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Energy Procedia 95 (2016) 200 – 207

Energy Procedia

International Scientific Conference "Environmental and Climate Technologies", CONECT 2015, 14-16 October 2015, Riga, Latvia

Forecast of waste generation dynamics in Latvia

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Abstract

Plausible data that illustrates future trends of waste production dynamics is essential for waste management system development. Optimal decisions regarding technological solutions for waste management or policy instrument application can be made if correct figures regarding the amounts of waste produced are available. This paper presents a study on the elaboration of estimations of municipal waste generation. The study covers the elaboration of a research algorithm, analysis of characteristics of factors that influence dynamics of waste amounts produced, and the elaboration and analysis of potential scenarios. As a result of this research, a prognosis of the waste amounts to be generated in for Latvia for the 2015 – 2020 period is elaborated.

Peer-review under responsibility of Riga Technical University, Institute of Energy Systems and Environment.

Keywords: waste generation; forecast; indicators

1. Introduction

The factor that significantly affects the functioning of the waste management system is changes in the amounts and composition of waste. Conditions for the operation of the system, necessary technical solutions starting from waste collection stage to waste treatment i.e. recycling facilities, landfill capacities and technologies, to a large extent are dictated by the dynamics of waste production. Plausible projections of waste production dynamics in waste management planning are essential to avoid any situation where infrastructure capacities are underestimated, thus causing inappropriate waste handling, or overestimated – leading to a decrease in the economic feasibility of the system. Review of former experience in Latvia shows that historical data represents considerable fluctuations in the amounts of waste produced, but what is more important – a comparison of previous projections with actual amounts

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Peer-review under responsibility of Riga Technical University, Institute of Energy Systems and Environment.
doi:10.1016/j.egypro.2016.09.049

of waste produced shows that there is significant disparity. The topicality of the issue are in a number of requirements regarding biodegradable waste and recyclable material recovery increase, which should be met in the period up to 2020 – i.e. – the current situation indicates that these requirements could not be met without significant system development activities. In order to make the right decisions regarding specific development activities, the prognosis of waste production dynamics should be elaborated.

The amount of waste generated usually is correlated with the level of prosperity, which is clearly illustrated by the comparative analysis of the volume of waste produced in European Union countries. Although the overall policy target is to break the link between increase of wealth and the corresponding increase in volume of waste produced, the progress varies among different countries. Besides economic conditions, the social ones are considered for elaboration of characteristics of waste production [1], however, the main obstacle is the availability of appropriate and plausible data. In addition, previous studies illustrate a situation where the prosperity level is directly linked to an increase in waste amounts produced [2]. An indicator such as household size also has some impact on waste amounts generated per capita. Namely – a study that was carried out in Finland [3] showed that decrease of household size increases amount of waste produced, as there are fractions of waste that do not depend on number of persons per household. A similar conclusion has been made in research carried out in Mexico [1]. Several case study analyses show results that larger quantities of waste produced per capita have been observed in urban regions [2]. Domestic material extraction is considered as a core indicator in studying a European model for waste and material flows [4].

A number of modelling methods are used for analysing waste flow dynamics i.e.: time series analysis; regression analysis, system dynamics, correlation analysis. According to the study [5] municipal waste generation analysis can be done using time series data of solid waste quantities by applying a technique based on non-linear dynamics with a seasonal Auto Regressive and Moving Average (sARIMA) methodology. The sARIMA model is based on the application of ARMA (Autoregressive moving average) models to transformed time series, where the seasonal and non-stationary behaviour have been eliminated. It is concluded that these methods show impressive results [5], but the downside is the need for a large amount of time series data. These methods are also more appropriate for short-term forecasts [1, 6]. System dynamics modelling is also used to address the elaboration of waste generation forecasts [7, 8]. The advantage of system dynamics is the possibility to include social, economic and environmental aspects in a unified model. A potential weakness of this approach is limited ability to acquire precise numerical results [9] as very detail model calibration should be made to acquire precise results, but calibration possibilities is limited due to lack of valid reference data. Studies exclusively focusing on waste production prognoses for Latvia are not carried out, however, there are in studies which address waste management issues. In a study on packaging waste management in Latvia [10] the system dynamics method is applied. Though exact input figures which are used for modeling are not presented, the trend calculated shows an increase in the amounts of packaging waste produced, which consequently indicates that the overall amount of municipal waste produced should be increasing. On the national level there is a strategic planning document elaborated for waste management system development. This document – "National waste management plan 2013–2020" [11] includes a section on the elaboration of waste management forecast. The modeling method applied for this in the document is based on an approach where waste production dynamics are interrelated to the development of the economy, though detail figures and assumptions applied for the calculation are not presented, thus clearly identifying a need for calculation method clarification in Latvia.

2. Methodology

Approved European Union standards or methodology for the elaboration waste production forecasts, in laws and regulations of waste management sector are not set. In most cases, calculation of expectable waste amounts are based on GDP values as well as on indicators that represent resource and/or goods consumption [12], purchasing power [2]. This approach is built on the assumption that the dynamics of municipal waste production are proportional to fluctuations in GDP values. The amount of waste generated, however, depends not only on the pace of economic development, but also on changes in the number of waste producers and thus waste production forecasting is calculated on the basis of both economic and demographic patterns.

Generally, the factors affecting the dynamics of the total amount of waste generated can be divided into:

- Internal factors - including the amount of waste generated per capita, population changes and changes in the welfare of the population;
- External factors, which include different policy instruments, the purpose of which is to reduce the volumes of generated waste, to promote reuse of waste, etc.

One of the tasks of this research is to identify indicators that are appropriate for the elaboration of forecasts of waste generation dynamics i.e. indicators that have dynamics related to historical data of waste amounts produced. The algorithm of the research process is presented in Fig. 1.

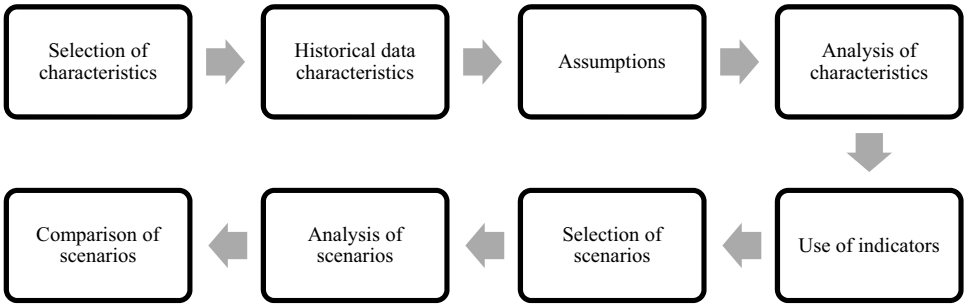

Fig. 1. Research process algorithm.

The research algorithm incorporates the structure of research and main tasks fulfilled. The initial task within the research is the selection of data and indicators that illustrate historical waste production and its relation to welfare characteristics. Indicators - amount of municipal waste collected, packaging waste collected through municipal waste management system - are selected to illustrate the waste dynamics, indicator - GDP at constant prices is selected for welfare level representation. The following step is the analysis of characteristics and indicators selected from a historical point of view which results in the elaboration of certain assumptions – types of waste to be included in municipal waste flow, correlation between waste amounts produced and values of economic development. Historical data that characterises the main indicators (dynamics of waste amounts generated, dynamics of population and GDP) are based on information available from statistical sources i.e.: waste amounts - State statistical report "No.3 – Waste. Report on waste", “National report on environment 2008 - 2011”; dynamics of population and GDP - Central Statistical Bureau of Latvia. It should be noted that historical data quality and availability is a factor that greatly affects the validity of the conclusions and assumptions made. In some cases, historical data raises the question of compliance with the actual situation. In the present case, the assessment of historical data that describes the managed volume of waste has grounds for concern that in some years, seeing changes of indicator value, they may not reflect the true situation (in detail discussed in section 3). Results of the historical evaluation of indicator characteristics are used to develop the potential scenario, which at the end will be incorporated to elaborate waste amount production prognosis. From the point of view of methodology, it should be noted that the term “municipal waste generated” is equivalent to the term “municipal waste collected”, which, considering the level of development of the waste management system, is estimated as an appropriate approach. With regard to the primary data necessary for the development of the forecasts – namely – demographic and macroeconomic indicator projections – EUROSTAT data is used for demographic projections and Ministry of Finance of the Republic of Latvia projections are used for macroeconomic indicators. As the macroeconomic indicator projections cover the period up until 2018, the same values as in 2018 will be applied for the years beyond 2018. Waste prevention policy impact indicators included in the calculation are estimated by the authors. Waste prevention policy impact evaluation is based on assumptions regarding waste produced per capita in Latvia in comparison with EU average figures and EU-level studies regarding possible policy outcomes of waste prevention measures.

3. Results and discussion

According to the historical data of the national indicator "quantity of municipal waste generated per inhabitant" for 2010–2013, fluctuations in amounts of waste produced reached 15 % [13]. In order to assess the possible relationship between welfare changes and the volume of waste produced, the comparison of characteristics was made for a 10-year period. Analysis of the dynamics of waste amounts produced during the considered period shows that the volume of waste generated has changing significantly. Particularly in 2005 and 2006, the volume of waste produced increased by 33 % or, quantitatively – by 226 thousand tonnes per year [14]. In the following period, with slight fluctuations in some years, the trend is towards a reduction of the volume produced. Analysing possible causes of the extreme rise in amounts of waste produced in 2006 compared to prevailing values in other years, there is a possibility that the increase most likely reflects the accounting system variations in 2006, rather than the actual waste production increase. Comparing the values of indicator "quantity of municipal waste generated per inhabitant" to dynamics of the GDP values, it can be concluded that the decrease in the volume of waste is directly linked to the Global financial crisis in 2008 which left substantial negative impact on Latvian economy and welfare as well. At the same time, it should be noted that, although there are common trends in both indicators, their relationship is not linear and the fall in the level of welfare has longer-term effects on waste production. Probably the reduction of waste amounts produced in the period after this crisis are linked with some changes in habit of waste producers. Respectively – during crisis households carried out expenditure reduction - probably, also intentional reduction of waste produced was one of those cost saving measures and this habit may continue even after the state of welfare improves. Historical values of indicators are reflected in Fig. 2.

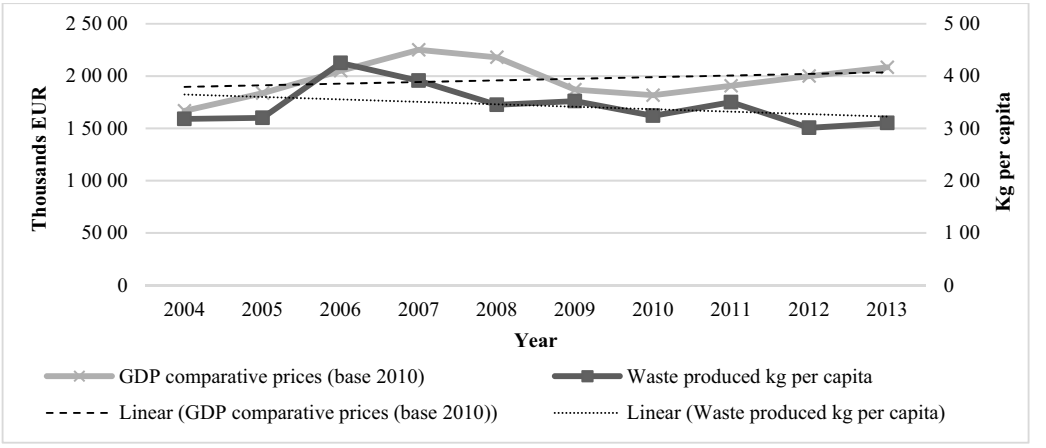

Fig. 2. Waste amounts produced and GDP dynamics 2004–2013.

An additional aspect regarding historical characteristics of waste amounts produced is related to the types of waste included in the calculation of the municipal waste flow. The basic approach includes the assumption that packaging waste, although the source of generation is households, is not included in municipal waste amounts. It is clear, however, that packaging waste from households is processed within the system of municipal waste management. It should be noted that, within the framework of the existing waste accounting methodology, in some cases packaging waste is reported as non-packaging recyclable materials and in other case so called non-packaging is related to packaging waste flow. In order to identify possible relation between amounts of municipal waste, packaging waste collected and GDP indicator dynamics [15], a comparison of calculation methodology "with" and "without" packaging waste from households included in total municipal waste quantities is made. The results are presented in Fig. 3.

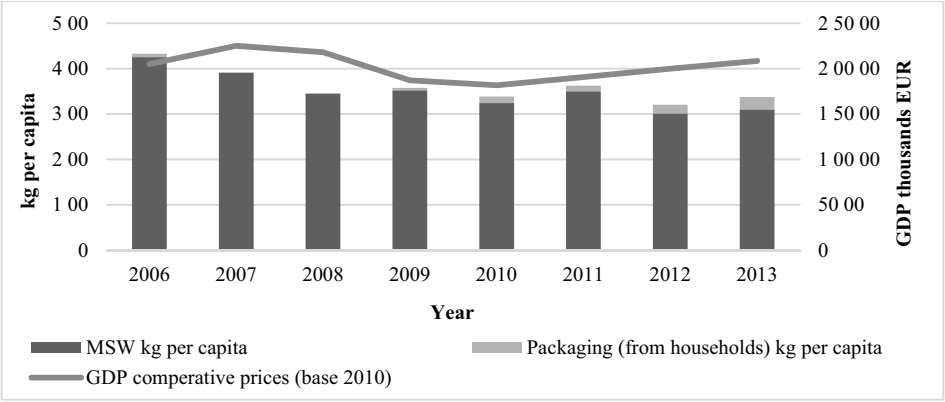

Fig. 3. MSW and packaging waste from households in comparison with GDP values 2006–2013.

Comparing scenarios “with” and “without” the inclusion of packaging waste in the total amount of municipal waste produced, that scenario “with” packaging waste amounts included shows narrower amplitude fluctuations compared to GDP values over the years, so, in fact, this approach could more accurately describe the actual amounts of total municipal waste produced. It should be noted that the amount of packaging waste collected separately during the period considered shows an increase, which also confirms the validity of the assumption. With regard to the relationship between GDP dynamics and amounts of waste produced, it should be noted that the relationship is not directly proportional. In the standard practice of elaborating waste production forecasts so far, changes in the amount of waste generated are expressed as 1/3 of the GDP changes at constant prices. In order to compare the rate of compliance between GDP dynamics and waste produced, simulation of waste production forecast for 2004 – 2013 has been made. During the simulation historical data for waste amounts generated were compared with three theoretically calculated scenarios where different shares of GDP values are applied. Fig. 4. summarizes the results of these simulations.

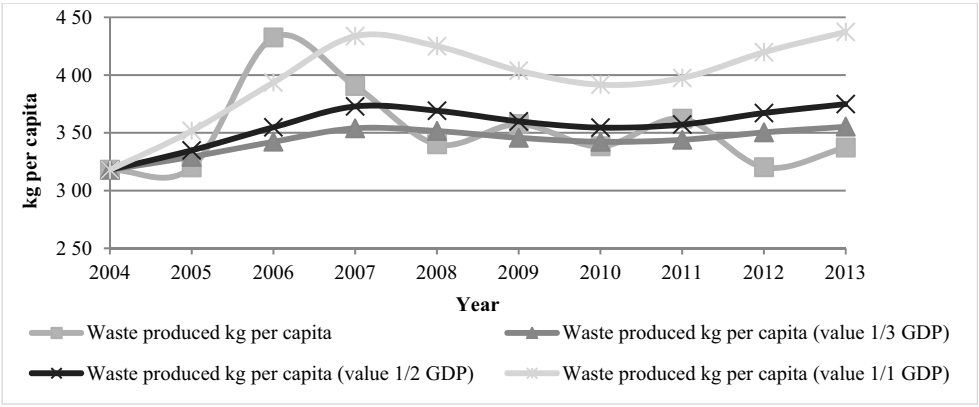

Fig. 4. Waste prognosis simulation using by applying different fraction of GDP value 2004–2013.

The results of the calculations show that none of the scenarios calculated correspond directly to the historical waste production data, though the scenario where share of 1/3 of GDP value is applied, could be identified as the most realistic one. One of the factors that affects the accuracy of the forecast is the increase in the amount of waste produced in 2006 compared to 2005. Also, it is concluded that the dramatic fall of GDP in 2008 – 2010 does not fully reflect in the waste amounts produced – this fact can be interpreted on the bases of assumption that a certain amount of municipal waste is unavoidable, i.e. a certain amount of waste occurs as a result of carrying out t basic functions -

respectively - except for the extreme situations, the value of the indicator below this threshold cannot be expected.

By evaluating the waste prevention policy in Latvia, it is concluded that, national document ”Waste management state plan 2013 – 2020” [11] foresees number of activities and expectable quantitative result of these activities is to keep value of the indicator “quantity of municipal waste generated per inhabitant” value below 400 kg per capita. At the same time, although the exact trends of waste reduction policy impact cannot be determined, considering topicality of waste prevention issue, it is necessary to include waste amounts reduction indicator in the prognosis calculation. Waste prevention measures are provided, at both the national and EU level. The issue of a common market and the activities carried out in other countries also needs to be taken into account, especially concerning the use of instruments such as eco-design, makes a positive impact on the reduction of waste amounts produced also in Latvia. At the same time, considering the amount of waste generated in Latvia which is already substantially lower than the EU average, as well as the schedule of the implementation of national waste prevention measures, the waste reduction factor is not identified as a key element in forecasting waste production. Though, as a number activities are scheduled and also there is expectable some transboundary influence, in calculation there is included an assumption made by authors, that waste amounts produced due to prevention activities will decrease from approximately 0.1 % in 2015 to 1 % by 2020.

One crucial factor, besides waste amounts produced per capita that influences total amount of waste produced is the resident population. EUROSTAT demographic projections developed for Latvia provide 5 possible scenarios:

- No migration;
- Reduced migration;
- Higher life expectancy;
- Main scenario;
- Lower fertility.

All of the scenarios for 2015 to 2020 foresees a reduction of the population in the territory of Latvia. Population decrease depending on the scenario during the calculation period of prognosis varies from 3.76 – 8.38 % [16], see Fig. 5. The key assumption in demographic projections is that the cause of population reduction is net migration. As it is presented, the scenario without the impact of migration “No migration scenario”, shows a slower pace of reduction in the population than others. The remaining scenarios illustrate very similar trends – the total reduction in the population in -these scenarios differs only by about 0.24 percentage points. Accordingly, as currently there is no argument in favour of improving the migration balance, the conventional “Base” scenario forecast will be used in the calculation of forecasts of waste amounts.

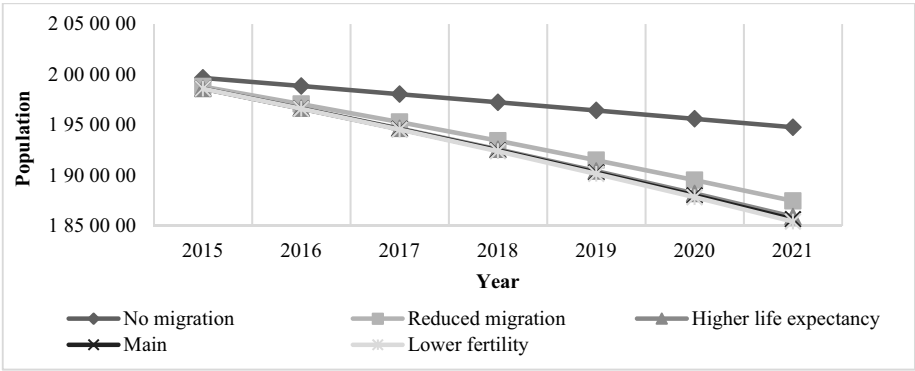

Fig. 5. Demographic forecasts for Latvia 2015–2020.

Municipal waste production forecasts for Latvia for 2015 to 2021 are elaborated on the basis on the following factors and assumptions:

- Forecast base year 2014, Indicator “amount of waste generated per capita” value for base year 343 kg;
- Changes in the amount of waste per capita are expressed as 1/3 of the GDP changes at constant prices;
- Numerical values of GDP dynamics [17], population projections [16] and impact of waste reduction policy are presented in Table 1.

Table 1. Numerical values of indicators for prognosis period.

Year	2015	2016	2017	2018	2019	2020	2021
GDP	4.7 %	2.9 %	3.0 %	2.9 %	2.9 %	2.9 %	2.9 %
Population	1 985 887	1 966 178	1 945 886	1 924 789	1 902 747	1 880 087	1 856 500
Impact of waste reduction policy	-0.100 %	-0.300 %	-0.500 %	-0.800 %	-1.100 %	-1.400 %	-1.700 %

Municipal waste production prognosis for the period from 2014 to 2020 is presented in Fig. 6.

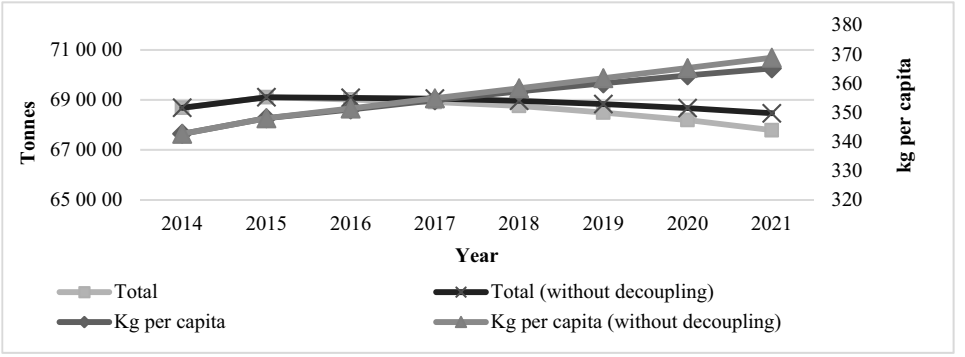

Fig. 6. Municipal waste production forecast, Latvia 2014–2021.

4. Conclusion

The forecasting elaborated shows an increase in the volume of waste generated per capita in the reporting period from 348 kg per capita in 2015 to 363 kg per capita in 2020. This is caused by positive GDP dynamics in the reference period, which leads to an increase of waste amount produced per capita. The forecast also illustrates that the estimated impact of waste prevention measures does not exceed the growth rate caused by prosperity growth. If the planned waste prevention measures [11] did not materialise accordingly to authors estimated values, the amount of waste generated per capita will rise up to 365 kg in 2020.

Total municipal waste amount production forecast, shows consistent decrease from 691.0 thousand tonnes produced in 2015 to 681.9 thousand tonnes produced in 2020. This decrease is influenced by demographic conditions i.e. quite rapid decrease of population in the country. If the planned waste prevention measures fail, the predicted amount of waste produced in 2020 will rise to 686.7 thousand tonnes.

It must be concluded that the fluctuations estimated are not significant and there will be no drastic changes in waste volumes produced, which would adversely affect the functioning of the waste management system. Note, however, that the credibility of the projection is largely affected by demographic forecasts and GDP dynamics compliance with the actual situation, so it is necessary in the reference period to update the data characterising the GDP and population, particularly focusing on the population, because former experience shows that population change has a much greater impact than GDP.

References

[1] Benķtez SO, Lozano-Olvera G, Morelos RA, de Vega CA. Mathematical modeling to predict residential solid waste generation. Waste Management 2008;28:7–13.

[2] Purcell M, Magette WL. Prediction of household and commercial BMW generation according to socio-economic and other factors for the Dublin region. Waste Management 2009;29:123–1250.
[3] Sokka L, Antikainen R, Kauppi PE. Municipal solid waste production and composition in Finland—Changes in the period 1960–2002 and prospects until 2020. Resources, Conservation and Recycling 2007;50:475–488.
[4] Andersen FM, Larsen H, Skovgaard M, Moll S, Isoard S. A European model for waste and material flows. Resources, Conservation and Recycling 2007;49:421–435.
[5] Navarro-Esbrı J, Diamadopoulos E, Ginestar D. Time series analysis and forecasting techniques for municipal solid waste management. Resources, Conservation and Recycling 2002;35:201–214.
[6] Beigl P, Lebersorger S, Salhofer S. Modelling municipal solid waste generation: A review. Waste Management 2008;28:200–214.
[7] Dyson B, Chang NB. Forecasting municipal solid waste generation in a fast-growing urban region with system dynamics modeling. Waste Management 2005;25:669–679.
[8] Kollikkathara N, Feng H, Yu D. A system dynamic modeling approach for evaluating municipal solid waste generation, landfill capacity and related cost management issues. Waste Management 2010;30:2194–2203.
[9] Rogelio O. Model calibration as a testing strategy for systemdynamics models. European Journal of Operational Research 2003;151:552–568.
[10] Berzina A, Dace E, Bazbauers G. Analysis of Ecodesign Implementation and Solutions for Packaging Waste System by Using System Dynamics Modeling. Environmental and Climate Technologies 2010;4:22–28.
[11] The Ministry of Environmental Protection and Regional Development, “National waste management plan 2013-2020”. Riga; 2013.
[12] Bruvoll A, Ibenholt K. Future waste generation forecasts on the basis of a macroeconomic model. Resources Conservation and Recycling 1997;19(2):137–149.
[13] “National report on environment 2008 – 2011. Latvian Environment, Geology and Meteorology Centre; 2012.
[14] State statsitical report No.3 – Waste. Report on waste. Latvian Environment, Geology and Meteorology Centre.
[15] Central Statistical Bureau of Latvia. Gross domestic product. Available: http://data.csb.gov.lv/pxweb/en/ekfin/ekfin__ikgad__ikp/?tablelist=true&rxid=a79839fe-11ba-4ecd-8cc3-4035692c5fc8 [14.07.2015]
[16] EUROSTAT Population projections. Available: http://ec.europa.eu/eurostat/data/database?node_code=proj [14.07.2015].
[17] Macroeconomic indicators. Available: http://www.fm.gov.lv/en/s/macroeconomics/main_macroeconomic_indicators/ [12.07.2015].