figure 5. Structure of waste in 2016 per month

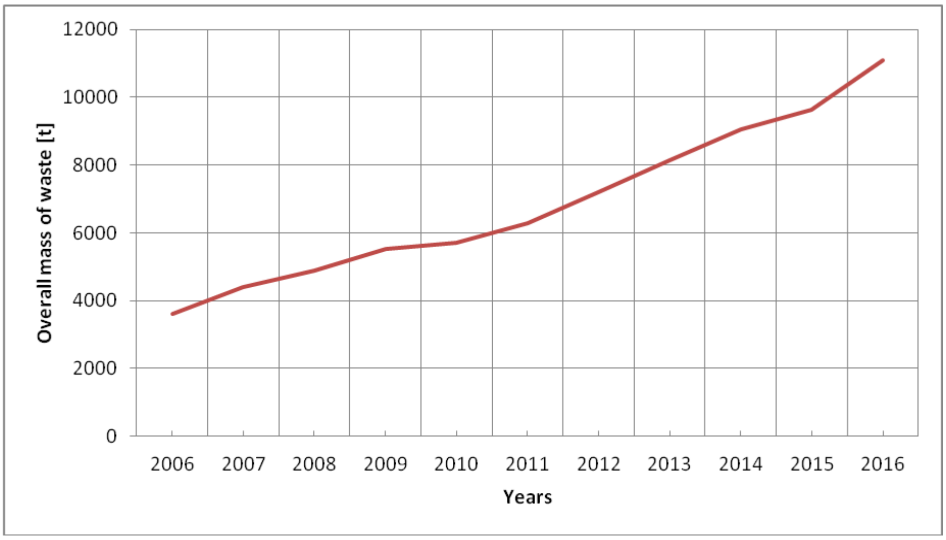

Figure 6. Overall mass of waste in period 2006-2016

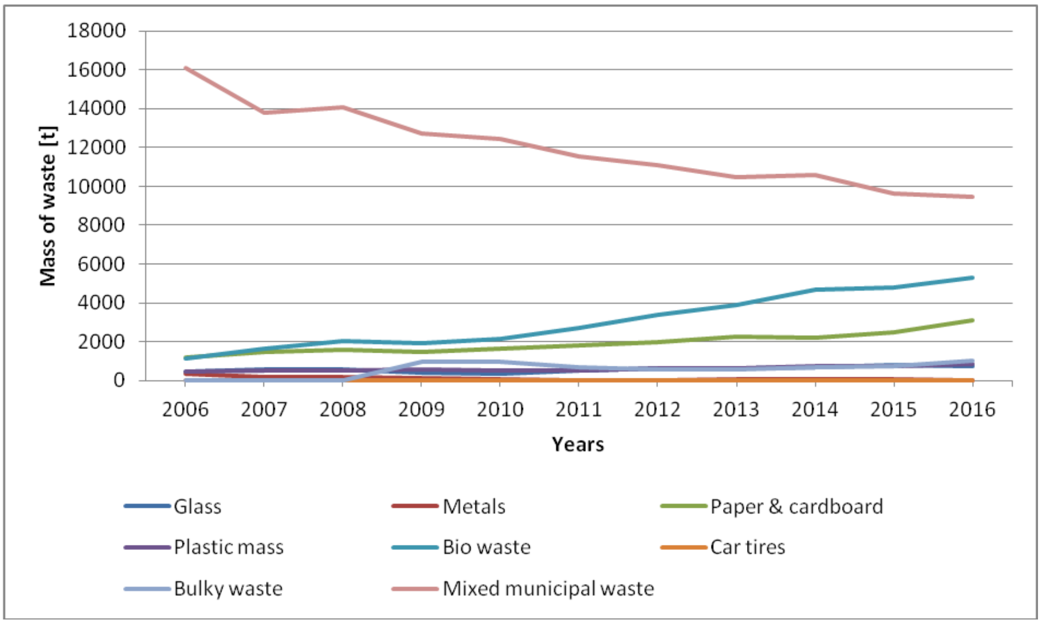

Figure 7. Mass of different waste types in period 2006-2016

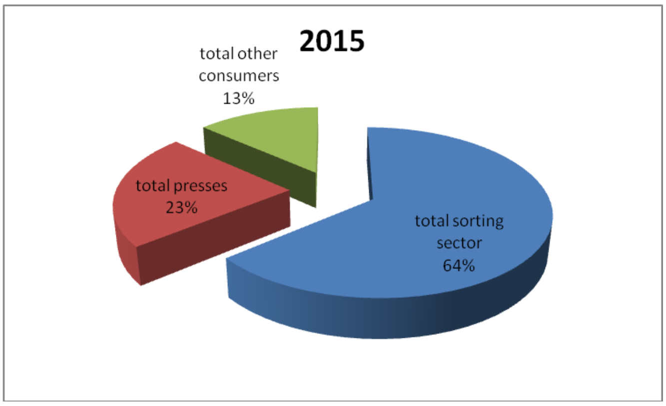

Figure 8. Energy consumption of waste sorting plant in 2015

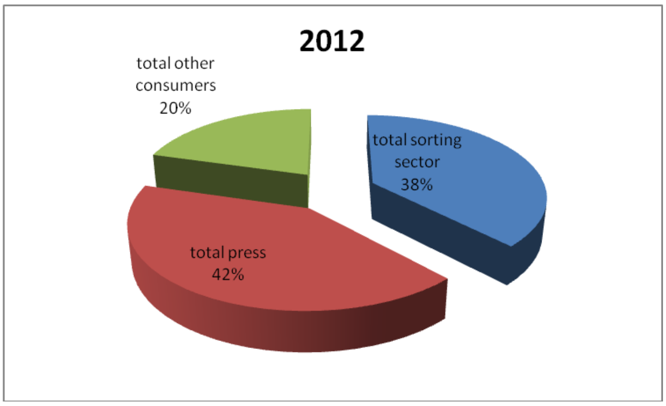

Figure 9. Energy consumption of waste sorting plant in 2012

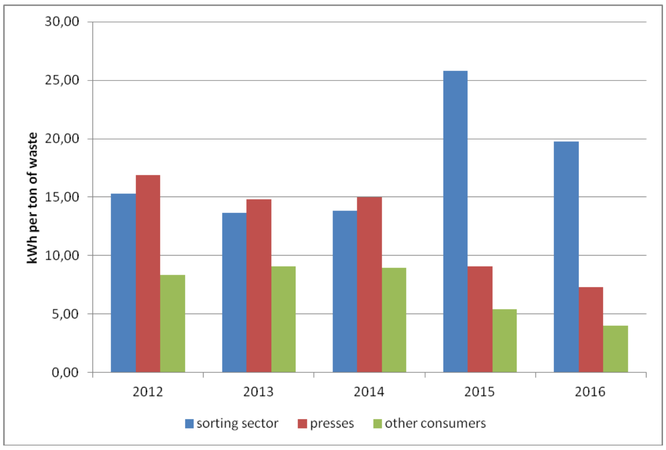

Figure 10. Energy consumption per sector of waste sorting plant in period 2012-2016

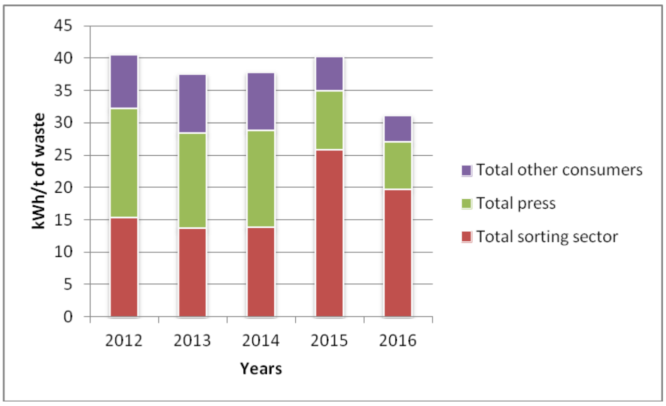

Figure 11. Energy consumption per sector of waste sorting plant in period 2012-2016

5. CONCLUSION

A minimization of the increase of waste is essential for a more sustainable development of the society [4].

For last ten years overall mass of waste in waste management system “*Ponikve eko otok Krk*” increases. The cause of that should be explored in next research. Still, it is assumed that one of the reasons is bigger amount of people and another is reduced number of wild landfill.

The Waste Framework Directive 2008/98/EC include two new recycling and recovery targets to be achieved by 2020: 50 % preparing for re-use and recycling of certain waste materials from households and other origins similar to households, and 70 % preparing for re-use, recycling and other recovery of construction and demolition waste [II]. This goal for waste management “*Ponikve eko otok Krk”* has achieved. The percentage of separated waste from households in 2016 was about 54 %.

The implementation of a new collection system "*door-to-door*" brought a large increasing in separate collection of bio waste.

In further research amount of people for last 5 years should be explored. Afterwards increasing of waste mass can be compared with amount of people.

It should be researched the impact of increasing and decreasing overall energy consumption (in kWh per ton of waste) for sorting plant (Fig 11.).

Moreover, energy analysis for transport of waste and compost plant should be done. Afterwards energy analysis of this waste management system will be complete.

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