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Faculty of Engineering Economics and Management
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THE ECONOMIC ASPECTS OF HAZARDOUS WASTE MANAGEMENT IN LATVIA

Summary of Doctoral Dissertation

Branche: Management Science
Sub-branche: Management of Enterpreneurship

Research supervisor
profesor, Dr. habil. oec., Anatolijs MAGIDENKO

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DOCTORAL DISSERTATION

PROPOSED TO THE RIGA TECHNICAL UNIVERSITY FOR THE PROMOTION TO THE SCIENTIFIC DEGREE OF DOCTOR OF ECONOMICS (*Dr.oec.)*

The Doctoral dissertation has been developed at the Department of Production and Enterpreneurship Faculty of Engineering Economics and Management of Riga Technical University (RTU). The defending of the Doctoral dissertation will take place during an open meeting of the Promotion Council „P-09“, Faculty of Engineering Economics and Management of RTU on May 10, 2011, Riga, 1/7 Meza Street at 10 a.m. in the room 209.

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CONFIRMATION

I hereby confirm that I have worked out this Dissertation that has been submitted for review to Riga Technical University for the promotion to the degree of Doctor of Economics (*Dr.oec.)*. This dissertation has not been submitted to any other university in order to recieve any scientific degree.

Nora Dubro.....

April 6, 2011

The Doctoral dissertation is written in Latvian. The totat page count is 180 p. Dissertation consists of introduction, 3 parts, conclusions and proposals, 29 tables, 50 figures and 12 annexes. The Bibliography contains 344 sources of references.

The Doctoral dissertation and Summary are available at the Scientific Library of Riga Technical University, Kipsalas Street 10.
To submit reviews please contact Secretary of the RTU Promotion Council „P-09“ professor, Dr.habil.oec. Anatolijs Magidenko; 1/7 Meza Street, Riga, LV-1007, Latvia.
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GENERAL DESCRIPTION

Topicality

On the threshold of the XXI century discrepancy between human activities and natural features that lead to environmental disaster has became obvious. Ecology and economy are in eternal conflict, thus modern scholars have to find compromise between economic development and ensuring of environmental quality. It is impossible to refuse from production and consumption processes and each of these processes result in reduction of products value, moral and physical depreciation that provokes necessity to dispose them. Consequently, waste production is an inevitable result of economical activity, which can be adjusted by the efficient use of resources, substitution of hazardous materials and development of innovative low-waste production technologies, as well as recovery of materials and repeated utilization.

Negative impact of waste on environment depends on the composition of the waste. Currently, the world is generating an unprecedented amount of waste in the whole human history. The total annual amount of waste in the world is 3100 millions t, structure of which is the following: 1,800 millions t is a non-toxic industrial waste, 1200 millions t - municipal waste and 100 millions t - toxic waste. Amount of chemicals used by humanity now is more than 100 thousands. Total value of manufacturing plants across the world in the middle 1990s reached 1500 milliards USD that 4 times exceeded this indicator three decades ago. Significant pat of chemicals gets in the air, soil and surface water.

The existence and security of mankind depend on the state of environment. More often people realize that threat to nature implies also threat to health, property, capital, the existing order, the country and the entire world.

The ecological and economic aspects of environmental protection acquired special urgency relatively recently, that is associated with the rapid increase of production and scientific-technical revolution. Nowadays economic growth rates promoted the aggravation of deficit problem of world's limited natural resources.

Impact of natural resources limitation on the perspectives of economic development is growing steadily: in result of declining of energy resources, mineral resources, increasing areas of unused land, raw materials and waste problems became topical globally.

In addition, it is important to take into account that in the system "economy-environment" preference cannot be given to any of elements, but it is necessary to ensure an

interaction of elements so that high production, economic and wealth fare growth rates are harmonized not only with the preservation of environment, but also with the principles of improvement and development of environment. Indicators of economic growth should be balanced with the natural resource usage and waste generation levels.

In world economic practice hazardous waste (HW) is understood as waste containing substances harmful for environment and health and, therefore, is not permissible to treat hazardous waste as household waste, as this can damage living organisms.

HW management system is recognized as the major environmental issue, which should be considered not only from ecological, but also from economical and social point of view. Waste Management, including HW Management System is one of the major Latvian national environmental and regional development investment strategies and environmental problems. Currently HW is the major environmental risk in Latvia. Large amount of HW causes the load in environment and pollutes it with dangerous substances. Although the HW problem in Latvia is receiving increasing attention, at present there is not a single Latvian hazardous waste management system (HWMS), whose services would be accessible to each resident and business. Until 1995 there was not any element of the HWMS in Latvia. HW was held in the territories of industrial enterprises, deposited in municipal waste landfills and other sites unsuitable for this purpose, causing significant threat to human health and environment. Unfortunately, still large amount of HW is not managed in manner secure to environment and health. Big part of HW gets in the municipal waste landfills, but some of them are stored in long-term temporary housings.

In addition, economical management problem of HW does not end only in neutralization of historical stock and current waste stream. The main purpose of sustainability concept is prevention of waste production and waste minimization, as well as waste processing in socially, environmentally and economically efficient manner, focusing on energy saving and alternative methods for the development.

Global practice shows that the HW problem must be tackled in a deeper level: it is necessary to develop low-waste technologies, to stimulate the market for ecological services, promote development of environment friendly products and technologies, to improve and harmonize statistical, administrative and legal mechanisms. Accordingly, the main economic aspects of HW management are related to regulation of turnover of product containing hazardous materials and choice of HW management methods balancing the best technical solutions with the available financial resources, ensuring compliance with the Latvian Republic (LR) and the European Union (EU) legislation.

Topical aspects of HW management system are development of methods of organizational and economical management as well as management of innovative activity in order to promote production process, improvement and modernization of companies and equipment, establishment of new technological lines, production of competitive products, use of highly productive technologies as well as modification of processing, recycling, deposition processes of HW.

Now HW management processes lack scientific reasoning. There is no systematic approach to HW management in Latvia, it lacks economically based methodology for HW economic management, for evaluation of risks and socially economic consequences, does not exist detailed on economic criteria based approach to HW management. HW system does not have clear determined boundaries. There is no philosophically economic understanding of the meaning HW management and consequences of this problem. Several assumptions in HW management aspect are controversial. Incomplete and improbable statistics on HW generation amount and its movement burdens planning of financial resources for HW. It can be concluded that there lacks understanding of HW concept. Companies lack stimulus for introduction of cleaner technologies in production. Main problems in HW management sphere are no effective coordination of HW management, insufficiently based determination of priority direction in the process of the distribution of limited financial resources. The above mentioned facts prove the topicality and well timeliness of this work.

Object and subject of the research

Object of dissertation - institutional units of HWMS (hazardous waste management system).

Subject of dissertation – economic aspects of HW sustainable management.

Theoretical and methodological basis of dissertation forms fundamental researches of Latvian and foreign scientists and analysis of experiments and results of generalization. Methodological postulates of systematic analysis of interaction processes of technological, organizationally economic and ecological factors of HW recycling, regeneration and utilization processes and products manufacturing are used in the research.

Aims and tasks of dissertation

Aim of dissertation is to work out methodology and theoretical basis for the economic management of HW.

For attaining of the established aim the following **tasks** were brought:

1.To identify economic aspects of HW management problems in Latvia and to work out basic principles of HWMS.

2.To investigate and evaluate current situation and development potential of HWMS in Latvia.

3.To determine priority directions of economic strategic management of HWMS in Latvia.

4.To work out methodologically based mechanism for economic influence of HWMS and ecologically-socially-economically based mechanism for HW economic management.

5.To work out basic approach to HWMS and methodological bases for HW innovative management.

6.To work out theoretical postulates for the development of standard base for HW management economic evaluation.

Theses established for defense:

1. Sustainable HWMS is delayed by the lack of functioning scientific basis for HWMS. Economic management of HW is performed basing on the incomplete statistical data basis concerning physical amount of HW. Physical amount of HW is one of the significant factors though it is not enough bases for HW economic management. Taking into account the difference of waste in the level of hazardness even in the frame of one hazardous substance, it is necessary to establish standardized indicator – unity of hazardness and to determine its price for ecologically-socially-economically HW efficient management.

2. HW negative impact on the environment and human health considerably decreases perspectives of socially-economic development. Any economic advantage from the HW impact on environment is questionable and it is necessary to promote its prevention by restructuring the industry and by use of substitute resources.

3. Significant aspect of HW sustainable management is providing of ecological-social-economic balance between the use of the products containing hazardous substances and prevention of HW production. For providing of HW sustainable management, it is important to compare economic effect from the prevention the use of the products containing hazardous substances and improvement of HWMS (technologies and infrastructure for HW processing and recycling).

4. The main stress in Latvian HW management is made on EU separate control indicator and fulfillment of regulations which prove the significant subordination of state

administrative bodies and formulation of regional tasks orienting on partly corresponding priorities that match technically economical potential of separate territories.

Methods of the research

During the development of the dissertation the following research methods were used: scientific analysis (analysis of HW kinds, HWM system and its management, HW impact on the environment, scientific researches and publications), synthesis (reviewing of interaction of ecologic and economic aspects in order to establish ecologically-socially-economically effective HWM system), evolutionary method (review of HWMS historical development in Latvia and in the world, normative documents that regulate HW management), assessment of experts (review of the reports of the competent institution on HWM, claims, suggestions and points of view), methods of mathematic modulation. When solving precise tasks technically economic analysis, mathematical statistics, comparative, analytic and graphic methods were used that allow disclose essence of the researched object. For providing demonstrative results of the research the author used tables, diagrams and pictures.

Theoretical and methodological basis of the research

Theoretical and methodological basis of the research are scientific works in the sphere of econometric modulation, rational use of the natural resources, HW management and assessment of eco-effectiveness of Latvian and foreign scientists and specialists. (A.Pigu, K. Rihters, A. Endres, N. Pahomova, V. Leontjev, Dr. Marcus Lehni, Hendrik A. Verfaillie, Robin Bidwell, Kaspar Mueller and Dr. Andreas Sturm, Lawrence K. Wang, Lawrence K. Wang, Yung-Tse Hung, Howard H., Richard N.L. Andrews, Raymond J. Burby, Alvis G. Turner); A. Magidenko; K. Didenko, Dz. Atstaja. Information from Central Statistical Bureau of LR and electronic reports of the Ministry of Environmental Protection and Regional Development as well as information on HW management issued by stock corporation Organization of hazardous waste and by state stock corporation Hazardous wastes management state agency, materials from scientific conferences and seminars, publications in mass media, specialized editions and Internet were used in the research work. The offered novelty was worked out basing on the EU Regulations and Latvian normative acts in the sphere of HW management as well as standards of ISO quality. Information and experience accumulated by the author of the dissertation during international scientific conferences, seminars, lectures, implementation of scientific projects while working at Ministry of

Environment of the Republic of Latvia and Riga City Council are significant theoretical and methodological basis of this work.

Restrictions of the research

Due to so many aspects of HW economic management problems and limited size of the paper the following restrictions are determined for the research:

1) only those significant HW economic management economic instruments and mechanisms are research which can be used for the achievement of research aim;

2) due to the limited size of the paper only those economic aspects of problem are observed which have the most important role in sustainable development of HWM system;

3) information concerning HW and its classes is provided in such a level that ensure overall economic impression concerning HW concept and economic essence of management system;

4) information is provided basing on the existing norms, set of laws and statistical data basis in the time period till 1 November, 2009;

5) the paper is worked out basing on the data of Central Statistical Bureau of LR on HW generation, recycling amounts and financing in the period from 2000 till 2009 and environment experts evaluation for the time period from 2004 till 2029.

Scientific novelties of the dissertation:

Main elements of novelty are the following:

1. Basing on the analysis of HW economic essence as well as on the research of world and Latvian legal order, economic definition of HW concept and new approach to hazardous waste management is offered.

2. After summarizing of legal basis of LR and EU for regulation of HWMS, standards of ISO quality, normative acts controlling innovative processes and granting of financial support, the scheme of legal system of hazardous waste sustainable economic management was drafted.

3. In the result of the study of the legally-economic role of the state and nongovernmental organizations on HW management, the scheme of institutional arrangement of HWM the base of which is structural unit was worked out. Collaboration, competence and participation effectiveness of structural units determine politics of HW economic management and social-ecologic-economic effectiveness.

4.For scientific substantiation of HW management in Latvia, theoretical framework of HWM was worked out that includes:

- The philosophy of HWM that is based on HWM four-areas – amount, hazardness, time and costs - model that is offered by the author;
- Scheme of HWM theory structure;
- HWM axioms and theorems. Set of axioms and theorems is offered which can be used for HW economic management;

5. Basing on the study of the world practical experiences and taking into account particularities of Latvian national economy, the author has offered and formulated the mechanism of HW innovative management including:

- the method of evaluation of price of hazardness unity;
- formulas of HW economic impact assessment;
- the scheme of HW statistical basis simplified template;
- the scheme of HW economic clarification;
- the mechanism for optimization of intensity of HW management activities (tetrahedron of HW economic management strategies and decision-making matrix);
- the marketing method of HW material management;
- the costs optimization method of HW processing;
- the formula for HWM eco-efficiency assessment.

Approbation and practical application of research results

The most substantial research results are presented in information forum and are discussed during scientific conferences as well as used in the following scientific projects:

1. Latvian Council's of Science project Nr.04-1026. The Role of Information Resources in the Development of Entrepreneurship of Latvia. 2008. Performer.
2. Latvian Council's of Science project Nr.1144. Economic aspects of innovation development in Latvia. 2009. Performer.
3. Latvian Council's of Science project Nr.09.1607 (02.02.2010. – 30.12.2010.) „Development of Latvian economic sectors and prediction of competitive using modelling tools, and economic aspects of innovative activities". Latvian Council of Science project Nr.1144. Economic aspects of innovation development in Latvia. 2009. Performer.
4. Ministry's of Education and Science Republic of Latvia (MES) RTU project R7217. Management of waste collection and processing. 2007. Performer.
5. Ministry's of Education and Science Republic of Latvia project Nr.R7215 „Analysis Tools of Dynamic Business Environment: research developments". 2007. Performer.
6. RTU project ZP-2008/13. Economic aspects of hazardous waste management in Latvia. 2008.- 2009. General contractor.

Scientific publications

Research results are published in 22 scientific publications among them 11 articles in reviewed and internationally accepted editions, 2 of which are articles in MES database:

1. Dubro N. The Main Principles of Hazardous Waste Management in Latvia. Economics and Entrepreneurship - number 3, vol. 15, 2007, p. 47. - 57.

2. Dubro N., Magidenko A., Didenko K. Economic Aspects of Hazardous Waste Management in Latvia. Economics and Entrepreneurship - number 3, vol. 16, 2008, p.35. – 45.

3. Dubro N., Magidenko A. Hazardous waste influence on Latvian Forestry economic results. XI-th International Scientific Conference "Management and sustainable development". Управление и устойчивое развитие Nr.2, 2009, Bulgary, Jundola, p. 59. - 66.

4. Dubro N. Innovation implementation in hazardous waste management system and eco-efficiency. 49 th International Scientific Conference of Riga Technical University „The problems of development of national economy and enterpreneurship", October, 2008, Latvia, Riga. Disk published. 6 pages, CD-ROM.

5. Dubro N., Magidenko A. Economic aspects of implementation of Innovation in Hazardous waste management system in Latvia. VI International Scientific conference „Management and engineering'08", June, 2008, Bulgary, Sofia – Sofia, 2008, p. 25. – 328;

6. Dubro N., Magidenko A. Иновационное управление опасными отходами в Латвии. VII International Scientific Conference „Management and engineering", June, 2009, Bulgary, Sozopol – Sozopol, 2009, p. 201. – 206.

7. Magidenko A., Dubro N. Организационно-экономические аспекты управления опасными отходами в Латвии// Международный семинар «Организационно-экономические проблемы современного производства в условиях глобализации экономики, October, Russia, Moscow. – Москва: МИЭТ, 2009, p. 50.-55.

8. Dubro N., Magidenko A. Hazardous Waste Management Philosophy and System of Evalution of Economic Impact. EKONOMIKA UN UZŅĒMĒJDARBĪBA**.** UZŅĒMĒJDARBĪBA UN VADĪŠANA. number 3, vol. 19, ISI Web Knowledge, 2009, p. 38.- 47. (EBSCO);

9. Dubro N., Magidenko A. System of Evalution of Hazardous Waste Economic Impact. 50. th International Scientific Conference of Riga Technical University, SCEE'2009 "Scientific Conference on Economics and Enterpreneurship." Latvia, Riga, 2009, 10 pages – CD-ROM.

10. Dubro N. The economic measurement of hazardous waste's parameters in waste management. 5-th International Scientific Conference „Business and Management", May, 2008, Lithuania, Vilnius – Vilnius: „Technika", 2008, p. 242. – 249. (Thomson Reuters „ISI Web of Knowledge");

11. Dubro N., Magidenko A., Didenko K. Об иновационном подходе к экономическому управлению опасными отходами. III International Scieintific Conference "Knowlage Society", Bulgary, Sofia, Volume 2, Nesseber, June, 2010, p. 12. – 17.

Other publications:

12. Dubro N., Magidenko A., Didenko K. „ Economic Aspects of Hazardous Waste Management in Latvia". 48. th Scientific Conference of Riga Technical, April, 2007, Latvia, Riga – Riga, RTU, 2007, p. 9.

13. Dubro N., Magidenko A., Didenko K. The Main Principles of Hazardous Waste Management in Latvia. 48. International Scientific Conference „The problems of development of national economy and enterpreneurship", October, 2007, Latvia, Riga. – Rīga: RTU, 2007, p.19.

14. Dubro N. Innovation implementation in hazardous waste management system and eco-efficiency. 49 th International Scientific Conference of Riga Technical University „The problems of development of national economy and enterpreneurship", October, 2008, Latvia, Riga – Rīga: RTU, 2008, p. 40. – 42.

15. Dubro N. Principles of hazardous waste economical classification. 49 th International Scientific Conference of Riga Technical University „The problems of development of national economy and enterpreneurship". 49 th International Scientific Conference of Riga Technical University „The problems of development of national economy and enterpreneurship", October, 2008, Latvia, Riga – Rīga: RTU, 2008, p. 42. – 43.

16. Dubro N., Magidenko A. The Economic measurement of hazardous waste's parameters in waste management. 5-th International Scientific Conference „Business and Management", May, 2008, Lithuania, Vilnius – Vilnius: „Technika", 2008, p. 85. – 86.

17. Dubro N., Magidenko A. System of Evalution of Hazardous Waste Economic Impact. 50 th International Scientific Conference of Riga Technical University, SCEE'2009 "Scientific Conference on Economics and Enterpreneurship", October, 2009, Latvia, Riga – Rīga: RTU, 2009, p. 21.

18. Informācijas resursu ekonomiskā nozīme Latvijas uzņēmējdarbības attīstībā. Magidenko A., Gaile-Sarkane E., Didenko K., Lāce N., Ketners K., Jansons V., Dubro N. LZP Ekonomikas, juridiskās un vēstures zinātnes galvenie pētījumu virzieni 2008.gadā Nr.14., 2009, p. 100. – 106.

19. Dubro N. Ecological aspects of ecological projects management in Latvia. Development of research methods: Management of knowledge, August, 2008, Latvia, Riga - Rīga: RTU, 2008, p. 11. – 13.

20. Dubro N., Magidenko A. Инновационность системы управления хозяйственной деятельностью в области опасных отходов в Латвии. V(XVII) Всеукраїнської науково-практичної конференції, 2009, marts, Ukraina, Kijeva - Київ: НТУУ «КПІ», 2009, p. 23.

21. Inovatīvās darbības attīstības ekonomiskie aspekti Latvijā. Magidenko A., Gaile-Sarkane E., Didenko K., Lāce N., Ketners K., Dubro N., R.Greitāne. LZP Ekonomikas, juridiskās un vēstures zinātnes galvenie pētījumu virzieni 2009.gadā, Nr.15., 2010, p. 109. – 115.

22. Dubro N., Magidenko A., Didenko K. Bīstamo atkritumu inovatīvās vadīšanas teorētiskie aspekti. RTU 51. Starptautiskā zinātniskā konference „Scientific Conference on Economics and Enterpreneurship" (SCEE'2010), October, 2010, Latvia, Riga - Rīga: RTU, 2010, p. 26.

Author has presented research results of the dissertation in **16 international scientific conferences and seminars** with the following reports:

1) 15.11.2007. VI Международная научно-практическая конференция студентов, аспирантов и молодых учёных «ЭКОЛОГИЯ И НАУЧНО-ТЕХНИЧЕСКИЙ ПРОГРЕСС»; report „Основные проблемы и ключевые принципы эффективного управления опасными отходами в Латвии" (Perm);
2) 11.10.2007 - 13.10.2007. 49 th International Scientific Conference of Riga Technical University „The problems of development of national economy and enterpreneurship"; report „ The Main Principles of Hazardous Waste Management in Latvia" (Riga);
3) 06.12.2007 - 07.12.2007. Всероссийская конференция с международным участием «Перспективы развития инноваций в энергоресурсосбережении»; report „Перспективы энергоресурсосбережения в процессе управления опасными отходами в Латвии" (Perm);
4) 15.05.2008 – 17.05.2008. The 5th International Scientific Conference "Business and Management'2008" (Vilnius);
5) 19.06.2008 – 21.06.2008. VI INTERNATIONAL CONFERENCE "MANAGEMENT AND ENGINEERING" (Sofia);
6) 27.08.2008 - 28.08.2008. 2-nd International Summer School for doctoral students and Workshop „Development of Research Methods: Management of Knowledge. Report „Ecological aspects of ecological projects management in Latvia" (Riga);
7) 09.10.2008. - 13.10.2008. 49-th International Scientific Conference of Riga Technical University „The problems of development of national economy and enterpreneurship" (Riga);
8) 12.03.2009-13.03.2009. V(XVII) Всеукраїнської науково-практичної конференції "СТРАТЕГІЧНЕ УПРАВЛІННЯ ТЕХНОЛОГІЧНИМ РОЗВИТКОМ ІНФОРМАЦІЙНО-КОМУНІКАЦІЙНИХ ПІДПРИЄМСТВ" (Kiev);
9) 20.03.2009. - 22.03.2009. XI-th International Scientific Conferenec "Management and sustainable development" (Jundola);
10) 22.06.2009 – 24.06.2009. VII INTERNATIONAL SCIENTIFIC CONFERENCE "MANAGEMENT AND ENGINEERING' 09" (Sozopol);
11) 02.09.2010. - 04.09.2010. IV INTERNATIONAL SCIENCE CONFERENCE for YOUNG RESEARCHERS "TECHNICAL SCIENCE AND INDUSTRIAL MANAGEMENT" (Sofia);
12) 23.09.2009. – International Scientific Conference of Riga Technical University and Ministry's of Education and Science Republic of Latvia „Innovations and new technologies" (Riga)
13) 15.10.2009. - 16. 10.2009. 50 th International Scientific Conference of Riga Technical University, SCEE'2009 "Scientific Conference on Economics and Entrepreneurship" (Riga);
14) 26.10.2009. – International Scientific Seminar «Организационно-экономические проблемы современного производства в условиях глобализации экономики» (Moscow);
15) 15.10.2010. 51 th International Scientific Conference of Riga Technical University SCEE'2010 "Scientific Conference on Economics and Enterpreneurship" (Riga);
16) 26.04.2007. – 48 th International Scientific Conference of Riga Technical University (Riga)

Size and structure of the paper

Dissertation is independent scientific research that is worked out in Latvian language and consists of introduction, table of contents, conclusions and suggestions, bibliographic content and attachments.

Table of contents consists of three chapters:

1.Economic interpretation and meaning of hazardous waste concept in sustainable development of Latvian economics;

2.Basic approaches to hazardous waste management theory;

3.Mathematic modelling of hazardous waste management and approbation of models.

The first chapter contains interpretational analysis of HW economic management and HW concept, evaluation of meaning of its understanding for sustainable development of state. Main deficiencies of HW concept understanding are established which can cause misunderstanding in the choice of management methods process, violation of laws and different speculations. As a result, it was determined that HW concept has special, unambiguous and ecologically-economically based interpretation. Review into history of HW management was provided as well as analysis of regulative normative base of HW management was performed, overview of strategic principles and politics of HW management was provided on the basis of which legally-economic base for HW innovative management and mechanisms for institutional system were offered. Analysis of HW structure and dynamics in European countries and in the world was performed, economic aspects for improvement of HW infrastructure were offered, financially-economic mechanisms for HW management were explored in the improvement sphere.

In the second chapter the author formulates theoretical basis for HW economic management and offers new philosophy of HW management in the framework of which traditional and innovative HW management systems were formulated and basic theoretical approaches to HW management were worked out. In the framework of innovative HW management system the author expresses basic principles that result from environmental legislation of LR and EU regulations, directives and decisions. The main axioms that show essence of HW management were formulated. In the base of axioms six HW management theorems were offered.

Third chapter contains mathematic formulation of HW management modules and their experimental test. Idea of HW management is offered and substantiated basing on the evaluation of unity of hazardness that is integral indicator of HW physical amount and level of hazardness. The method of evaluation of price of unity of hazardness is offered. To prevent statistical deficiencies, the mechanism for calculation and control of unity of hazardness was offered. In the basis of the worked out innovation the author offers to use mechanism for optimization of intensity of HW management activities that can serve as balance between the use of the products containing hazardous substances and financing of implementation of ecologization actions. During the research the main regularities of HW recycling processes were discovered and methodology for optimization of characteristics of HW recycling process was offered.

Materials of the dissertation can be used for making decisions on environmental investment projects and for the planning of Latvian economics development.

MAIN SCIENTIFIC DEVELOPMENTS OF THE WORK

1. Economic interpretation and meaning of hazardous waste concept in sustainable development of Latvian economics

HW philosophy as well as its structure and dynamics is altering during the time and in every country it develops under the influence of changing economic, social, cultural and political factors. Still one of the main aspects that determines basic features and tendencies of HW market (including the use of processing and recycling methods) is a question about the interpretation of HW concept that in the world is one of the reasons for conflict among industrial companies, lawyers, economists, environmental and political officials as well as separate countries. During the research the author has concluded that discrepancies in the HW concept interpretation are one of the factors promoting deficiencies in statistical calculations.

In the result of HW economic essence analysis it was concluded that HW is non-natural formation, product of scientific and technological purposeful impact on natural elements that obtaining resources from the earth depth and modifying them simultaneously disarranging environmental balance. Thus it is necessary to determine HW concept with the special, unambiguous and ecologically-economically based interpretation to provide effectiveness of HW calculation, registration and corresponding management.

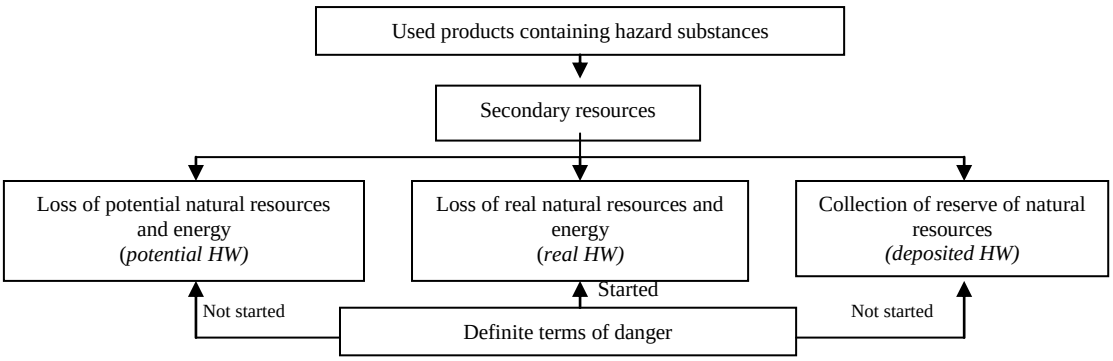
It can be concluded that HW generation process facilitates not just pollution of environment but also loss of the materials and energy as well as additional costs and ecological consequences relevant to collection of waste, provisional storage, recycling and utilization processes.

From the point of view of economic management the following HW summary definition is offered: HW is *natural resources* which under the influence of anthropogenic factor (human) has changed its spread or has acquired one/several hazardous characteristics that make them dangerous for human life, health, environment and person's property in case of *definite terms of danger*. HW is economic loss, resources that are recognized to be useless for economic activities due to technologically limited options.

Definite terms of danger in author's interpretation are requirements for the display of dangerous features of waste in the result of which hazardous substances, components of physical energy or microorganisms penetrate into environment in such an amount that cause changes in physical-chemical structures of natural elements or leave negative impact on people. The most popular example in economic practice are un-appropriate management of

products (economic benefit) after their physical or moral use, termination of period of use as well as in case of accident.

Thus in the framework of the offered interpretation, products containing hazard substances till the beginning of the definite terms of danger is offered to consider as *secondary resources.* Depending on the status of definite terms (started/not started) three natural resource groups can be established: 1) economic loss of potential natural resources and energy or *potential HW*; 2)) economic loss of real natural resources and energy or *real HW; 3*)) economic collection of reserve of natural resources (see 1.1.pic.).



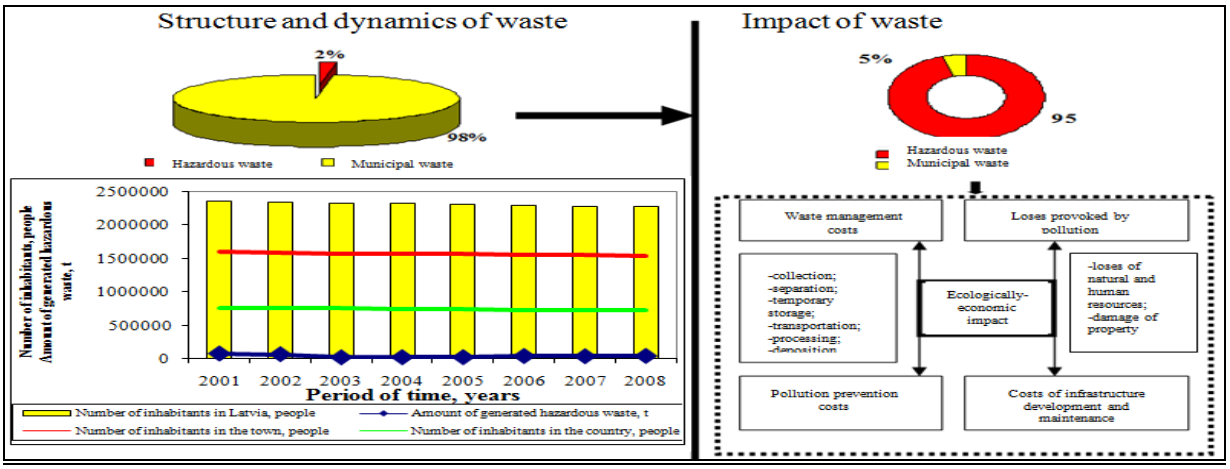
1.1.pic. Hazardous waste as secondary resources

Useless products containing hazardous substances, the secondary use or recycling of which at present is not possible due to technical-economic factors but which are deposited in environmentally safe manner is offered to consider as *collection of reserve of natural resources* and to store in specially equipped site.

Under nowadays globalization and development circumstances it is obvious that it is necessary to safe energy, to organize economic system so that the basic recourses would be secondary raw material, occurred transition to low-waste production technologies and level of toxic substances would be limited in produced goods. Important place in globalization of resource use have principles of replaceability of resources that prescribes mutual replaceability of natural components with components that dominate according to economic criteria and are ecologically safer. It is important to notice that not all substitution of technically mutually replaceable components corresponds to requirements of economic and ecologic mutual replaceability and vice versa.

The main aim of HW management system is the minimization of HW hazardous impact. Though HW is not the main creator of pollution, its characteristic features make it very dangerous for environment and health of living beings. In its turn health problems that are provoked by the contact with HW are difficult to prove because human health is influenced by many other factors. Each type of waste provokes individual health problems

depending of substances physical-chemical characteristics and personal physiological features of influenced object. When characterizing the essence of the HW dangerous impact on development of Latvian economics it can be said that the caused impact is not proportional to its specific weight in overall amount of produced waste and significantly exceeds it in financial sphere (see 1.2.pic.)



1.2.pic. The essence of the hazardous waste economic impact

HW impact can be seen in the loss and costs of direct and potential resources that are connected to management process. Different HW groups can provoke different scale of losses. According to evaluation results of direct or non-direct hazardous impact on environment, HW can be divided into hazardous classes according to the amount of economic loss.

Evaluation of HW economic impact is necessary not only for the choice of optimal technical solutions, but also for providing of management system that corresponds to states financial and economic opportunities. HW economic impact should be understood as results of real/potential actions/inaction provoking direct or non-direct damage/benefit that is evaluated in financial means. *Damage* is the loss of human life and health, environment as well as personal property in the result of hazardous waste impact. *Benefit* is profit from prevention/decrease of HW resources, innovative management of waste flow and actions for development of infrastructure of HW management.

Now one of the most significant steps in the direction of HW sustainable management system is the retrieval of raw materials and recovery of waste that are suitable for secondary recycling processes. As the result of recycling new resources and energy are saved. 70% of waste from the municipal waste totality is possible to use as secondary raw material and as source of energy production. Experts' reviews show that the refusal from waste utilization

produces additional opportunities – calculation of models basing on USEPA (United States Environmental Protection Agency) data shows that repeated use and recycling of 70% of waste in USA would have promoted saving of 14,8 millions USD that is equal to exclusion of 5,4 millions of cars from exploitation. Equally from 1 t of recycled mobile phones 150g of gold can be produced.

Diminishing of HW unfavorable impact in Latvia should be adapted to „Zero Waste" concept which in last twenty years is widely known in all industrially developed countries adopting ideas and principles of total quality created in Japan in ecologic sphere. Originally idea of total quality management conception was based on principle of Zero Defects working out methods that allow totally exclude defective articles.

Main instruments of prevention/limitation of HW dangerous impact are severe control of emission of chemical connections, economically based rating of the use of hazardous substances in the process of production, optimization of company placements with the intention of minimization of hazardous emission from transport and management of produced HW according to the alternative management hierarchy offered by EU. In general legislation of LR on waste management results from the EU politics on waste management. Basis of HW legislation form three directives: Directive 2006/12/EC of the European Parliament and of the Council of 5 April 2006 on waste that is new edition of previously existing basic Directive 1975/442/EEK on waste, Directive 91/689/EEC on hazardous waste with amendments 94/31/EEK and Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste.

Development of new technological processes which are directed to the development of zero waste production that is characterized not just by providing of high technical-economic indicators, but also complex approach to the use of natural resources. Still due to technical and economic reasons transition to zero waste technologies with closed cycle can not be performed in short term. Real ecologization course of technologies contains gradual transition to intermediate of low waste technologies. Results of the research show that in present economic circumstances entrepreneurs do not have stimulus for introduction of cleaner technologies in production which can be changed by adopting corresponding political decisions in the sphere of financial support. More effective HW management requires creating and maintaining of based, balanced and flexible financial administration that includes the use of guarantees, subsidy, taxes and penalties. It should be taken into consideration that financial instruments and norms of legislation can not be alternatives, they should be harmonized.

It should be taken into account that groundless determination of financial instruments can cause contrary ecologic-economic result. For example, too high level of taxes on natural resources concerning deposition of HW can facilitate unauthorized waste disposal. During the analysis of the situation it was concluded that when determining economic instruments for the development of HW management system, the main aim is to create *stimulant mechanism* that prescribes not only financial support but also penalty sanctions that would give consumers or producers stimulus to change their behavior t.i. to create financial instruments for reduction of waste production and introduction of cleaner technologies.

Environmental experts offered schema of sustainable HW management that ensures effective reflexive string with the producer of the product and main principles: to base on the products life-cycle and to orient on the gaining of benefit from the use of the product through product life cycle; to define precisely articles of responsibility; to adapt ecologization strategies to precise system of goods; to stimulate introduction of innovation, concentrate on the successful gala results not the processes; to work out based base of indicators for evaluation of ecologic-economic results; to prescribe participation of interested people in ecologization strategy. For the providing of the mentioned principles the author has offered scheme of legal base of sustainable HW economic management and organizational mechanism of institutional systems that unite four legal and institutional aspects: 1) politics of modification of products containing hazardous substances; 2) politics of innovative entrepreneurship; 3) politics of financial support; 4) politics of HW management.

In order the system is methodologically based and cheap for its user, equality principle of payment is noted in the mechanism of hazardous waste management: it is necessary to exclude possibility to impose one object with a tax repeatedly, for example, payment rate for HW deposition should not include payment for storage of waste and payment for waste receipt at site according to Law on natural resources tax actually rate already includes payment for waste receipt at site.

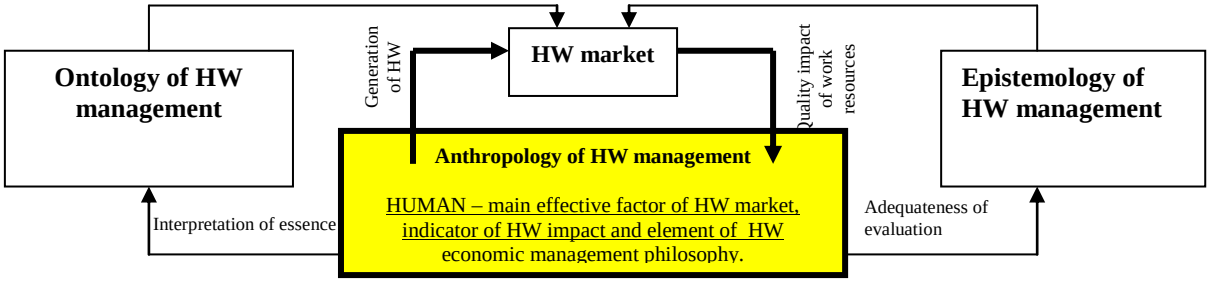
Significant role in solution of HW management problems has international cooperation main reasons of which are unwarranted spread of hazardous substances across the borders in the result of circulation of environmental elements which in its turn determines necessity of development of united political and technical management strategies, innovative strategies and possibilities of improvement of political quality, necessity of information circulation and common research, improvement of accessibility of financial resources for solving of HW management problems, due to international financial support.

2. Basic approaches to hazardous waste management theory

Peculiarities of particular state HW management philosophy are determined by the combination of several qualitative and quantitative factors and compliance of their exhaustiveness. During the process of introduction of state HW management system it is important to critically evaluate experience of other countries and possibilities of their adoption, to adjust to the influence of affective factors and their changes. That is why it is important to work out HW management philosophy.

Basing on the aspects of research of general philosophy as science it is concluded that basis for the development of HW management philosophy is *economic evaluation* that includes not just analysis and modulation of *effective factors of HW market* but also formalization of the results of *HW impact on economic development*. Grounding on this, main components of HW management, acceptable for author's opinion, are formulated 1) ontology of HW management – specification of HW essence, unification of objective, subjective, physical, social, legal and technologic factors in economic management view; 2) anthropology of HW management – specification of active and passive roles of human factor in HW generation and management processes; 3) epistemology of HW management – research of correctness and adequateness of HW economic management conception and conceptualization of ideal economic model. Epistemology of HW management prescribes several scenarios of HW management according to potentially possible changes of effective factors. The *concept* of HW management *philosophy* is defined by author as science about origin, socially-economic impacts and research principles of HW. Cycle of research is created by the following chain: scientific problem – hypothesis – theory.

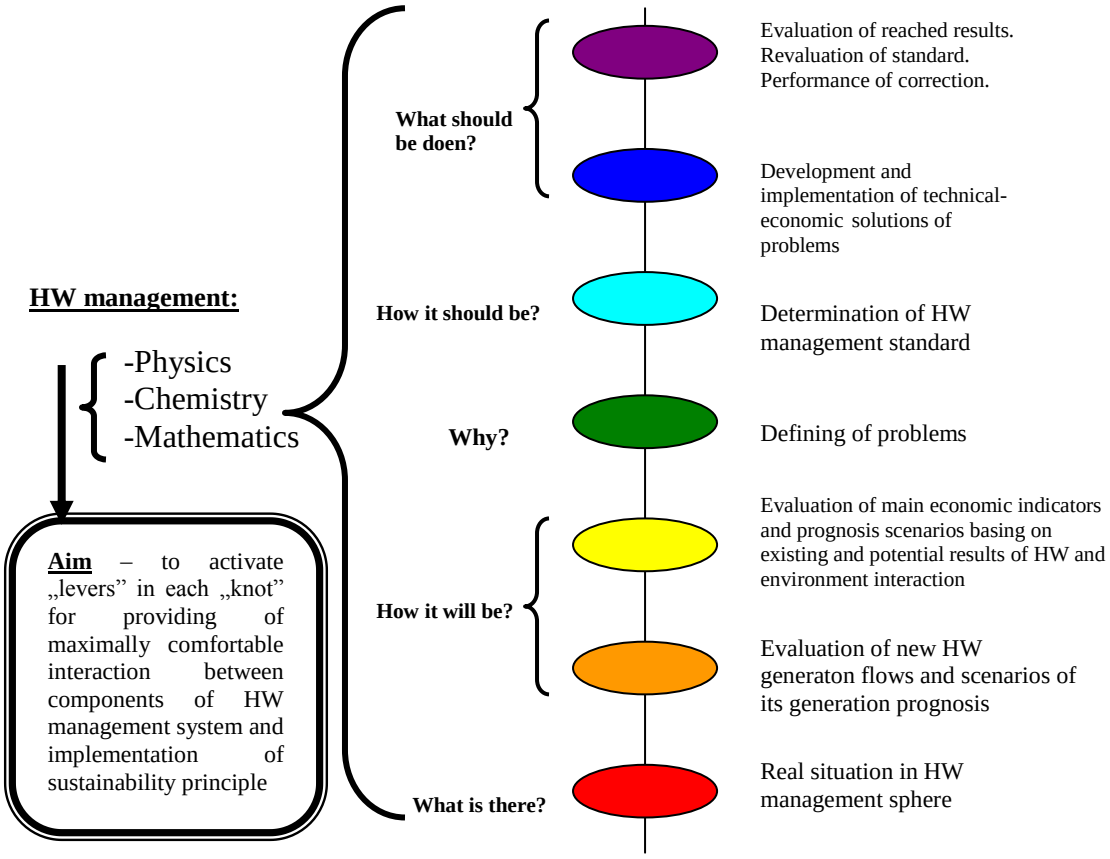
Ecology of environment in many aspects depends on us. During research it was concluded that human factor in anthropological understanding of HW economic management is, first, effective factor of dynamics and structure of HW market, secondly, main indicator of HW impact on socially-economic environment (see 2.1. pic.).



2.1.pic. Interaction of hazardous waste management philosophy components

Hazardous waste pollution results from human economic activity and is the main factor of its hazardous impact on the environment. Ecologic situation in the country indicatively reflecting in the quality of natural resources, accordingly influences also compliance of natural resources to requirements of labor market and their operational capacity – ability of potential individuals perform useful activities in certain level of effectiveness in particular time which would in direct way reflect in the level of welfare of life and determine perspectives of state's sustainable development. Accordingly, such general economic growth factors as offer and demand, quality of natural resources, amount of capital resources, level of development of new technologies, demand and division of resources can be expressed through quality indicator of work resources and HW economic impact can be measured with the element of demographic component of work resources quality indicator – health level of country inhabitants.

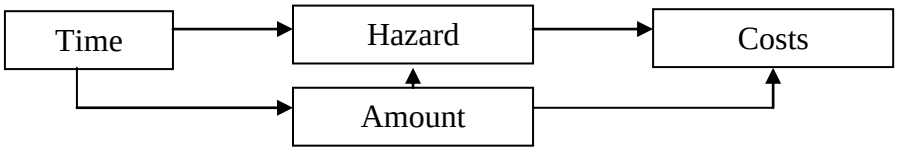
Political sphere is the main effective factor of HW market (both stimulant and delaying). From the point of view of validity of political decision, as well as the aim of the political decisions depends HW management base and its regularity which is developed from seven "knots" (see 2.2. pic.) and their engagement "levers" – "knots" activation actions.



2.2.pic. System of seven "knots" for hazardous waste management systematization

It can be established that activation of seven “knots” system for systematization of HW management should occur through introduction of actions in management practice which are economic evaluation and coordination instruments determined by the results of scientific research of separate aspects with the help of which it is possible to obtain development of HW management system.

It should be noted that for the activation of each “knot”, state, municipality and private structures should be involved. The main principle of conceptualization of HW management philosophy bases on tetrahedron of economic management (see 2.3. pic.).



2.3. pic. Tetrahedron of hazardous waste economic management

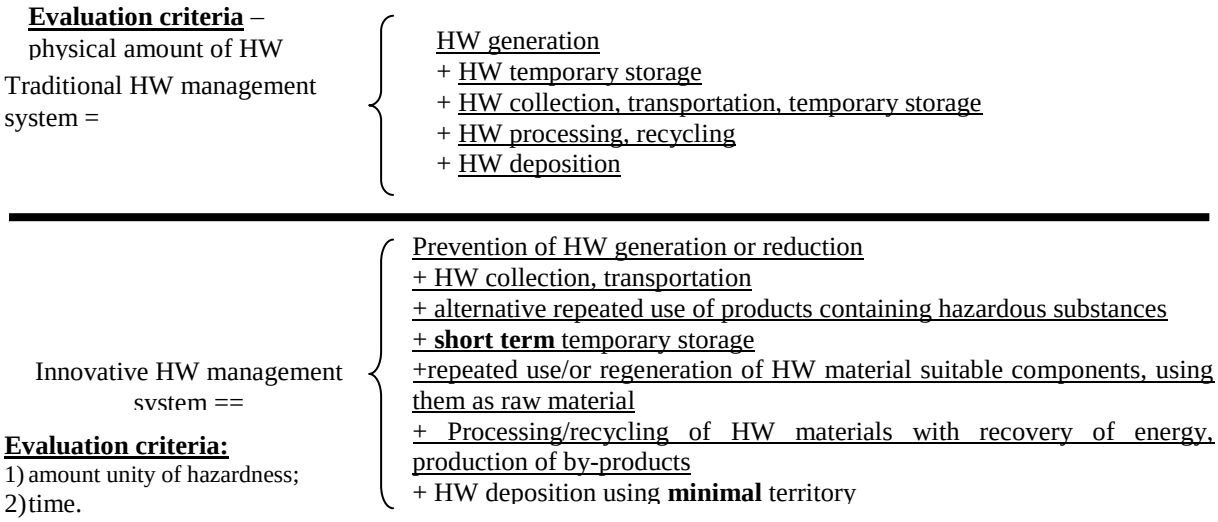
Requirement for effectiveness maximization of all HW management processes is minimization of time, hazard and costs of management process.

The main stress in HWM plans is made on the implementation of separate EU control indicators and directives which are characterized by significant subordination of local government institutions and formulation of regional tasks orienting on the discrepant, customized priorities of technical-economic potentials of separate territories. Author considers that implementation of EU control indicators is compulsory, but indicators should be corrected according to socially-economic features characteristic to specific territory and should be resulted from strategy of state HW management and its general tasks instead of serving as its basis and reasoning.

For realization of strategy it is necessary to provide four implementation points: 1) presentation of strict and precise requirements; 2) changes of promotion system; 3) development of special financial strategy for transition of management system; 4) introduction of specialized social institutes.

The offered conception should be evaluated with the help of flexible control indicators system. During the process of conception realization it should be provided that control indicators are flexible, could be regularly revaluated according to the quantitative measures of aim gaining progress, they should be realistic, but at the same time they should be ambitious enough and should stimulate integration of radical innovations into HW management system.

When indicating the deficiencies of traditional system, scheme for innovative HW management system is offered that is based on ecologization principles (see 2.4.pic.).



2.4. pic. Main differences in traditional and innovative hazardous waste management systems

Innovative HWM system should provide following basic principles that result from the Latvian environment legislation and EU directives, regulations and decisions established in Latvia:

1) Maximization of ecologic safety for HW management processes;

2) Minimization of HW negative impact on staff involved in management processes;

3) Maximization of effectiveness of HW management processes:

3.1) Minimization of costs for HW collection and transportation and speed maximization by optimization of number and location of collection stations and amount of staff involved in transportation process and amount of fixed assets, developing optimal transportation routes and optimizing number of vehicles with particular technical indicators;

3.2) Minimization of temporary storage time;

3.3) Maximization of HW recycling effectiveness by optimization of qualitative content of waste flow piloted into recycling device;

3.4) use of the modern technology for processing and recycling;

3.5) recovery and recycling of raw material from waste that is suitable for secondary processes;

3.6) acceleration of final deposition of HW slag and ashes as well as non-recyclable HW part;

3.7) maximal prevention of danger during processing and recycling;

3.8) Minimization of territories provided for HW deposition and their maximal maintenance;

4) Choice of specially denoted, physically-geologically based sites for HW storage and its further monitoring;

5) Improvement of information and cooperation among organizations and institutions involved in management process;

6) Integration of EU norms into HWMS institutional base and providing of implementation of EU environmental basic political principles ("polluter pays");

7) Increase of qualification of staff involved into HW management;

8) Providing of openness and social discussion of HWMS monitoring;

9) Establishing of cleaner technologies in the production and minimization of impact of HW management costs on competitiveness of products (proportion of quantity of products to the HW optimization resulting from production and consumption).

Effective economic management process should orient on that that none of normative recommendation for waste management is to be considered as dogma forever. HW management system should be flexible, with the possibility to choose one or other management approach depending on the certain situation, orienting in the situation and basing on the last technical achievements at the same time preserving main principles of environmental safety.

Basis of the worked out philosophy of HW management theory form combination of economically based production of products containing hazardous waste and alternatives of HW management as well as evaluation of different forms of financing, diversification and financial aspects that are connected with the eco-effectively of HW management.

It is offered to include five theoretical elements of HW management into HW management theory (see 2.1.tab.)

2.1.table

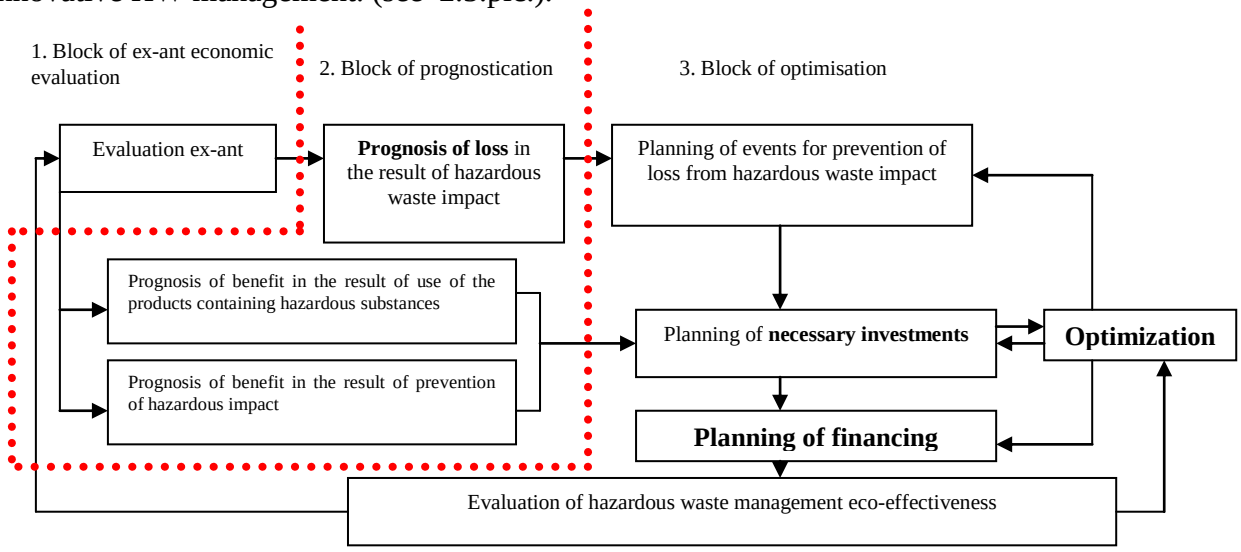
Theory elements of hazardous waste management

Element	Basic data
Theory of HW ex-ant economic evaluation	Modulation aspects pf universal economic indicators during HW generation process and economic evaluation of HW generation are considered
Theory of optimization of economic characteristic quantity of HW management	Planning aspects of HW management systems providing minimal financial amount of HW management danger and maximal financial benefit of use of products containing hazardous substances are researched
Theory of investment into HW management	Questions connected with the performance of investment t.i. financial analysis, evaluation of investment attraction, investment planning, that provides flow of HW and waste resources and progress of their resources through certain management systems are researched
Theory of HW management financing	Range of questions connected with the optimization of involvement of financial resources in certain investment directions taking into account the necessary investment. In majority of cases eco-effectiveness of HW management depends on the financial diversification are considered
Theory of HW ex-post economic evaluation	Aspects of system modulation of HW management economic results and evaluation results are researched

According to the author's worked out basic approaches of HW management theory, main elements of HW management is prevention of generation and renovation of polluted

regions that required corresponding knowledge, involvement of experienced specialists, guaranty of technical and scientific potentials and financing. Practical meaning of HW management theory is HW impacts and prognosis of their financial regulations that in its turn determine corresponding practical actions. Basic approaches of HW management theory determine formation principles of economic politics (trade economy, industry, transportation branch, building, etc.), aspects of functional economic science (finances, credits, management, prognostication, etc.) and inter-branch politics (geography of economics, statistics, etc.). HW management theory serves as basis for the development of sub-science complex of economics, ecologization of natural resources and providing of necessary economically-mathematic regulators for HW management.

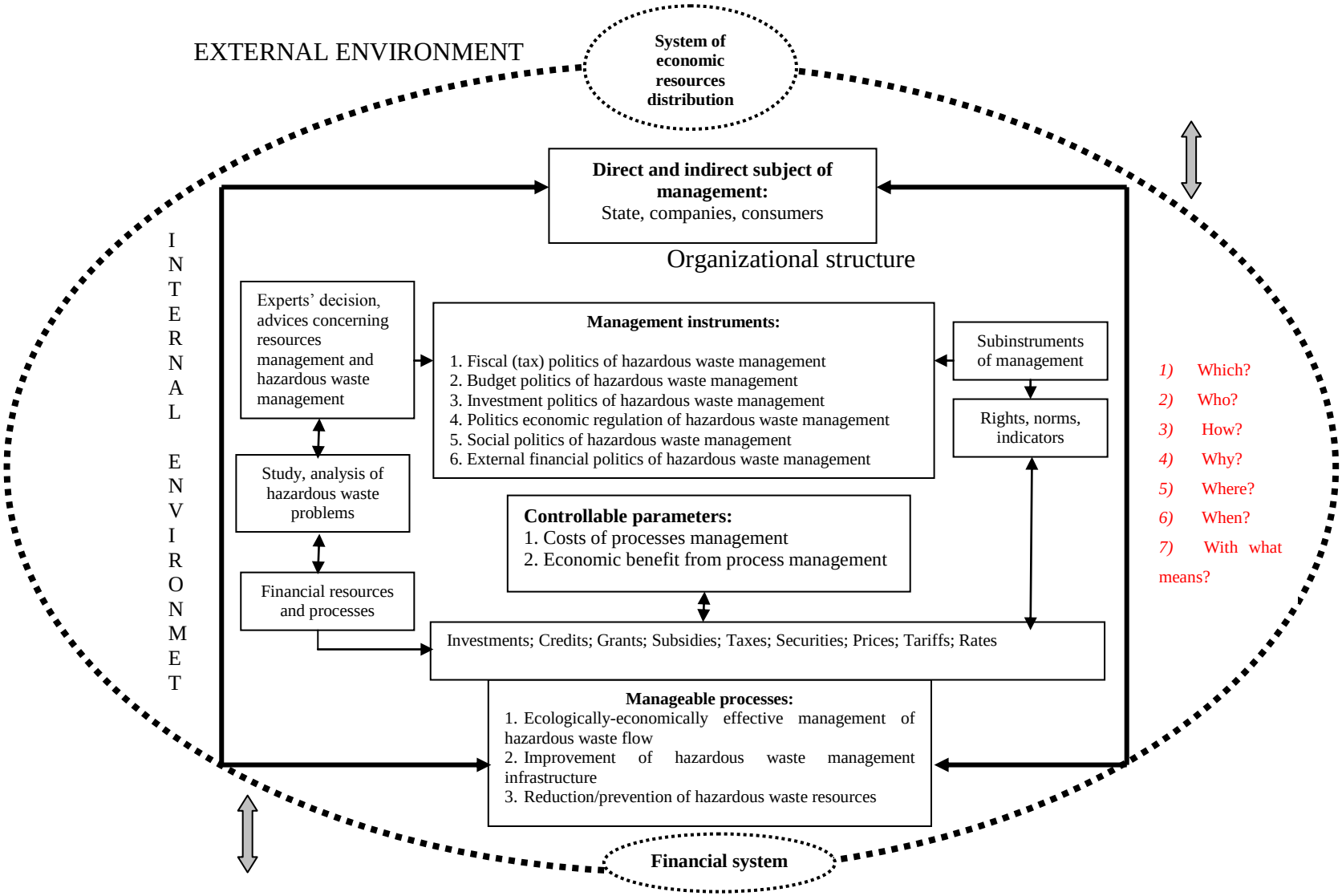
Theoretical basic approaches determine modulation of HW management system and basic principles of modulation use according to Latvian socially-economic circumstances and are directed towards consummation of unified strategic aim. Thus we offer mechanism of innovative HW management. (see 2.5.pic.).



2.5. pic. Mechanism of hazardous waste innovative economic management

Model is provided as instrument for inquiry of economic opportunities of HW management improvement. One of the significant problems of the model - dynamics of economic processes which can be solved with the help of seven questions system which was used by ancient Greeks: Which? Who? How? Why? Where? When? With what means? (see 2.6.pic.)

Basing on the functional aim of HW management theory, main subsystems are distinguished: 1) system of economic resource distribution; 2) financial system.



2.6. pic. System of hazardous waste management

Sub-systems act basing on mutual addition principle thus providing internal unity of HW management system, existence of its elements, stability, conditional independence and link to external environment of all elements operating with: 1)tax politics, by improving mechanism of imposing and collecting of HW management taxes and rates; 2)budget politics, by creating HW management financial funds and regulating the use of these means; 3)investment and financing politics, by promoting favorable climate for investments into HW management, determining management priorities, according to which division and control of EU structural funds means should occur; 4)economic regulation politics, by determining distribution of means among the sector of production of products containing hazardous substances, HWM sector and state providing also guaranty mechanisms, determining financial and general economic indicators for private structures; 5)social politics, by determining relationships to society in HW management aspect, legally recording guaranties of these relationships and establishing organizational structures for fulfillment and control of these relationships; 6)external finance politics, by implementation of EU directives on HW management in Latvia involving also foreign means as well as fulfilling state's financial commitments and guaranties.

For theoretical reasoning of HW management system modulation, fundamental statements were formulated the truth of which is obvious – these are HWM axioms. On the basis of non-provable assumption, inductive hypothesis for the improvement of HWM effectiveness were offered (see 2.2. tab.).

2.2. table

System of axioms and theorems of hazardous waste management

Axioms	**Theorems**
Integral part of economic growth is increase of production and consumption waste including HW amounts	Growth of gross domestic product (GDP) in base prices is potential reduction resource of hazardness amount produced by HW.
HW generation is negative consequences of economic resources management	Ecological-social-economic effectiveness of HW management depends on coordination among state, entrepreneurship and interests of inhabitants
HW pollution negatively influences quality of natural and labor resources in long-term	The main role in effective HW management belongs to positive economic sanctions
HW temporary storage process provokes risk and additional costs for waste management	Reduction of time of HW storage is potential financing resource for reduction of financial hazardness amount produced by HW
One and the same HW neutralization stage can be reached using different means and economic results	Economic effectiveness of HW recycling technologies depends on combination of HW recycling set and content of prescription
Multiple recycling leads to the reduction of HW secondary resources quality due to destruction of material and loss of suitable functional characteristics which provokes additional limitations for the use and realization of secondary products	Production and use of suitable secondary HW resources has a limit which divides this process into economically based and economically unsuitable zones

All theorems are provable basing on socially-economic and mathematic regularities of HW management processes.

3. Mathematic modelling of hazardous waste management and approbation of models

3.1. The price of unity of hazardness and assessment of amount of hazardness

Material sciences have **a notion of hazardness index**, **which characterizes** concentration of hazardous components in a material physical unit. Basing on this characteristic, it is possible to create a hazardness unity standard. In the author's interpretation **the unity of hazardness** is a component of a primary hazardness division, a standard, which characterizes a hazardous element, with a certain total hazardness level, concentration in a conditional unit of physical amount. A sum of hazardness unities forms **an amount of hazardness**. Respectively, a certain physical amount of HW can be characterized by hazardness amount, i.e. a number of hazardness unities. For the purpose of preserving the unity of scientific terms, costs and damages, which are caused by hazardness amount, are defined as **financial amount of hazardness.**

Therefore, from the HWM point of view, each product is characterized not only by its benefits of use, but also by financial amount of hazardness (see Fig.3.1)

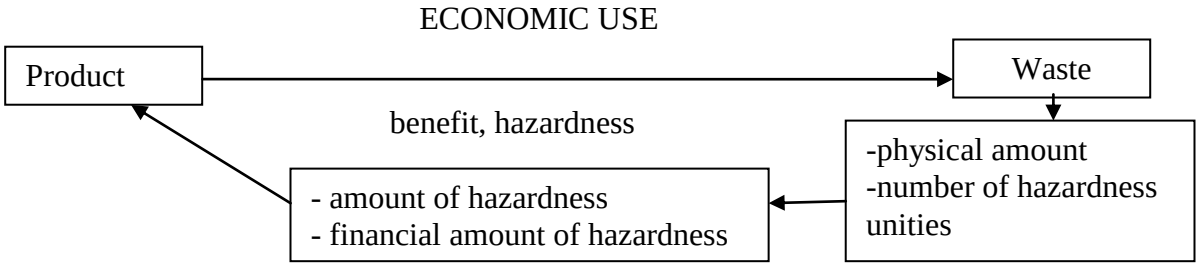


Fig. 3.1 Characteristics of a product containing hazardous substance

Basing on the arguments, that certain financial amount of hazardness is resulted from a concrete number of hazardness unities, it shall be concluded that it is possible to determine **the price of unity of hazardness**, the basis of which shall be technical characteristics of the unity of hazardness. The price of recovery of one unity of hazardness is a constant amount for all waste categories. **The price of the unity of hazardness** is an index, which represents the costs of the influence of one unity of hazardness on environment related expenditures.

Calculation of the price of the unity of hazardness shall be started by determination of chemical and physical characteristics of the unity of hazardness, which is the subject of material scientists' researches. Theoretically, characteristic of the unity of hazardness shall be started by determination of the hazardness level of a hazardous element (class).

For HW hazardness class determination a range of mathematical calculations is necessary. In the world practise a lot of indices are determined by the help of tables and formulas, applying correction indices. As a result, quantitative hazardness characteristic is obtained, which points to HW hazardness class. HW can be divided into hazardness classes according to the characteristic economic damages (see Table 3.1).

Table 3.1

Hazardness classes and influence thereof on economic damages

No.	Level of HW hazardous influence on environment	Criteria for HW hazardness class determination	Hazardness class	Hazardness index	Economic damages
1.	Very high	Ecological system is irreversibly damaged as a result of HW	Waste of particular hazardness category	$10^6 > Ind. > 10^4$	Uncompensated damages
2.	High	Ecological system is significantly damaged. Period of environment recovery exceeds 30 years after liquidation of a hazardness object	Waste of high hazardness	$10^4 > Ind. > 10^3$	Hard-to-compensate damages
3.	Average	Ecological system is damaged. Period of environment recovery exceeds 10 years after liquidation of a hazardness object	Waste of average hazardness	$10^3 > Ind. > 10^2$	Compensated damages
4.	Low	Ecological system is damaged. Period of environment recovery is >=3 years after liquidation of a hazardness object	Waste of little hazardness	$10^2 > Ind. > 10$	Relatively easy-to-compensate damages
5.	Very low	Ecological system is almost not damaged	Almost non-hazardous waste	$Ind. > 10$	

Operating the data on the financial amount of hazardness caused by HW, the price of the unity of hazardness can be calculated using the following formula (3.1).

$$P(HU) = \frac{\sum_{i=1}^{n} (L_n + C_n)}{\sum_{i=1}^{n} (\sum_{j=1}^{m} \frac{c_j}{w_j}) * n_{hw_j}}, \quad (3.1)$$

where $P(HU)$ - the price of the unity of hazardness, LVL;

c_i - level of concentration of the hazardous component j in HW n unity, mg/kg;

w_j - index of hazardness of the hazardous component, mg/kg;

n_{hw_j} - number of the unity of hazardness of the hazardness category j per year, unit;

L_n - economic damage, connected with n number of unities of hazardness, LVL;

C_n - ecological expenditures, connected with n number of unities of hazardness, LVL;

n – number of hazardness categories, unit;

m – number of hazardous components in HW n, unit.

In fact, in the formula (3.5) the counter is a number of unities of hazardness or the amount of hazardness caused by HW. Alternatively, the price of the unity of hazardness can be reflected by the formula (3.2).

$$P(HU) = \frac{Q(BA)_F}{N(HU)}, \tag{3.2}$$

where $Q(BA)_F$ - financial amount of hazardness, LVL;

$N(HU)$ - number of unities of hazardness per year, unit.

Information on the average period of product life and the number of the unities of hazardness allows to foresee precisely enough the future factor values and to timely plan HW management events into the special budget. Currently state waste database does not have enough information to prepare corresponding reviews, to do planning work and checking. In this field the two main problems are found – identification of waste origin (administrative territory code, municipality, etc.) and a big number of economic sectors, which work without integrated permissions or waste management permissions. Organization and maintenance of unified HW statistical base is the duty of the state institutional structural unit involved in HWM. For the better visualization of information the simplified template of the HW statistical database is applied, which should be used for compilation and systematization of the data on the number of the unities of hazardness (see Table 3.2).

Table 3.2

Simplified template of hazardous waste statistical database

Product	**Number of exported and imported products per year**	**Number of exported products per year**	**Hazardous substances and concentration thereof in the product**	**Indices of hazardness of the hazardous substance of the product**	**Number of the unities of hazardness in the product, unit**	**Period of product life, years**	**Potential management technologies of product waste**
Electric and electronic equipment category and EEE types included therein	Q_m	Q_ex	N, ci	K	N(HU)	T1	T
...							

Basing on a deduction method, it can be concluded that the economic damages caused by HW influence are expressed in two stages: first stage damages – deterioration damages to environment ecological condition; second stage damages – damages connected with human health deterioration, which can be represented by the formula (3.3).

$$Q(BA)_F = \sum_{\mu=1}^{t} (a_{1_t} * C_t + a_{2_t} * L_{I_t} + L_{II_t}) * (1+d)^{-t} \tag{3.3}$$

where a_{1_t} - HW specific part, which is subject to organizational and economic management during time period t, %;

a_{2_t} - HW specific part, which directly influences environment as a result of

unauthorized/undue management during time period t, %;

C_t - HW organizational and economic management costs during time period t, LVL;

L_{I_t} - first stage damages, caused by HW $a2$ part during time period t, LVL;

L_{IIt} second stage damages, caused by HW $a2$ part during time period t, LVL;

d – discount rate;

t – number of time periods, years.

The ecological condition in the country, indicatively reflecting the quality of natural resources, respectively, influences also operational capability of work resources. Negative changes of environment influence human health condition; therefore, HW negative influence can be interpreted as the damages and expenditures of economically active and potentially active work resource, which emerged as a result of HW polluted water consuming, breathing with polluted air. The mentioned connection is described by the formula (3.4).

$$Q(BA)_{F\,HR} = \sum_{\mu=1}^{t} (\Delta HR_{EA_t} * I_{HR_{EA_t}} + C_{med\_HR_t} * n_{HR_t}) * (1+d)^{-t}, \qquad (3.4)$$

where ΔHR_{EA_t} - deterioration of economically active number of population, pers;

$I_{HR_{EA_t}}$ - average contribution of economically active population to GDP during time period t, LVL/pers;

$C_{med\_HR_t}$ - health care expenditures (medical care expenditures, out-patient treatment of population, in-patient treatment, recovery of sick notes) connected with human resource subjection to HW hazardous influence during time period t, LVL/pers;

n_{HR_t} - amount of human resources, subject to HW hazardous influence during time period t, pers.

While economically characterizing financial amount of hazardness, it is important to take into account the fact that economic damages as to the type thereof can be direct and indirect.

3.2. Optimization of hazardous waste management strategies

The most importance of HWM shall be paid to life cycle of the material, which can be represented as a spiral. At the basis of HWM is not only the problem of the decrease in the created amount of hazardness and resource preservation, but also the increase of resource value as a result of processing and secondary use, the basic component of which is production validity. To ensure production validity it is essential to determine the range of material input per unit, the permitted level of production waste, to revalue the period of product life and efficiency of product use. Shifting the emphasis from the purely economic efficiency to

social, ecological and economic validity, the functional wholesomeness of the products can be reached decreasing the amount and hazardness of the material. One of the basic HWM tasks is minimum permitted return of the used material to economic cycle.

Basing on Walter Stahel's postulates, it is determined that there exist 4 scenarios for HW economic management:

1) production of the products containing hazardous substance on constant level + traditional (existing) HW management system;

2) regulation of manufacturing of the products containing hazardous substance + HW innovative management system (innovative HW processing methods, new technologies);

3) manufacturing of the products containing hazardous substance on constant level + HW innovative management system;

4) regulation of manufacturing of the products containing hazardous substance + standard HW management system.

In order to secure observation of the certain provisions of the European directives and favour sustainable economic development of the state, it is necessary to determine the optimal combination of directions for priority HWMS development and HWM management, basing on the economic result of certain natural resource extraction, production, consuming process ecologization, waste secondary use, processing energy use, secondary processing optimization and HW infrastructure fulfilment process (see Fig. 3.2)

The main criteria of tetrahedron segments is technical potentiality, political potentiality, financial potentiality, effectiveness, ecological efficiency, costs efficiency and justice of choice. Parameters of assessment of the strategy intensity are as follows:

1) economic benefit of the use of the products containing hazardous substance;
2) benefit of the use of the products containing hazardous substance;
3) expenditures for modernization of HW management methods;
4) economic benefit of modernization of HW management methods;
5) expenditures for modernization of HWMS infrastructure;
6) benefit of modernization of HWMS infrastructure.

While determining intensity of each strategy application, it is necessary to note the regularity of interaction of strategies, which is the result of the future studies of the author, and limited financial resources of the special budget, which are dedicated to HWM. It is important to note that the interaction of strategies is characterized by synergy effect. Combining a lot of activities, which are aimed at reaching a unitary goal, the achieved result is greater than the summarized result of individually performed strategies.

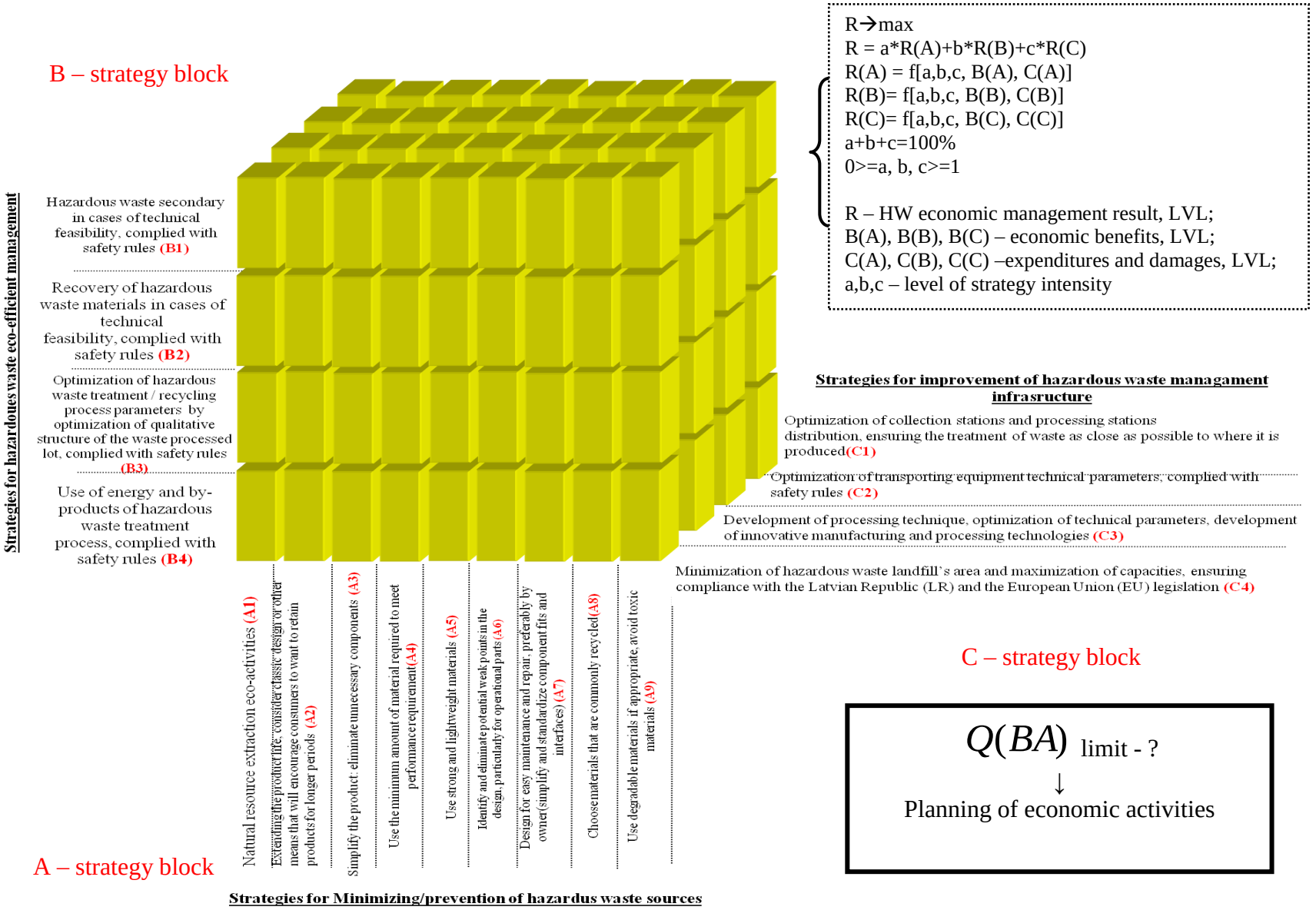


Fig. 3.2. Tetrahedron of hazardous waste management strategies

The segment basis of the tetrahedron of the HWM economic management strategies is the price of the unity of the waste hazardness, which is determined by the total expenditures of segment activating. In reality, a great importance at taking economic decision is turned to the factor of political stand, which regulates economic basis.

At the basis of all processes there is waste separation. The integral stage of the HWM process is preliminary separation, which provides for division of the waste according to the kinds, form and in separate cases colour thereof. When taking a decision on investing in waste management system it is important to assess not only the price for processing one physical or hazardness amount in various treatment plants (disposal in the landfill, incineration, separation, etc.), to determine expenditures for collection of one waste t, but also to assess distribution by collection methods and waste kinds and expenditures of transportation of one waste t depending on waste kind. Respectively, the basis of HWM event planning is waste **classification.** There are several classification features, but the main features of the economic classification are the following: 1) economically beneficial waste; 2) economically non-beneficial waste. The basis of economically non-beneficial waste management is assessment strategy. The level of waste economic sustainability is the main economic classification feature.

Essential aspect that shall be taken into account in the process of secondary resources industry planning, is the conditionality of the secondary resources as the goods, because the secondary resources *per se* are waste – substances, which are not the aim of economic activity. Besides, the market of secondary resources is characterized by the lower quality of the secondary resources. According to the peculiarities of the second resources market, the price of the waste at the market can be positive, null and negative, if the seller is ready to pay for waste receipt in order to avoid ecological payments and fines. Expenditures of each of HW secondary processing stage and benefit depend on material marginal utility, which depends on the speed of material utility and amount changes. Material utility depends on HW financial amount of hazardness at each processing stage. Basing on physical and chemical laws, it is assumed that the financial amount of hazardness of each processing stage will differ from other processing stages in the quantity of this index.

Number of material recovery is limited in the defined **theorem**: recovery of the material, containing hazardous substance, is useful until the summarized benefit of the material use exceeds the total expenditures, connected with material processing and manufacturing process of secondary raw products, which is described by the formula (3.5).

$$\sum_{\alpha=1}^{l}\sum_{\beta=1}^{h} C_{srec_{hl}} \leq \sum_{\alpha=1}^{l}\sum_{\beta=1}^{h} B_{srec_{hl}}, \qquad (3.5)$$

where $C_{srec_{hl}}$ - h-type HW l stage processing expenditures, LVL;

$B_{srec_{hl}}$ - from h-type HW suitable material l stage use benefit, LVL;

α - HW processing stage;

β - number of HW types;

This condition is also secured under the following circumstances: material use utility maximum is achieved when the marginal utility is equal to zero.

The development stage of secondary raw product includes marketing research, generating of ideas and filtering thereof, scientific, research and practical construction work, constructive, technological and organizational preparation of production. Here it is important to pay attention to the fact that production use benefit is not proportional to the number of material recovery. As a result of recovery it is possible to manufacture a product the economic benefit of use of which exceeds the use benefit of the initial product.

3.3. Mathematic modelling of hazardous waste processing

The important HW economic management task is optimization of HW treatment process. For optimal performance of the plant, it is necessary to denote the waste formula composition, optimizing the proportion of various HW kinds in the processing lot, *what* secures minimum processing costs and minimum productivity of waste treatment plant.

The special medicinal HW treatment plant SteriMed, developed by the Israeli company Environmental Technologies Ltd., which is meant for destruction and utilization of waste and corresponds to ISO 9000:2000, ISO 14001:96 quality standards. The plant is meant for plastic (syringes, tubes, catheters, probes, etc.), latex (gloves), tissues (tapes, drapes, etc.), glass (test glass, bottles), metal (injection needles, disposable scalpels, small instruments, electric wires, electrodes, etc.) waste processing. Currently, two popular plants are known: SteriMed-1 and SteriMed Junior. Chemical disinfection is made by the preparation Steri-Cid, attached thereto, which consists of glutaraldehyde, alkyl dimethyl benzyl ammonium chloride and other chemical substances. Syringes and injection needles are especially dangerous, as in the result of unapproved activity they can get into secondary use, infecting with hepatitis virus (HBV).

Performance of the plant is aimed at liquidation of waste hazardness factor – removing contamination and diminishing the amount; the plant can process any medicinal waste, excluding biological waste, solely it is advisable to get rid of large amounts of glass and plastic waste, which favours wear of pulping mechanism. For optimal performance of the plant the HW shall contain more than 2/3 of plastic goods; therefore, the technical and economic characteristics of the plant Starimid 1 are determined providing that only plastic waste is being processed (see Table 3.3).

Table 3.3

Technical and economic characteristics of the plant Starimid 1

Model	**Sterimed 1**
1. HW utilization principle	Unified system with chambers for chemical disinfection and mechanical pulping
2. Value of the plant	159.800 USD
3. Capacity of the plant	70 l
4. Length of HW processing cycle	12-15 min.
5. Necessary number of operators for servicing the plant	1 person
6.Power of the plant	4 cycles/h
7.Productivity of the plant	45 kg/h

During processing HW can get involved into chemical reactions that influence the speed of the processing and resource consumption. Optimizing waste flows that enter treatment plant or treatment lots, formula, the treatment lot shall be formed taking into account the heating values of the separate flow components, as well as the content of halogen, sulphur and other chemical elements, in order not to exceed the technical capacities of the plant. Basing on the physical and chemical features of the processed hazardous materials, which have a crucial importance in the processing, it is suggested to characterize the regularities using the author's definite *proportional distribution factors*.

As medicinal HW can contain various kinds of metal and plastic, average indices of frequently found materials are accepted. The indices that characterize the processing of waste that contains plastic are accepted as a base; therefore, the proportional distribution factor of the plastic waste costs is equal to 1 (see Table 3.4).

Proportional distribution factors

Index	**Plastic**	**Metal**	**Glass**
Specific heat capacity кJ·kg−1·K−1	**1.595**	**0.5**	**0.84**
Density, kg/m3	2500	7700	1360
Proportional distribution factors	1	0.96551724	0.2864953

As waste is not homogenous, it is impossible to fully load the plant volume. The mass of the waste, which can be put into the plant, depends on HW size. Basing on the data on the characteristics of the plant processing, treating 45 kg of plastic HW and using the proportional distribution factors, defined basing on the physical features of the plastic, metal and glass, the consumption of HW lot processing resources and the limits of processing productivity are determined (see Table 3.5).

Table 3.5

Maximum productivity of hazardous waste treatment plant, kg/h

Waste category	**Plastic**	**Metal**	**Glass**
Processed waste amount, kg	45	43.45	12.89

While calculating the processing costs it is accepted that the plant performs 24 hours a day. This performance is more economic and optimal, as a lot of power shall be used to prepare the plant for work – to secure the necessary temperature and pressure. It is accepted that the waste is soaked in the disinfectants, without additional changes of pressure or temperature. For servicing the plant one person is enough. The energy tariff 0,0414 LVL/Kwh is accepted for assessment of the HW processing costs; the tariff for water and canalization services - 0,423 LVL/m^3; amount of water for 1 kg of HW is 5 litres. Water consumption is necessary, as HW after pulping is soaked in the disinfectant; after processing the amount of HW diminishes for 90%; for assessment of the remaining waste utilization costs the tariff of waste receipt at the Getlini landfill is accepted as 4,23LVL/m^3 (see Table 3.6).

Table 3.6

Technical indices of treatment plant and used resources costs for 45 kg of plastic waste

Index	Unit of measurement	Index value	Price
Power consumption	KW/h	3	0,04011 Ls/kWh
Water consumption	l/kg	5	0,422 LVL/m^3
Disinfectant Stericid consumption	l/kg	0.175	5,36 LVL/l
Intensity of waste removal	kg/h	0.045	3 Ls/h
-	-	-	4,23 LVL/m^3

Depending on HW formula content, various amounts of resources are involved in the processing. Basing on the data on resource prices and resource expenditures, processing costs per hour for various processed lot structure variants are calculated.

For various alternative structures of the processed lot, processing can be performed with different processing productivity and costs. Respectively, the same waste processing productivities have various processing costs values (see Fig. 3.3).

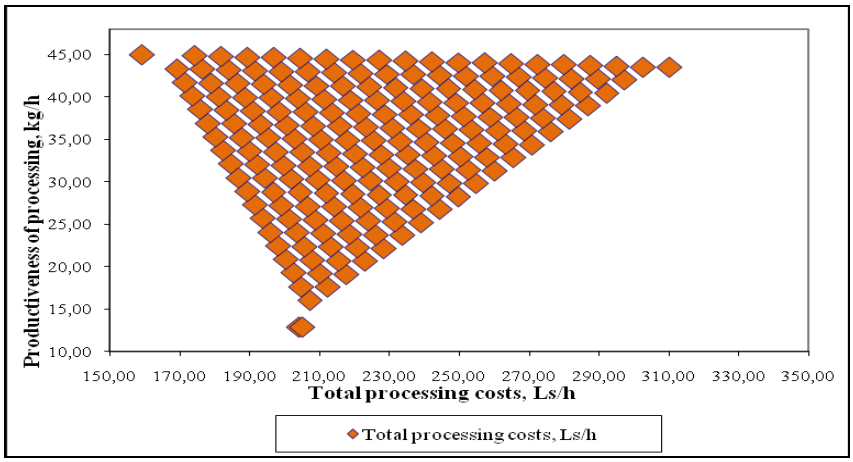


Fig. 3.3 Group of possible combinations of hourly processing costs and processing productivity, depending on the structure of the processed lot

For all possible processing lots that contains metal, glass and plastic hazardous components in various proportions, as a result of the study it can be concluded that each processing lot is characterized by various total hourly processing costs and processed waste amount.

For creating HW processing costs and productivity optimization model it is necessary to mathematically describe the regularities among the processed materials during treatment thereof, characterizing the main characteristics of the processing – productivity and costs.

Basing on the data on processing productivity, which corresponds to various processed lot structures, it is possible to mathematically describe the processing productivity of the treatment plant as processed lot structure's regression function, which is described by the formula (3.6).

$$R= f_1 (q(P),q(M),q(S)),) \quad (3.6)$$

where R– waste processing hourly productivity, kg/h;

q(P) – plastic waste proportion in the processing lot, %;

q(M)– metal waste proportion in the processing lot, %;

q(S)– glass waste proportion in the processing lot, %.

As a result of parameters optimization, processing productivity regression equation is determined, which is described by the formula (3.7).

$$R= 45*q(P)+43,45*q(M)+12,89*q(S) \quad (3.7)$$

The parameters of the processing productivity function are the same as the maximum productivity of the separate HW materials. Basing on the information on the technical indices of the HW treatment plant, resource prices used in the processing and total resource expenditures, and using proportional distribution factors, it is possible to mathematically describe the functions of the hourly processing costs of each waste lot, which are described by the formulas (3.8), (3.9) and (3.10).

Function of the hourly processing costs of the plastic waste category:

$$Cp(P)=q(P)*E\ *k(P)*W+q(P)*\bar{U}d\_kop*k(P)*C(\bar{U}d)+q(P)*Dez\_kop*$$
$$*k(P)*C(Dez)+ q(P)*Izv\_kop*k(P)*T+DSop/3 \rightarrow$$

$$\rightarrow Cp(P)= q(P)*k(P)*E\ *W+ q(P)*k(P)*\bar{U}d\_kop*C(\bar{U}d)+ q(P)*$$
$$*k(P)*Dez\_kop*C(Dez)+ q(P)*k(P)*\ Izv\ *T\ +DSop/3 \quad (3.8)$$

where Cp(P) – one hour processing costs for plastic, LVL;

k(M) – proportional distribution factor for metal waste, n/a;

E–total power consumption for one processing hour, KW;

W – energy tariff, LVL /kW*h

Ūd_kop – total water consumption for one processing hour, l;

C(Ūd) – water tariff, LVL/l;

Dez_kop – total disinfectant consumption for one processing hour, l;

C(Dez) - total disinfectant costs for one processing hour, LVL/l;

Izv–amount of the processed waste, m^3;

T – tariff for waste removal and disposal, LVL /m^3;

DSop – hourly rate for plant operator, LVL.

Function of the hourly processing costs of the plastic waste category:

$$Cp(M)= [q(P0)*E(P) *k(P)*W+ q(P0)*E *k(P)*W*k(M)]*q(M)+ +[q(P0)*Ūd\_kop*k(P)*C(Ūd)+ q(P0)*Ūd\_kop*k(P)*C(Ūd)*k(M)]*q(M)+ +[q(P0)*Dez\_kop*k(P)*C(Dez)+q(P0)*Dez\_kop*k(P)*C(Dez)*k(M)]*q(M)+ + [q(P0)*Izv\_kop*k(P)*T+ q(P0)*Izv\_kop*k(P)*T *k(M)]*q(M)+DSop/3 \quad (3.9)$$

where C(M) – costs for one hour processing of metal, LVL;

q(P0) –proportion of metal waste in the processing lot, which is equal to 100%;

k(M) – proportional distribution factor for metal waste.

Function of the hourly processing costs of the glass waste category:

$$Cp(S)= [q(P0)*E *k(P)*W+ q(P0)*E *k(P)*W*k(S)]*q(S)+ +[q(P0)*Ūd\_kop*k(P)*C(Ūd)+ q(P0)*Ūd\_kop*k(P)*C(Ūd)*k(S)]*q(S)+ +[q(P0)*Dez\_kop*k(P)*C(Dez)+ q(P0)*Dez\_kop*k(P)*C(Dez)*k(S)]*q(S)+ + [q(P0)*Izv\_kop*k(P)*T+ q(P0)*Izv\_kop*k(P)*T *k(S)]*q(S)+DSop/3 \quad (3.10)$$

where Cp(S) – costs for one hour processing of glass, LVL;

k(S) – proportional distribution factor of the costs for glass waste,

The total processing costs are described by the formula (3.11)

$$Cp= Cp(P)+Cp(M)+Cp(S) \quad (3.11)$$

Basing on the data on the processing costs for each waste processing lot per hour, which are calculated as the total sum of the resources costs, the function of the costs for processing hour of the treatment plant is mathematically described.

$$Cp=f_2(q(P),q(M),q(S)), \quad (3.12)$$

where Cp – waste processing costs, Ls/h.

When optimizing parameters for the processing costs function, which is described by the formula (3.13), it can be seen that the parameters of the regression equation are the same as the processing costs for the separate types of HW.

$$Cp= 159,32*q(P)+ 310,24*q(M)+204,10*q(S) \quad (3.13)$$

The main condition of the processing optimization is minimum costs and maximum processing productivity, i.e. the proportion between the processing costs and the plant productivity – minimization task efficiency function. Analyzing various regularities between the processing lot formula content and efficiency function, it can be concluded that the proportion of each material is determined by the dependency of the efficiency function values on the formula content of the whole processing lot.

Using the obtained regression equations, it is possible to determine in the optimization of waste processing characteristics in which proportions the hazardous metal, glass and plastic waste parts shall be present in the processing lot and what is the optimal length of the treatment process, which secures maximum processing productivity and minimum costs.

Limits of model application:

1) proportion of each HW category in the processing lot shall be within the range of [0; 1], and in total category proportions amount 100%;

2) processing length shall be of positive value;

3) hourly processing productivity of each category, which is multiplied by number of processing hours, shall be the same as the planned processed amount of each category waste.

The optimization model of the efficiency function F is generally described by the formula (3.14).

$$\begin{cases} \mathrm{F} = \dfrac{\mathrm{Cp}}{[\sum_{k=1}^{g} Q_k]} * h \to \min \\ \mathrm{Cp} = f1(q_1, q_2, \ldots, q_g) \\ R_g = f2(q_1, q_2, \ldots, q_g), \\ \sum_{j=1}^{g} q_j = 1 \\ q_j \geq 0 \\ Q_k = const, k = 1,2,\ldots,g \\ R_{\mathrm{g}} = \dfrac{\sum_{i=1}^{g} Q_k}{h} \\ h >= 0 \end{cases} \quad (3.14)$$

where Cp – processing costs, Ls;

F – efficiency function;

R_i - i-group waste processing productivity in a certain plant, kg/h;

g – number of groups, item;

q_j - j-group waste proportion in the waste lot, %;

h – length of the processing, h;

Q_k - k-group waste amount, kg.

To show the possibilities of application of the processing optimization model, it is provided that it is necessary to process plastic, metal and glass HW with maximum possible plant productivity and minimum costs. It is necessary to determine the optimal length of the processing and corresponding the formula content of the processing lot.

For illustration of the application of the optimization model various HW processing lot variants are considered (see Table 3.7).

Table 3.7

Optimization tasks of hazardous waste processing

HW type	**Mass 1, kg**	**Mass 2, kg**	**Mass 3, kg**	**Mass 4, kg**	**Mass 5, kg**	**Mass 6, kg**
plastic	100,00	1500,00	450,00	1000,00	50000,00	45000,00
metal	1500,00	100,00	100,00	1000,00	50000,00	10000,00
glass	450,00	450,00	1500,00	1000,00	50000,00	150000,00
time	?	?	?	?	?	?
q(P), q(M), q(S)	?	?	?	?	?	?

Basing on HW amounts, processing costs optimization model, which is represented by the formula (3.28), is mathematically described, placing dependencies of the total costs of one performance hour of the treatment plant on the structural function of the processing lot, which is described by the formula (3.16) and dependencies of one hour processing power of the treatment process on waste processing lot structural function, which is described by the formula (3.15).

$$\begin{cases} F = \dfrac{Cp}{Q} * h \rightarrow \min \\ Cp = [159{,}32 * q(P) + 310{,}24 * q(M) + 204{,}10 * q(S)] \\ Q = [45 * q(P) + 43{,}45 * q(M) + 12{,}89 * q(S)] \\ q(M) + q(S) + q(P) = 1 \\ q(M), q(S), q(P) >= 0 \\ Q(P) = 100 \\ Q(M) = 1500 \\ Q(S) = 450 \\ R(P) = \dfrac{100}{h} \\ R(M) = \dfrac{1500}{h} \\ R(S) = \dfrac{450}{h} \\ h \geq 0 \end{cases} \quad (3.15)$$

Solving optimization task, it is determined that processing 100 kg of plastic, 1500 kg of metal and 450 kg of glass HW, maximum treatment process power and minimum processing costs (18188,71 Ls), i.e. F=min, are reached, forming processing lots out of 3,10% plastic hazardous parts, 48,18% metal hazardous parts and 48,71% glass hazardous parts. Changing fixed amounts of waste, it is possible to determine optimal formula content and processing time (see Fig. 3.4).

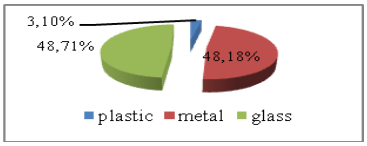
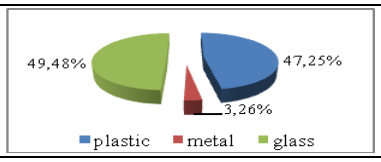
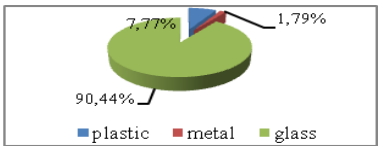
No.	HW type	Mass, kg	HW proportion, %	HW processing lot structure	Processing length, h	F	Processing costs, LVL
1	plastic	100,00	3,10%		71,65	8,87	18188,71
	metal	1500,00	48,18%				
	glass	450,00	48,71%				
2	plastic	1500,00	47,25%		70,54	**6,41**	13148,55
	metal	100,00	3,26%				
	glass	450,00	49,48%				
3	plastic	45000,00	7,77%		12865,02	**12,71**	2605382,91
	metal	10000,00	1,79%				
	glass	150000,00	90,44%				

Fig. 3.4 Results of solving the task of optimization of the processing characteristics

It is possible to use the model, optimizing processing characteristics also in other plants, as well as processing other materials, assessing cost and parameters of the power functions according to the physical and chemical features of the processed materials and technical and economic parameters of the plant. It shall be noted that assessment of the parameters is one of the intermediates of the optimization of the processing characteristics, wherein the assessment of material science experts is necessary. Only optimization methodology is reflected within the frames of this dissertation.

CONCLUSIONS AND SUGGESTIONS

The result of the study performed within the frames of the dissertation is HWM method and mathematics models, which secure economic assessment of HWM process and possibility to set forth scientifically grounded solutions, balansing the best engineering solutions with accessible financial resources and ensuring correspondence to the provisions of the legislation.

1. HWM system problem is recognized as one of the most serious problems in the sphere of environment protection. Taking into account a huge technogenic burden on the environment, globalization and limitation of the Latvian power resources, which in complex create ecological balance problems, in the aspects of HWM organizational and economic management special attention shall be drawn to the preservation of the resources, effective production and waste recovery into the secondary raw resources. To make hazardous waste useful for national economy, not only a new philosophy of HWM is required, but also the effective measurement of the HW characteristics in a form of technical and economic indices.

2. The basic task of the HWM theory – clarification and modelling of the process of technical and legal as well as social and economic management of HW generating. HWM system for economic organization shall be in line with Latvian macroeconomic indices. According to the requirement of the European Commission, the main strategy task of the HWM sustainability is to reach the increase of the speed of economic growth on the reckon of the resource usage increase. According to the expert assessments, the speed of HW increase shall be 15 % slower than GDP increase. The character of economic regularities depends on the results of the assessment of HW characteristics and introduction of the corresponding scientific and technical innovations into HWM system.

3. In the organization process of ecologically effective HWM system the criterion of hazardness diminishing is more important than profit securing. Meanwhile, the circumstance that the process of diminishing the amount of HW financial hazardness shall be determined with minimum expenditures and maximum economic return should be taken into account. HWM process shall include three main components: time, intellectual and material resources and numer of the unity of hazardness. The basic task of any HWM strategy – prevention of hazardness. The toxicity of HW can be diminished by excluding a number of hazardous component products, as well as minimization of waste generating, which is closely related to the fulfilment process of the production technologies and consumer influence policy.

4. The concept of the sustainable HWM management provides for a comprehensive approach that includes also the ability of authorities and operators, who are engaged in regional development, to comprehensively assess the problem and use maximum full information on

various HW kinds, which appear in the course of economic activity in order to secure the greatest return of the invested financial resources. Incomplete understanding of HW problems in the region and inappropriately chosen technical and economic solutions can be detrimental to the level of region economic development. Due to the unity of approach, in the frames of which the concept considers all sources of waste generating, types and characteristics thereof, it is possible to reach synergy effect in the field of nature, human health protection and utilization of financial resources.

5. HWM – set of multilayered and complex events, which covers not only collection, processing, utilization, neutralization and disposal systems, but also the processes of product manufacturing, in the realization of which a lot of subjects and organizations, engaged in economic activities, take part. The effect of minimizing the amount of financial hazardness can be reached, if the events turned to the environment protection are introduced not only at the stage of waste generation, but during the whole technological process of product creation. Giving preference to "greener" manufacturing or waste management method, simultaneously also resources preservation problem is solved.

6.The theoretical studies of the HWM sustainable management concept prove for the necessity of one main problem solution – securing ecological and economic balance between manufacturing of hazardous substance products and prevention of HW generating. Here, using eco-effective methods, it is important to assess, what is more useful – to prevent HW manufacturing or to fulfil the system of waste management. It is necessary to compare the profit from manufacturing and consuming products that contain hazardous substance and from complete exclusion thereof from circulation, replacing them with eco-friendly analogues. One of the possibilities to perform a comprehensive approach to the realization of HWM sustainable management concept is following "Zero Waste" ideas and principles in the whole HW management chain. For this purpose new manufacturing processes, replacement of the used hazardous materials with alternatives thereof, increase of effectiveness of material usage, product design according to the principle of sustainable life are required. In the situation of the announced power crisis the ways for maximum effective usage of waste and resource saving effect, shall be searched for. Of course, the idea of total HW prevention looks like Utopia. However, the positive effect as a result of HW amount decrease, product manufacturing technology modernization and alternative material usage is quite real. In the optimization processes not only direct economic profit shall be taken into account, but also hidden ecological profit shall be assessed. Using HW materials as energetic and technological raw materials, it is necessary to fulfil both the assessment methods of basic products and by-products manufacturing expenses, with the help of which the realization prices can be consistently determined.

7. It is useful to consider and model HWM system as a flexible system, which can be adjusted to the changing conditions of the environment. During realization of concept it shall be secured that the control indices be flexible, regularly converted depending on the progress of reaching the aim of quantitative measurers, they should be both realistic and ambitious enough and they should stimulate introduction of drastic innovations in the HWM system.

8. The expenditure of the resources used in HW processing is divided into the certain categories proportionally to HW proportion in the processing lot, what is explained by different physical features of various materials. HW with the same processing productivity in a concrete plant has a lot of values of processing expenses, depending on various waste category materials / substance proportion in the processing lot. HW treatment plant expenses and HW processing productivity can be regulated correcting the structure of processing lot. Using the suggested method – HW processing according to the optimization of the principle of the proportion of the waste of various categories in the processing lot, the maximum effectiveness can be reached in short time.

9. At the basis of HWM system there is an innovative approach, including also events for promoting human resources education and employment. In HWM event planning process the orientation should be to active business activities supporting policy for capitalizing of nature assets. Sustainable nature asset usage can promote development of various economic and creation industries, for example: service industry – ecotourism, recreation and medicine, etc.; agriculture – biological agriculture; industry – renewable power, manufacturing of eco-cosmetics or medicine, manufacturing of wooden furniture; creative industry – creation of environmental audio and video products, etc.; high technology industry – creation of eco-friendly technologies, simultaneously minimizing HW generation amount. While using HW materials as energy and technology raw materials, it is necessary to fulfil the assessment method of the manufacturing expenses of both the basic product and by-product, by the help of which grounded realization prices can be determined.

Basing on the results of the conducted study, the suggestions for HWM process optimization are developed:

1. In order to diminish waste generation, it is necessary to foresee a range of events for diminishing the hazardous features and amount of the generated waste, as well as the increase in proportion of the waste, which can be used as the secondary raw resources. The highest attention is turned to the increase in ecological and economic effectiveness of the product usage and to the decrease in pollution. Assessing the possibilities of preventing or diminishing HW generating as well as managing HW technical and economic processes, it is necessary to reach waste grouping, taking into account the possibilities of the material and hazardous substances

mutual compatibility in the processing flow, taking into account the physical and chemical features of the waste, as well as the technical characteristics of the certain plant at all management, treatment and recovery stages. For decision making in the mentioned processes it is suggested to use HW economic classification scheme developed by the author.

2. Waste is one of material immoderateness symbols, which is characterized by mass manufacturing and consuming. Currently, waste is perceived as a threat. Interpreting waste as polluting substances, the main emphasize shall be laid to the control of its generation amount and activities organization policy. Another approach of perceiving waste as a raw product and a power source provides for an alternative solution development and integration in order to solve three main problems – decreases in environment pollution, regulation of climate changes and decrease in resource exhaustion. As a result of philosophy change the waste is considered as resources and raw products, remainders or products, which lost their consuming features. Technological process of manufacturing, as a result of which remainders, not waste, appear, can be considered as waste-free production process.

3. The main idea of HW regeneration system efficiency and optimization provides for the use of the material, which lost its primary features as a result of goods exploitation and processing and is not valid for satisfaction of basic functions, alternative functions satisfaction, providing that it is not detrimental to the environment. Recovery of hazardous substances containing materials is useful, as far as the summarized profit of the material usage is more than the total expenses, connected to material processing and secondary raw product manufacturing process. For optimization of waste secondary processing it is advised to use the mathematical model of the secondary processing, which is one of the components of innovative HW management mechanism.

4. The main emphasis of the HW management plans is laid upon observation of separate EU control indices and directives, as a result of which not always regional features and territorial technical and economic potential are taken into account. Observation of EU control indices is obligatory, but they should be corrected, according to certain territorial characteristics, social and economic features, and they shall emanate from state HWM strategy common tasks, they should not be the basis and reason of development thereof. The political administration support has a primary importance in the process of HWM technical and economic decision-making and determines concept basic point. In the process of concept development and integration it is important to observe not only technical HWM aspects, but also a wide value circle and necessity to cooperate with the public of the corresponding territory. The essential aspect is securing financing of concept realization, as eco-friendly technologies are connected with large investments, sustainable lower economic effectiveness. The main financial HWM problems are

limited by municipality finance resources for securing co-financing, project realization, including also undertaking credit liabilities. Small number of assets sometimes secures very good possibility for project financing and lead to more stable, but smaller accessibility of total financing. HWMS financing depends on state legislative basis. It is necessary to introduce precisions into the scheme of regional and state obligations and responsibility in HWM system. HWM management policy should correspond to the National strategic framework document (NSFD), which emphasizes that the most important task for the period of 2007-2013, which is performed with the help of the Structural Funds and the Cohesion Fund (CF), is to create necessary preconditions as well as to manage directly the changes, which would secure the creation of knowledge containing economy in the state. HWM events are closely connected with the three NSFD thematic axes (human resource development and effective use); increase in competitiveness and move to knowledge containing economy; public services and infrastructure improvement as precondition for the balanced development of the state and territories thereof) as well as the three operational programs ("Human resources and employment", "Business activities and innovations", "Infrastructure and services") are integral part thereof. Taking into account inflation factor, it is necessary to develop and introduce the system of conversion of the financial allotment of the Cohesion Fund co-financed projects in order to get rid of financial deficit risk as a result of project rise in price. Regulation of the mentioned issues is offered basing on the scheme of the legal base of the HWM sustainable economy management by launching the organizational mechanism of HWM economic management in the institutional system.

5. Maximum precise information on HW generating amounts and structure according to management types is necessary for determination of total investments amount in creating and maintaining waste collection net, planning optimal transporting routs, as well as decision making on the basic resources involved into collection and transporting, with corresponding technical parameters, number, processing and treatment plant number and land areas, which are necessary for final depositing. In the process of the study the author faces deficiencies in HW registration and accounting, which makes it difficult to plan and assess economic management. To prevent statistical deficiency, for compiling and systematization of data on the number of the unities of hazardness the author offers to use the simplified template of HW statistical database, in the form of the unified database for control and recordal.

6. During making a decision on investments into waste management system it is important to assess the price for processing one unity of amount/hazardness by various treatment plants (including waste disposal on landfills, incineration, separation, etc.), to define collection expenses, separating them according to collection methods and waste types, as well as

transportation expenses for various waste types. Therefore, the method of assessment of the price of the unity of the hazardness is suggested.

7. In case of materials generation it is necessary to prolong the life of goods/products cycle, diminish the costs connected with resource output as a result of generation of material. It is important to pay attention to the fact that the profit of product usage is not proportional to the material generation number. As a result of regeneration it is possible to manufacture product, the benefit of economic usage of which exceeds the benefit of initial product usage. In order to widely use HW materials as energy and technology raw materials, it is necessary to fulfil the methods of costs assessment for both basic product and by-product manufacturing, by the help of which the realization prices can be determined. For the purpose of the solution of the mentioned aspects the basic performance mechanism of HW resource management is suggested, wherein the stages of the modified life cycle of the goods, containing hazardous substance, are determined and corresponding marketing purposes are described.

8. Taking into account the dependence of HW processing indices on waste formula content, it is advisable to use general-purpose waste treatment plants in HW processing. For the optimization of the plant performance (productivity of costs and processing) the author suggests to use the method of HW processing costs optimization, which can be adjusted to concrete HW categories, basing on the physical and chemical features of the processed materials and technical characteristics of the treatment plants.

9. Taking into account that natural resources renewal is a sustainable process and, correspondingly, any benefit that is connected with an excess of the allowed level of certain pollution is doubtful, in HW management sphere it is necessary to avoid policy that provides for short-term benefits, economy or profit in a concrete moment, not improving or even diminishing nature quality and increasing the possibility of future economic damages. In this connection the author points to the fact that, it is not advisable to increase number of HW landfills in Latvia, despite larger transporting expenses in case of centralized waste disposal, in order to get rid of additional necessity for land expropriation and control mechanism disruption. For HWM ecological and economic effectiveness regulation activity intensity optimization mechanism is offered, with the help of which it is necessary to determine the intensity of priority HW management activities, as well as HWM eco-effectiveness assessment method.

Additionally, the advised marketing events for management of the waste containing hazardous substance product:

1. Prolongation of product life, securing classical design, other things that will promote longer product use.

2. Specifying target audience determination.

3. Forming public awareness on HW management basic principles with the help of mass media, changing and education of consumer habits in respect of HW, increase in "green" thinking.

4. Events for consumers to expand/secure the possibilities to get rid of the used hazardous products.

5. Orientation to export markets.

6. Changes in product manufacturing, minimizing of packaging. Product modification, simultaneously securing satisfaction of clients desires (simplification: exclusion of insignificant elements, minimum usage of material amount for securing product consistency), durable and light material usage, awareness and prevention of potentially poor points in construction especially in operational parts, securing of light exploitation and repair products (simplification of element junction), choice of recyclables and use thereof in product, use of decomposable materials in product manufacturing, avoiding toxic materials.

7. Introduction of anti-marketing events in respect of products containing hazardous substances (increase in prices, market accessibility limitation, advertising limitation).

8. Popularization of eco-friendly products (mass media, advertising, lotteries, sponsorship, presentations during fairs, exhibitions).

9. Development of e-commerce, which provides for limitation of environment pollution with hazardous substances in the process of goods distribution.

Together with the mentioned advantages the deficiencies of the developed models shall be mentioned in the frames of this dissertation, which is the object of the author's future studies and fulfilment.

1) The functions of the optimization model of HW management process costs shall be adjusted basing on the technical characteristics of the concrete treatment plant and physical and chemical features of the materials;

2) the suggested HW processing optimization model is appropriate only for regulation of the three categories of HW processing.

3) in the intensity optimization mechanism of HWM activities the mathematical regularities of the HW economic management strategies are not formalized, as a result the models can be used only basing on five indices of HWM decision taking, which are influenced by political stand at the certain time period;

4) the method of assessment of the price of the unity of hazardness is based on the management costs of three various HW categories, providing that one category is taken as a basis, as currently there is no hazardness unity standard, determination of it lies within the scope of material science experts.

The results of the dissertation have a practical importance in economic management, municipality services, and technology choice for technical and economic substantiation at various HWM program development stages.