STUDY FOR HAZARDOUS WASTE MANAGEMENT (COLLECTION, TREATMENT AND DISPOSAL) IN MACEDONIA

A) Report for mapping of generated hazardous waste, and analysis of treatment options (reuse, recycle, incineration, and disposal).

VERSION 1.8.

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ABBREVIATIONS

EFTA – European Free Trade Association

CEFTA – Central Free Trade Agreement

ICT – Information and Communication Technology

GDP – Gross Domestic Product

CO – Custom Office

MOEPP – Ministry of Environment and Physical Planning

MOAFWE – Ministry of Agriculture, Forestry and Water Economy

HW – Hazardous Waste

HWMS – Hazardous Waste Management System

BAT – Best Available Techniques

IED – Industrial Emission Directive

IPPC – Integrated Pollution Prevention and Control

WAP – Waste Acceptance Criteria

CFC – Chlorofluorocarbon

PCB – Polychlorinated biphenyl

WWTP – waste water treatment plant

PCB –polychlorinated biphenyl

NWMP- National Waste Management Plan

SSO- State Statistical Office

1. INTRODUCTION

Waste is classified as being hazardous when it displays one or more of the hazardous properties listed in Annex III of the Waste Framework Directive (e.g. explosive, oxidizing, flammable, irritant, harmful, toxic, carcinogenic …). The relevant property or properties are determined by property testing or, where applicable, concentration based criteria.

Like in most of EU countries, industry is the largest generator of hazardous waste in Macedonia, giving rise to hazardous waste materials such as industrial solvents, sludge, oils and chemicals. Households, small businesses, farms and the healthcare and construction sectors also generate substantial quantities of hazardous waste such as lead-acid batteries, waste electrical and electronic equipment, healthcare risk waste, solvent-based paints and varnishes, pesticides, waste oils and asbestos.

In order to set out the priorities to be pursued over the next number of years to continually improve the management of hazardous waste in the Republic of Macedonia, MOEPP intiated preparation of this Study for hazardous waste management (collection, treatment and disposal) in Macedonia, as a part of "Integrated Pollution Prevention and Control in Macedonia" – a project financed by the Norwegian Ministry of Foreign Affairs jointly implemented by NORSK ENERGI and CCC in cooperation with MOEPP.

This report represents a first step in this study development focused on mapping of generated hazardous waste, and analysis of treatment options (reuse, recycle, incineration, disposal).

As a first step of HW management study in Macedonia,the main objectives of this report are to provide data about:

- Country settings which reflect HW generation and management,
- Generation of hazardous waste by industry and society generally,
- Current HW management practices with a viewto reducing the environmental and health impacts.

This data presented will serve as a base for development of HW management approach at a national level, including:

- Minimisation of environmental, health, social and economic impacts of hazardous waste generation and management,
- Promotion of increased self-sufficiency in the management of hazardous waste and reducing costs through minimisation of hazardous waste export.

The whole assignment was divided in three phases:

- Developing of most appropriate methodology for assessing the data and approaching the stakeholders,
- Data collection and analysis,
- Analysis of treatment options,

One of the most important aspects of the mapping was assessing of the real amount of quantities of produced hazardous waste. Based on strong past experience of the project team, the engaged personnel made evaluation of the current studies, databases, legislation, adopted national strategies and action plans and other related documents.

This report on mapping HW in Macedonia is structured as follow:

1	Introduction	General country description (politic and territorial unit)
		Social and demographic data
		Economy (current settings and projections)
2	Legal Framework	Description of legal frame regulating HW management at European and National level
3	Hazardous waste profile	Legacy and stored hazardous waste
		Industrial Hazardous waste
		Household hazardous waste
		Special waste streams (EEW, ELV, Mining waste, Medical waste)
4	Future HW generation	Definition of growth coefficients and prediction of future waste quantities
5	Treatment options	Review of existing and emerging treatment options

The project team implemented the study in close cooperation with relevant stakeholders, including ministry officials, local government representatives and business sector representatives involved in the hazardous waste generation and management.

1.1 General socio-economic and demographic situation

The Republic of Macedonia aspires to join the EU in the near future and expects to start negotiations on integration. However, such a perspective requires thorough arrangement at all levels in the society to prevent possible negative impacts on the environment and to reach optimal benefits which may be derived from the offered opportunities.

In the last years, Republic of Macedonia has focused all its strengths and potentials in economic development and creation of favourable business environment. With long-year macroeconomic

stability and low inflation rate of average 2% in the last 10 years, the country has a balanced public finances with low budget deficit, stable exchange rate and low public debt (32.5% of the GDP). Within the last three years a list of reforms were conducted in the area of labour market, along with active employment measures, which contributed to decrease of unemployment for about 4%.

Republic of Macedonia is a signatory of multilateral agreements for free trade with EFTA countries (2000) and CEFTA (2006), while with the Agreement for Stabilization and Association with the European Union (2001) Macedonia gained more favourable position on the EU market such as complete liberalization of the Macedonian products entering European market, as well as liberalization of the EU products into the domestic market.

Strategic industrial sectors in the country are agriculture and food processing, mining, metallurgy, textile industry, automotive components industry, construction, chemical industry and ICT sector. All these sectors contribute to the total GDP of the country (2011) with $9.8 billion or GDP per capita (2010 est.) $9,400. Real growth of the GDP in the country for 2014 is estimated on 3.5 %.

According estimations of the population made by State Statistic Office of Macedonia, in the country currently live **2 062 294** citizens, out of which 1 032 532 male and 1 028 512 female[1]. This number is higher for 0.8% in comparison with 2007 and 1.9 % more in comparison with 2002.

Table 1 below shows figures for population starting from 2002.

Population in Republic of Macedonia

	2002	2007	2012
Population at the end of the year (31.12) Total	2 023 654	2 045 177	2 062 294
Men	1 015 888	1 025 239	1 033 138
Women	1 007 766	1 019 938	1 029 156

In the graphic below is given pyramid presentation of the number of population in Republic of Macedonia according five years groups of age and sex.

[1] State Statistic Office

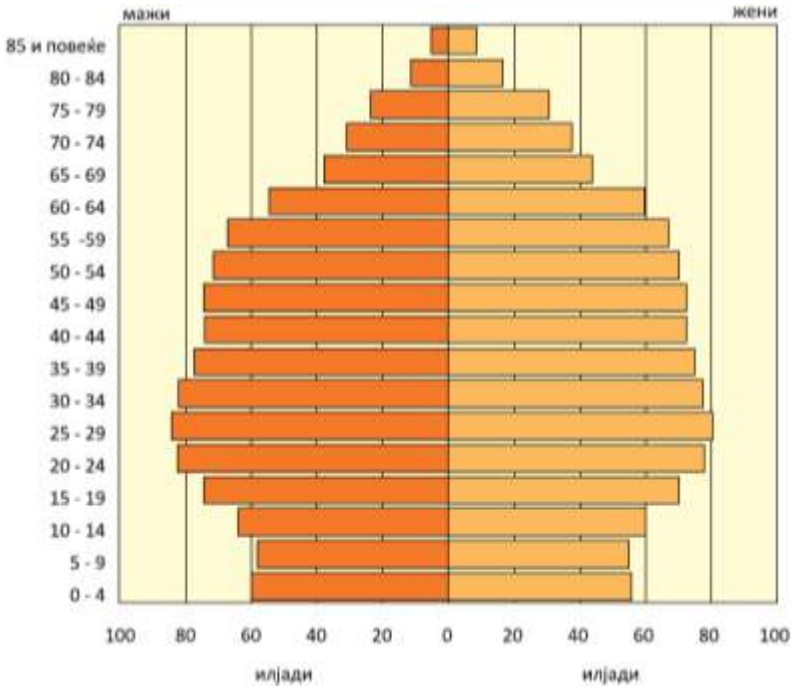


Figure 1 Populations in Republic of Macedonia according five years groups of age and sex

Within the same research done by State Statistic Office, Macedonian population each year is older and older. In the period between 2002 and 2012 participation of the young population (0-14) in the total is decreased from 21% to 17%, and participation of the older (65+) is increased from 10.6% to 12%.

According the official data from the last Census in 2002, in Republic of Macedonia is living 2022547 citizens, in 564 296 households with average annual growth of 9577 citizens in the period between 1994 -2002 or average annual rate of 0,6%. On longer period there is significant decrease of the intensity of population growth in comparison with demographic flows in the previous decades when average annual rate of growth was approximately 1.6%. That indicated lower demographic increase in the country especially in the last decade.

Natural population growth in the country in average is approximately 22.630 citizens. The rate of natural population growth has permanent decrease since the year of 1946 (26.3%) and in2002 is 4.8%. This is because of the decrease of the rate of fertility from 40% in 1948 to 20.6% in 1981 and 13.6% in 2002. Still, rate of fertility is still high in some municipalities such as 15.8% in Lipkovo and 18,7% in Zelino. On a contrary in the municipalities with low rate of fertility the tendency is permanent decrease of the rate of fertility.

Projection of the population

Based on current parameters it is envisaged that in the year 2020, total population in Macedonia will be 2 225 000 citizens (the projection is done with the software program

developed in company POPTECH, from Washington, USA, and is average annual increase of population of 0.5% in comparison to 2002.

In the frame of general fluctuations of the population it is estimated that the older population will increase. It is expected that population on age 0-14 to decrease in the total share from 24.8% to 19.9%. Bigger share is expected of population on age 15-64 (from 66.7% to 67% in 2020. In terms of sex structure there are no significant changes expected.

Expected changes in the socio-economic and educational structure of the population are reflecting on the way of living and in the same time in the structure of the households and the size of the households. In that context in 2020 in the country are predicted 646.283 households with average 3-4 members in each household. The map below shows natural increase and net migration in 2012.

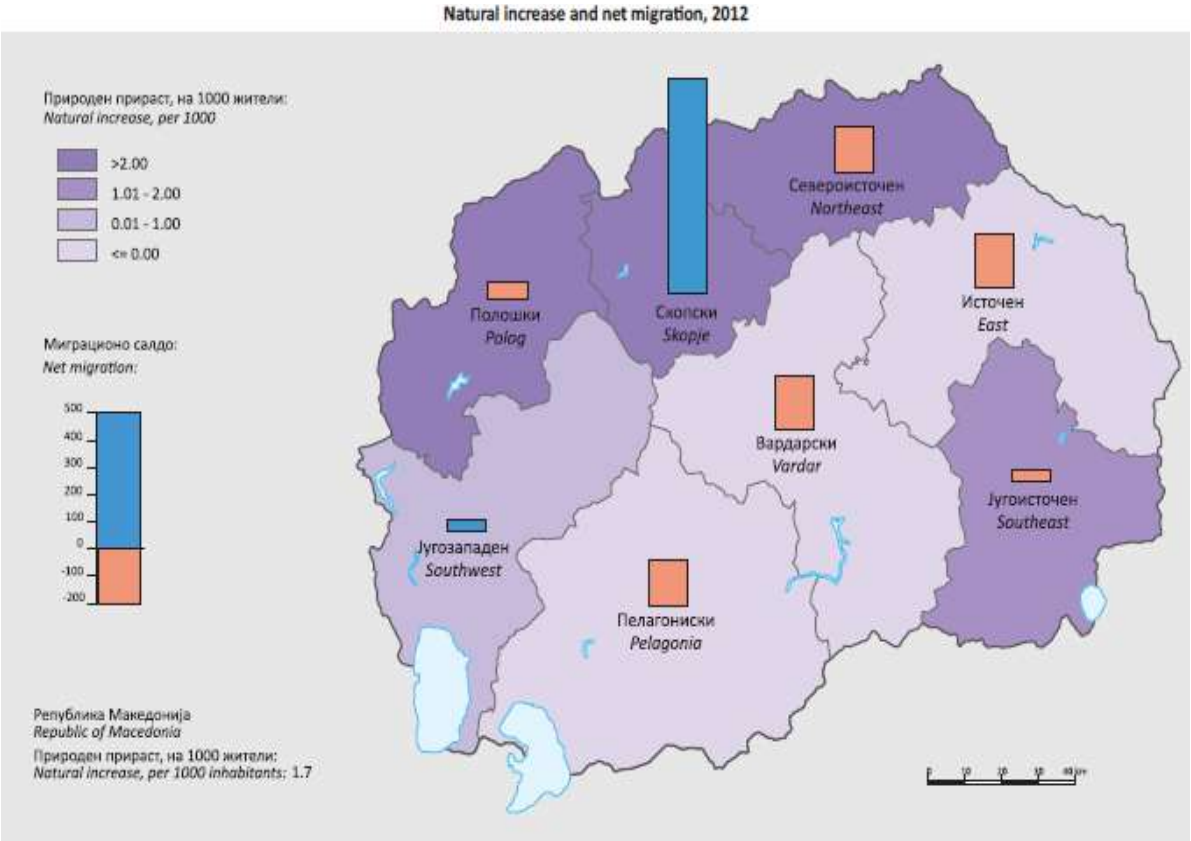


Figure 2. Natural increase and net migration

*Source: Regions of Macedonia, 2013, State Statistical Office of Macedonia

1.2 Regions in Macedonia

The country is divided on 8 regions: Varadar, East, Soutwest, Southeast, Pelagonia, Polog, North east and Skopje region. Basic information for each region in the country is shown on the Table below.

Table 1 Basic information of the regions

Region	No of municipalities	Population, 2002	Active business entities 2012	GDP per capita 2011
Vardar	9	154 535	5975	228 324
East	11	181 858	5913	206 773
Southwest	13	221 546	7564	162 253
Southeast	10	171 416	6373	258 230
Pelagonija	9	238 136	8468	227 732
Polog	9	304 125	7285	105 728
Northeast	6	175 442	4283	145 554
Skopje	17	578 144	28 563	321 544

The Vardar Region comprises the central part of the Republic of Macedonia and spreads along the Vardar River and Ovchepole Basin. This region had the smallest number of citizens, 7.5% of the total population, in 2012. It covers 16.2% of the area of the Republic of Macedonia and at the same time is the most sparsely populated region with only 38.0 citizens per km^2. The abundance of water resources - rivers and artificial lakes, the favorable Mediterranean climate that penetrates along the Vardar River valley and the geomorphologic configuration of the terrain are the main preconditions for this region to be renowned for its production of fruit and geographically specific grape vines. As a result, this region has the largest number of wine cellars and grape processing facilities in the country. Another important industry is the manufacture and processing of ferronickel.

The East Region is mainly a mountainous region and comprises the extreme east of the Republic of Macedonia. It spreads along the Bregalnica River, over the basins of Shtip, Maleshevo and Pijanec and the field of Kochani. The region comprises 14.2% of the total area of the Republic of Macedonia, with 8.7% of the total population in 2012, and 50.6 citizens per km^2.

The natural, geographical, climate and hydrological characteristics give the potential for production of rice, especially in the Kochani Field, which is well renowned for its rice. The basins of Pijanec and Maleshevo are favorable for growing fruits and vegetables. Due to the specific

geological characteristics of mountain ranges, the region has a developed lead and zinc mining industry. Another important industry is the textile industry and a large number of textile manufacturing plants are located in this region. The mountainous terrains in the region have great potential for development of winter and alternative tourism even though they are still in the early stages of development.

The Southwest region comprises the extreme southwest part of the Republic of Macedonia. According to the 2012 population estimates, 10.7% of the total population in the country lived in this region. It takes up 13.4% of the total area of the country and has a population density of 66.1 citizens per km2. The configuration of the terrain, encompassing the river basins of Treska and Crn Drim and the Ohrid Lake basin, indicates the great hydro potential of the region, partly utilized by the artificial lakes Shpilje and Globochica with their hydroelectric plants. These natural geographical characteristics and the mild climate provide opportunities for development of fruit growing.

The region includes a number of high mountains covered with lush forests, which provide timber for the needs of the wood processing industry. Tourism has great importance for the development of this region, mostly owing to the natural characteristics of Ohrid Lake and the cultural and historical significance of the Ohrid area, protected by UNESCO. No less important for the development of tourism is the National Park Galichica, as well as the mineral and hot water spring near Debar.

The Southeast Region is located in the extreme southeast part of the country and comprises the Strumica-Radovish and Gevgelija-Valandovo basins, the Strumica River valley and the lower course of the Vardar River. In 2012, 8.4% of the total population in the Republic of Macedonia lived in this region. The region covers 10.9% of the total land area of the country and has a population density of 63.2 people per km2 . The extensive hydrographic network, the great number of sunny days, the climate and the favorable pedologic conditions characterize the region as predominantly agricultural.

The large-scale production of high-quality early vegetables, fruits and industrial crops enable the development of the canning and food processing industry, for which this region is renowned. In recent years, there has been an increasing trend in tourism, shown by the increased number of accommodation facilities, tourists and nights spent in the region. This is mostly due to the revitalization of the Dojran Lake and its exploitation for tourism.

Another specific feature of the region is that in 2012, compared to the other regions, it had the highest activity and employment rates (70.7 and 60.9, respectively) and the lowest unemployment rate (13.8).

The Pelagonia Region is located in the south of the Republic of Macedonia and comprises the Pelagonia basin and the Prespa Lake basin. This region is the largest, covering 18.9% of the total land area of the country, but also one of the most sparsely populated, having a population density of 49.4 people per km2. In 2012, 11.3% of the total population of the Republic of Macedonia lived in this region. The Pelagonia basin, which is the largest plain in the country, the Prespa Lake basin, the specific climate and the extensive hydrographic network are the basic preconditions for the agricultural development in the region. All of this makes this region the breadbasket of the country and the largest producer of tobacco, apples and milk.

At the same time, the largest coal deposits are located in this region, making it the country's largest producer of electricity.

The Polog Region comprises the northwest part of the Republic of Macedonia, the Polog basin and the valley of the river Radika. It covers 9.7% of the country's total land area. With 131.2 people per km2, Polog is one of the most densely populated regions, and 15.4% of the total population lived in this region in 2012. The extensive hydrographic network has great hydroelectric potential, which is utilized to some extent by the hydroelectric plants on Mavrovo Lake. The specific vegetation of the Polog basin and the surrounding mountains create favorable conditions for the development of agriculture, and especially cattle breeding, for which this region is renowned. Owing to the high mountain ranges, the specific landscape and the climate, the most popular winter resorts are located in this region. One of the most striking features of the region is the low GDP per capita, which in 2011 was 105 728 denars. The region participated with 7.3% in the total GDP.

The Northeast Region comprises the extreme northeast part of the Republic of Macedonia and spreads along the rivers Pchinja and Kriva Reka. It is one of the smallest regions, covering only 9.3% of the country's total land area and with population density of 75.9 people per km2. In 2012, 8.5% of the total population of the Republic of Macedonia lived in this region. Owing to the geological features of the Osogovo mountain range, the region has several lead and zinc mines. The natural conditions and resources of the Northeast Region provide good opportunities for the development and promotion of the meat and dairy processing industry.

In 2011, the region had a share of only 5.5% in the total GDP, the smallest compared to the other regions. The employment rate in 2012 was 24.6 - lowest compared to the other regions, whereas the unemployment rate peaked at 52.8 - the highest in the country.

The Skopje Region comprises the northernmost part of the Republic of Macedonia and extends across the Skopje basin. This region is the smallest and covers only 7.3% of the total land area of the country. With 336 people per km2 and 29.6% of the country's total population (2012), Skopje is the most populous region in the Republic of Macedonia.

This region is the main hub of the country and has the most developed traffic infrastructure. Most of the country's industrial, trade and service capacities are concentrated in this region. Skopje, the capital of the Republic of Macedonia, is located in this region, and it is the economic, administrative, cultural and academic center of the country. As a result, regarding the internal migrations, this region represents the largest immigration area.

In 2011, the Skopje Region had the highest GDP per capita (321 544 denars) compared to the other regions, and it participated with 42.4% in the total GDP of the Republic of Macedonia.

The regional distribution of active business entities in the country is shown in the Picture below. It is evident that the number is highest in Skopje region, and then comes Southwest and Pelagonija and Vardar, East and Northwest are regions with lower number of active business entities.

Figure 3 Regional distribution of active business entities

*Source: State Statistic Office

According to the official data from the State Statistic Office the number of active business entities is distributed in several sectors. The number of active business entities distributed in different sectors within the period of 4 years is presented in the Table 3.

Table 2 Distribution of business entities per sector

	Total			
	2010	**2011**	**2012**	**2013**
Total	**75 497**	**73 118**	**74 424**	**71 290**
Agriculture, forestry and fishing	3 038	2 963	3 072	2 866
Mining and exploration	164	176	182	164
Manufacturing	8 263	8 155	8 251	7 918
Supply of energy, gas, steam and air conditioning	107	98	134	132
Water supply; waste water discharge; waste management; remediation	273	283	321	306
Construction	4 368	4 400	4 541	4 322
Wholesale and retail trade; repair of motor vehicles and motorcycles	28 326	27 468	27 307	25 429
Transport and storage	6 417	6 380	6 445	6 095
Accommodation and food services	4 433	4 313	4 611	4 482
Information and Communications	1 412	1 419	1 515	1 446
Professional, scientific and technical activities	5 228	5 369	5 707	5 817
Administrative and support service activities	2 519	1 319	1 438	1 514
Public administration and defense; compulsory social insurance	249	203	268	258
Activities of health and social care	3 166	3 246	3 298	3 315

*Source: State Statistic Office

In order to see more clearly the trend of each sector and the future expectation of hazardous waste, data from Table 4 are put in excel sheet and the distribution is shown in Figure 2.

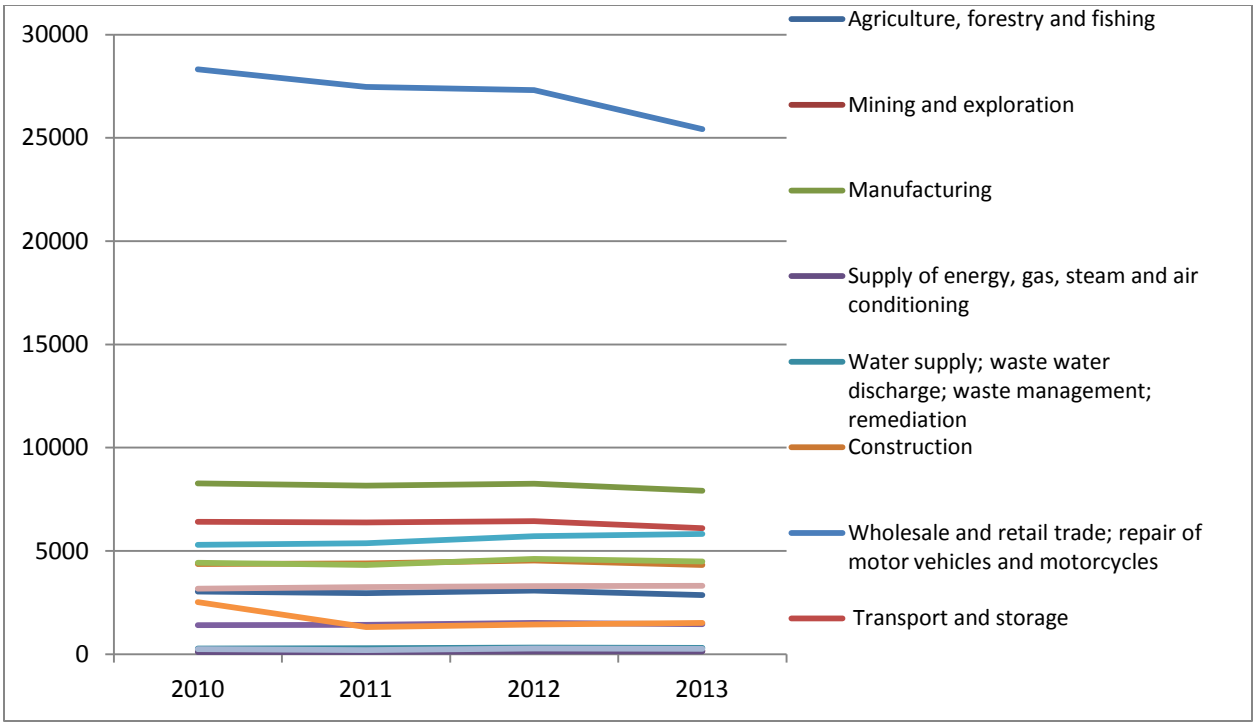


Figure 4 Trend of establishing new entities per sector

From the Figure above it is evident that the trend of establishing new entities is more or less constant in all sectors with small decrease during the years in most of them. The largest amounts of entities belong to the sector wholesale and retail trade, repair of motor vehicles and motorcycles, followed by manufacturing, transport and storage; professional, scientific and technical activities and so on. The distribution of different types of industry sectors, monitoring points (for air and water), protected areas, mines and zones for preventive protection within the country is shown on the map below.

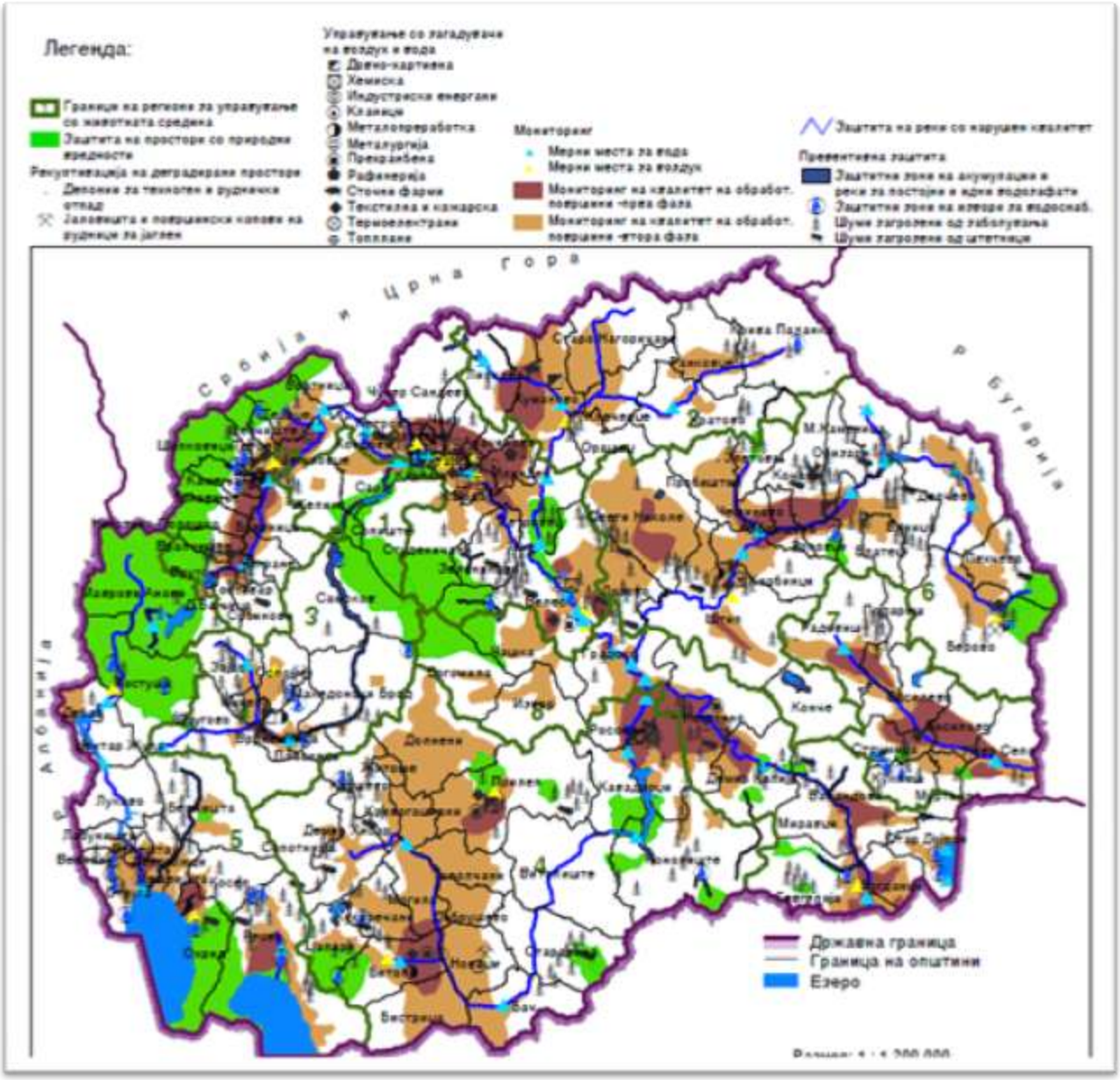


Figure 5 Environmental protection

*Source: Spatial plan of republic of Macedonia

The agriculture production and agribusiness sector are the most important economic sectors in Macedonia. Almost 435.500 people, out of a population of 2 million, make whole or part of their income from agriculture activities. The great natural preconditions and an existing tradition enriched with newly developed skills create a variety of opportunities in agriculture, from high mountain pastures of over 2000m high, to the rich water valleys with a Mediterranean climate.

The agricultural sector is prioritized as one of the most important sectors of the Macedonian economy due to its importance for social security and poverty reduction. It provides sustenance to the absolute majority of the population and accounts for 9.7% of GDP in 2009. 14% of the

total working population is engaged in agriculture and 43% of the population lives in rural areas.

Land use for agriculture in the form of cropland and pastures is substantial in Macedonia and occupies approximately 50% of the surface area of the country, with forests constituting another 37% .The total agricultural cultivable area in 2005 covered 546,000 hectares, out of which 82% were arable land and gardens. Pastures cover 682,000 hectares.

Figure 6 Land usage

*Source: Spatial plan of republic of Macedonia

Or more precisely the Figure below shows the total share of the cultivated agricultural land by categories for 2012.

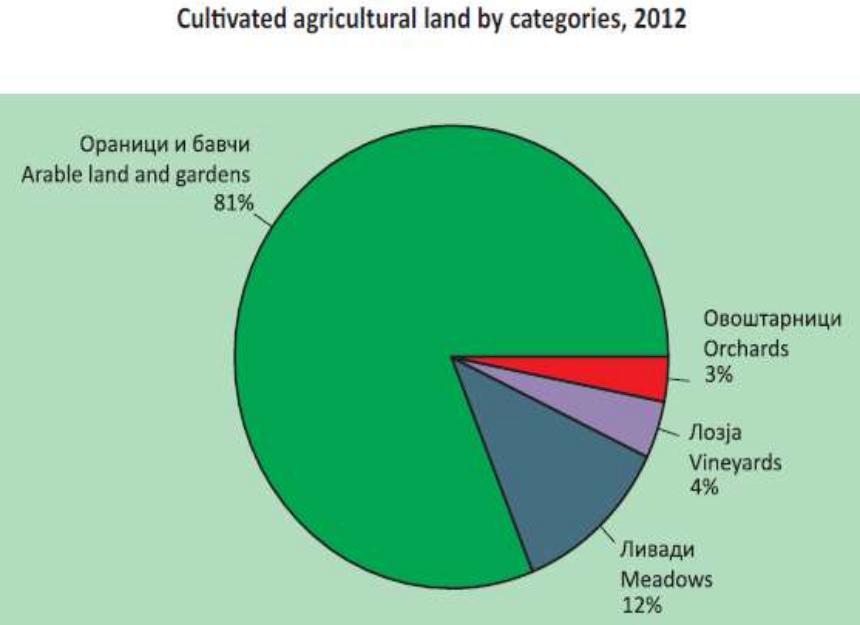


Figure 7 Cultivated agricultural land by categories for 2012

*Source: State Statistical Office of Macedonia

2. LEGAL FRAMEWORK FOR WASTE MANAGEMENT IN REPUBLIC OF MACEDONIA

The management of hazardous waste at national level is governed by comprehensive legislation. The legislation principally originates in EU directives and regulations and is implemented in Macedonia by the Waste Management Law adopted 2004, and continuously updated (2007/08/09/10/11/12/13) to reflect need and changes in relevant EU regulations.

This chapter provides a listing and description of the principal EU and National regulations governing:

- requirements to prevent hazardous waste and restrict the use of hazardous substances in products;
- the management of hazardous waste that is generated; and
- regulation of the waste management and brokerage industries.

2.1. EU Legislation on hazardous waste

EU Waste Framework Directive

Waste management at EU level is regulated by the Waste Framework Directive (2008/98/EC)14. The Directive lays down measures to protect the environment and human health by preventing or reducing the adverse impacts due to the generation and management of waste. This revised Directive streamlines EU waste legislation by replacing three existing directives, the previous Waste Framework Directive 75/442/EC, the Hazardous Waste Directive 91/689/EC and the Waste Oils Directive 75/439/EC.

The Directive updates the Waste Hierarchy outlining the following in order of priority:

- Prevention – including reducing hazardous materials content in products;
- Preparing for re-use;
- Recycling;
- Other recovery, e.g. energy recovery; and
- Disposal.

In its previous form, the Waste Framework Directive required Member States to take steps to encourage waste prevention. The revised Directive outlines an updated hierarchy which should act as a priority order and reinforces waste prevention at the top of the hierarchy. When applying the waste hierarchy, Member States have to take measures to encourage the options that deliver the best overall environmental outcome.

In relation to hazardous waste, several requirements under the Directive include the establishment, revision and reviewing of hazardous waste management plans, inspections of hazardous waste facilities, record keeping, hazardous waste classification, banning of the mixing of hazardous waste, packaging and labelling requirements.

Other key issues of relevance addressed in the revised Directive include:

- Extended producer responsibility – Member States have powers to introduce new producer responsibility measures to increase levels of recycling, reuse and waste prevention;
- Waste prevention plans
- Energy recovery – energy-efficient incineration facilities dedicated to the processing of municipal solid waste will be able to be classed as 'recovery' rather than 'disposal' operations, moving them up the waste hierarchy;
- End of waste criteria - by which a material which is recovered or recycled from waste can be deemed to be no longer a waste;
- By-products – the Directive provides clearer distinction between by-products and waste and sets out conditions to be met for which material can be deemed to be a by-product.

Other relevant EU legislation

The following EU Directives and Regulations are of relevance to the National Hazardous Waste Management Plan and in the prevention (principally by restriction of hazardous substances) and management of hazardous waste generally:

- Industrial Emissions Directive - which sets out licensing procedures and criteria for certain industrial activities. Licences make specific provision for the prevention of waste and for its proper management. The Directive revises and merges seven separate existing Directives related to industrial emissions into a single Directive, including the Integrated Pollution Prevention and Control (IPPC) Directive (2008/1/EC), Volatile Organic Compounds (VOC) Solvents Directive (99/13/EC), Waste Incineration Directive (2000/76/EC), Large Combustion Plants (LCP) Directive (2001/80/EC) and Titanium Dioxide Directives (78/176/EEC, 82/883/EEC and 92/112/EEC) on waste from the titanium dioxide industry.
- Decorative Paints Directive - which limits the solvent content of several classes of paint product. A scheme using Inspection Contractors is in place to monitor vehicle refinishing activities including disposal of VOC-containing wastes.
- The PCB (polychlorinated biphenyls) Directive - requiring the disposal of PCBs and the environmentally sound decontamination or disposal of PCB-containing equipment.

- The WEEE (Waste Electrical and Electronic Equipment) Directive18 - imposing a producer responsibility obligation in respect of WEEE management, several categories of which are classified as hazardous waste.
- The RoHS (Restriction of Hazardous Substances) Directive19 - restricting the use of lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) or polybrominated diphenyl ethers (PBDE) in new electrical and electronic equipment.
- The Classification, Labelling and Packaging of Substances and Mixtures Regulation20 - which uses internationally agreed classification criteria and labelling elements in order to facilitate trade and to contribute towards global efforts to protect humans and the environment from hazardous effects of chemicals.
- The End-of-Life Vehicles Directive - obligations with regard to the restriction of use of certain hazardous substances in vehicles and the collection, treatment, reuse and recovery of end-of-life vehicles.
- The Batteries Directive- obligations with regard to the restriction of use of certain hazardous substances in batteries and accumulators, collection, treatment and recycling of batteries.
- The Packaging Directive23 - restricts the aggregate concentration of heavy metals (lead, cadmium, mercury and hexavalent chromium) in packaging. Packaging essential requirements are set out such that packaging is so manufactured that the presence of noxious and other hazardous substances and materials as constituents of the packaging material or of any of the packaging components is minimized with regard to their presence in emissions, ash or leachate when packaging or packaging residues from management operations or packaging waste are incinerated or landfilled.
- The Transboundary Shipment of Waste Regulation - as discussed above - imposes controls on the import, export and transit of waste, including hazardous waste.
- The Animal Remedies Directive - putting in place appropriate collection systems for veterinary medicinal products that are unused or expired.
- The Registration, Evaluation, Authorisation and Restriction of Chemicals (REACh) Regulation – applies to the identification of the properties of chemicals, the provision of safety information and calls for progressive substitution of dangerous chemicals as suitable alternatives are identified.
- The Ozone Depleting Substances Regulation28 – prohibits and restricts the use of ‘controlled substances’ that have the potential to deplete the ozone layer, including inter alia chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), halons, methyl bromide and carbon tetrachloride.

- The Fluorinated Greenhouse Gas Regulation29 - regulates the containment and handling of fluorinated greenhouse gases (f-gases), such as hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride. The European Commission published a proposal for a revised F-gas Regulation in November 2012, with the view to phasing down the supply of bulk HFCs, and introducing additional prohibitions on certain products and equipment. There is an increased focus in the proposed revision on global warming potential (GWP), with more onerous controls proposed for those f-gases with high GWP. The Commission Proposal is being negotiated by the Council and Parliament in 2013.
- The Persistent Organic Pollutants (POPs) Regulation - sets out the requirements for the prohibition, management, monitoring and control of persistent organic pollutants including persistent organic pollutants in wastes.
- Pollutant Release and Transfer Register (PRTR) Regulation - sets out the requirements for a European Pollutant Release and Transfer Register.
- Mercury Export Ban & Storage Regulation - sets out the requirement concerning the banning of exports of metallic mercury and certain mercury compounds and mixtures and the safe storage of metallic mercury.
- Extractive Industries Waste Directive - concerns the management of waste from the extractive industries.
- The EU Animal By-Products Regulations (Regulation (EC) No 1069/2009 & Commission Regulation (EC) No. 142/2011) lay down the rules concerning Animal By-Products including disposal requirements.

2.3. National legislation in relation to HW management

The Law on waste management was adopted for the first time in 2004 and since this date, the country is actively working on transposition of the EU legislation into national legislation and its implementation.

In the general environmental policies and Sixth Action Programme of the European Community for environmental protection, there are measures introduced for providing and application of the hierarchy of waste management and general principles of environmental protection. The European Union Waste Framework Directive (2008/98) generally defines key concepts and principles for waste management, according to the established hierarchy of waste management and general principles of environmental protection, such as the precautionary principle, sustainability, technical feasibility and economic viability, protection of resources and environmental impact.

In the integrated waste management system in accordance with the proximity and precaution principle, as general principles of environmental protection, waste should be treated or disposed as close as possible to the place of its generation, in the region where it is produced in order to avoid negative environmental impacts. In most countries of the EU, waste management accepted the concept of regional bodies. These bodies are usually established on regional level and are the responsibility of the regional authorities. The area that regional bodies cover can sometimes deviate from the established field of administrative region to respect the principle of proximity in waste management and cost effectiveness.

Starting from the abovementioned and the transposition of EU legislation on waste management into national legislation, there is a need for transformation of the current system of waste management, and establishing of operational integrated network for waste management on regional level. Also it results in a need to introduce a variety of services, facilities and installations for waste management which proportionately to this will incur higher costs.

Within the past 5-6 years the Ministry of Environment and Physical Planning has made great progress in transposition of EU legislation in the area of waste management into national by transposing most of the directives. In parallel, the Ministry has been working adoption of horizontal legislation for environmental protection such as the Law on environment and the related sub legislation. For preparation of this report the following national legislation, planning documents as well as other documents were used:

1. Law on waste management (Official Gazette of Republic of Macedonia No. 68/04, 71/04, 107/07,102/08, 143/08, 171/08, 82/09, 124/10, 09/11, 51/11, 123/12 and 163/13);
2. Law on management of batteries and accumulators and waste batteries and accumulators (Official Gazette of Republic of Macedonia No. 140/2010, 47/2011, 148/2011, 39/2012);
3. Law for packaging and packaging waste management (Official Gazette of Republic of Macedonia No. 161/2009, 17/2011, 47/2011, 136/2011, 6/2012, 39/2012);
4. Law on managing electrical and electronic equipment and waste electrical and electronic equipment (Official Gazette of Republic of Macedonia No. 6/12 and163/13);
5. Law on ratification of Basel Convention for control of transboundary shipment of hazardous waste and its disposal Annex VA and Annex V b (Official Gazette of Republic of Macedonia No. 49/97)
6. Law on environment (Official Gazette of Republic of Macedonia No. 53/05, 81/05, 24/07, 159/08, 83/09, 48/10, 124/10, 51/11, 123/12, 93/13);
7. Waste management strategy of Republic of Macedonia (2008-2020);
8. National waste management plan of Republic of Macedonia (2009-2015);
9. List of wastes (Official Gazette No. 100/05);
10. Ordinance for the format and content of the templates for transboundary shipment of hazardous waste (Official Gazette of Republic of Macedonia No. 37/03);

11. Ordinance for the manner and conditions for handling PCB, manner and conditions that should fulfil installations and objects for disposal and decontamination of PCBs, used PCBs and manner for labelling the equipment (Official Gazette of Republic of Macedonia No. 48/07);
12. Ordinance for the manner for handling waste from titanium dioxide, manner for monitoring and the format, the content and manner for data submission (Official Gazette of Republic of Macedonia No. 108/09);
13. Ordinance for measures for environmental protection that should be undertaken by producers, owners and subjects that are handling used vehicles, their components and materials, aims and deadlines for its handling and manner and conditions for storage, the format and the content for undertaking of the vehicle for destruction, the format and content of the template for notification and manner for recording (Official Gazette of Republic of Macedonia No. 108/09);
14. Ordinance for the manner for handling medical waste and manner for storage and labelling medical waste (Official Gazette of Republic of Macedonia No. 146/07);
15. Ordinance for manner for handling asbestos waste and waste from products containing asbestos (Official Gazette of Republic of Macedonia No. 89/06);
16. Ordinance for procedures and manner for collecting, transportation, processing, storage, treatment and disposal of waste oils, manner for recording and data submission (Official Gazette of Republic of Macedonia No. 156/07);
17. Ordinance for conditions for handling hazardous waste and manner for packaging and labelling hazardous waste (Official Gazette No. 15/08);
18. Ordinance for the manner and conditions for waste storage, as well as conditions that should be satisfied by the locations that storage waste (Official Gazette of Republic of Macedonia No. 29/07);
19. Ordinance for criteria for undertaking the waste from landfills from each class, preparatory procedures for undertaking the waste, general procedures for testing, taking examples and undertaking the waste (Official Gazette of Republic of Macedonia No. 8/08);
20. Ordinance for manner and procedure for work, monitoring and control of the landfill during working hours, monitoring and control of the landfill in the closing phase and further care for the landfill after closing, as well as the manner and conditions for landfills after they stop with operation (Official Gazette of Republic of Macedonia No. 156/07);
21. Ordinance for the conditions that should be fulfilled by landfills (Official Gazette of Republic of Macedonia No. 78/09);

22. Ordinance for the format and the content of the application for issuing permit, as well as format and content for the permit for landfill operator (Official Gazette of Republic of Macedonia No. 140/07);
23. Ordinance for the format and the content of the application for issuing permit for processing, treatment and/or storage of waste, the format and the content of the permit as we as minimal technical conditions for performing the activity for processing, treatment and/or waste storage (Official Gazette of Macedonia No. 23/07);
24. Ordinance for the format and the content of the permit for collecting and transport of hazardous waste (Official Gazette of Republic of Macedonia No. 118/10);
25. Ordinance for the format and the content of the template of annual report for the type and quantity of packaging that are put on the market or imported in Republic of Macedonia in the previous calendar year and for handling waste from those packaging, the format and the content of the template of the production specification, the format and the content of the template for recording total packaging put on the market or imported in Republic of Macedonia as well as on the manner how to make the recording (Official Gazette of Republic of Macedonia No. 41/10 and 184/11)
26. Ordinance for the manner of recording, the format and the content of the data base and informative system for packaging and waste packaging (Official Gazette of Republic of Macedonia No. 113/10);
27. Ordinance for the manner for numerating of the abbreviations on which is based the system of identification and labelling of the materials from which is produced the packaging as well as the format and the content of the label for handling the packaging (Official Gazette of Republic of Macedonia No. 62/10);
28. Ordinance for the format and the content of the template for recording of legal subjects which are handling packaging waste with waste packaging, producers and individual handling of waste packaging, manner for recording and the format and content of the confirmation letter for registration as individual collective scheme for waste packaging (Official Gazette of Republic of Macedonia No. 41/10);
29. Ordinance for the format and the content of the diary for recording of waste handling, format and the content of the forms for identification and transport of waste and format and content of the templates for annual reports for handling waste packaging (Official Gazette of Republic of Macedonia No. 7/06);
30. Ordinance for the content and manner of keeping, storing and maintaining of the records at waste register (Official Gazette of Republic of Macedonia No. 39/09);
31. Ordinance for the manner and conditions for functioning of the integrated network for waste disposal (Official Gazette of Republic of Macedonia No. 7/06);
32. Comparative study of solid waste management in Macedonia and Sweden 2009;
33. Spatial plan of Republic of Macedonia 2004;

2.4. Classification of hazardous waste

Waste producers are required to classify their waste as either hazardous or non-hazardous. On completion of the classification, the correct European Waste Catalogue (EWC) code must be assigned from the List of wastes (Official Gazette No. 100/05). Assessing waste as hazardous or non-hazardous is a multi-stage process, based on up to date standards and information, for the identification and categorisation of the hazardous components of waste.

The LoW provides a harmonised, non-exhaustive waste list and it is divided into 20 chapters which must be used in order of precedence. The LoW codes reflect either the origin of the waste from a particular sector, or the type of waste. A waste producer may classify its activities in several chapters of the catalogue. For instance, a machinery manufacturer may find its wastes listed in chapters 12 (wastes from shaping and surface treatment of metals), 11 (inorganic wastes containing metals from metal treatment and the coating of metals) and 8 (wastes from the use of coatings), depending on the different process steps.

Within the LoW, waste can be categorised into the following:

- hazardous, known as “absolute” hazardous entries
- non-hazardous, known as “absolute” non-hazardous entries, and
- wastes that may be hazardous or non-hazardous, known as “mirror hazardous” and “mirror non-hazardous entries”.

The “mirror entries” on the LoW allow for certain wastes to be classified as hazardous or non-hazardous waste depending on the presence of dangerous substances at certain concentrations.

The presence of dangerous substances in a waste could imply a hazardous waste classification. The waste producer may demonstrate through compositional analysis that the substances are present in concentrations not exceeding prescribed threshold values. The results of the compositional testing must be populated into the amended paper tool on the identification of the hazardous components of waste.

Currently, a review of the LoW and of the hazardous properties is being carried out by the European Commission which will lead to amendments to the catalogue.

3. HAZARDOUS WASTE PROFILE OF MACEDONIA

Hazardous waste management could be pointed out as one of the major environmental problems in Macedonia. Although in most cases the proper regulation framework is in place, implementation is still lacking or is in very early stages. This study, just confirmed lack of proper management system at all levels, low institutional capacities as well as lack of proper financial support needed for HW transport, storage, treatment and disposal.

Current situation of the hazardous waste management can be characterized as sub-standard in terms of human and financial resources, as well as ineffective in terms of monitoring and enforcement of the legislation. This conditions result in many detrimental effects on the human health as well as on the environment.

Current studies and data obtained from the MOEPP, as much as IPPC analyses performed during this report development, clearly indicates that largest quantity of hazardous waste is generated by industry and includes such materials as thermal processes waste, industrial solvents, waste oils, industrial sludge and chemical wastes.

Nevertheless, households, small businesses, farms and the healthcare and construction sectors also generate significant quantities of hazardous waste including batteries, electrical equipment, healthcare risk waste, solvent based paint and varnish waste, sheep dip and fluorescent lamps.

This chapter provide overall statistics in relation to the generation and management of hazardous waste.

Having in mind specific national conditions, information on hazardous waste generation and management presented in this chapter is divided in following waste groups:

- legacy and/or stored hazardous waste,
- generated hazardous waste divided in industrial and household hazardous waste,
- and special waste streams (wastes that may in some cases be classified as a hazardous but are managed under separate management schemes).

In order to provide the data for HW estimation, surveys in selected generators within each industry sector were planned. The surveys were intended to provide the information on industry type, size and production volume, amount of hazardous waste generated, physical state (liquid, solid, etc.), types (chlorinated, non-chlorinated, organic, inorganic, etc), source and current fate of the waste (in storage ,recycled, recovered, landfilled or other treatment) and data were to be used estimate the total volume generated within each industrial sector.

But although the data about the companies were provided, they were far to general and differences within the sectors were far too large to obtain reliable data from small sample surveys. In order to overcome the situation and provide reliable data and having in mind that IPPC plants were dominant (if not exclusive) waste generators within the all industrial sectors, the IPPC application were used as only verified source of data. The new approach was approved by the MOEPP and access to IPPC data was granted. Only final versions of the permits, verified by on-site inspections were included in our review.

The data were updated to current status on the joint sessions with the MOEPP staff so the team was able to include data from all (100% or 136 in total) A category installations and approximately 36 % of B category installations. Data were additionally crosschecked with all available reports and stats (including the data from Statistical office, Custom and other governmental bodies) and statistically adopted in order to estimate the total HW generated within the industry.

The data for HW generated within the households and service sector were estimated based the available data using estimation factors for household hazardous waste in the European Union, (Vassilis J. at.all, IJCEES Vol 3(3):40-48, 2012).

Detailed elaboration of the data including the sources and assumptions made are given in this chapter.

3.1. Stored and Legacy HW

The period of transition has devastating effects on national economy, so most of the manufacturing and processing industries have stopped their activities, and significant amounts of processing wastes were abandoned and little or no information is available on the history of these dumpsites. During the privatisation process, in most cases no clear arrangements were made with the new owners in respect to a clean-up of the old dumpsites. So these industrial contaminated dumpsites are considered as environmental “hot spots”.

Different studies and documents identified 16 major industrial hot-spots contain hazardous waste on national level, including nine industrial areas, two power plants and five mining areas.

Due to changes in current status and measures taken at most of them, only few still posse significant risk to environment and are not under the control of new owners (table 3). Those “hot spots” are ranked regarding their detected impact on the environment and their hazardous potential as follow: two “hot spots” were ranked as high environmental risk, two as medium environmental risk and three as low environmental risk (see Table 7).

Table 3 Industrial contaminated sites ("hot-spots")

No.	Hot-spot	Operational status	Deposits (m^3	Area (m^2)
1	OHIS A.D	Abandoned	252.200	76.725
2	MHK ZLETOVO (smelter slag)	abandoned	1.115.000	95.000
3	Lojane (chromium, arsenic, antimony mine)	Abandoned	1,000,000	100,000
4	SILMAK (ferro-silicium plant)	Operational	851,000	80,000
5	MHK ZLETOVO (fertilizer)	Abandoned	3,700,000	70,000
6	GODEL (tannery)	Abandoned	5,600	500
7	TANE CALESKI (metal surface treatment)	Abandoned	10	100
	AVERAGE/TOTAL		6,923,810.00	328,320.00

Highly contaminated sites

Middle contaminated sites

Low contaminated sites

*Source NWMP 2008-2014

Those sites contain phosphate tailings, lead slag, Lindane, Chlorine, HCH and other highly toxic materials which render these wastes hazardous.

For most of this sites rehabilitation activities are already planned and in some cases partially implemented, like in case of OHIS, so most probably they will not be part of future HW management system, but project team strongly advice this wastes to be taken in consideration during the development of HWMS.

In addition to legacy waste, there is a strong trend of temporary storage/disposal of HW noticed at the waste generators as much as at the collection companies.

Due to obvious lack of regulation enforcement and lack of adequate reporting system, most of the companies just keep the hazardous waste stored at their premises, or temporary disposed at provisional landfills without proper standards for disposal.

This conclusions are supported with data obtained from waste generators as much as the data from the MOEPP.

Data about preferred HW treatment collected in IPPC companies survey (see figure 8) clearly indicate that more that 91% of hazardous waste is stored or disposed at generator premises, and only 9% of the hazardous waste is recycled, reused, treated or incinerated.

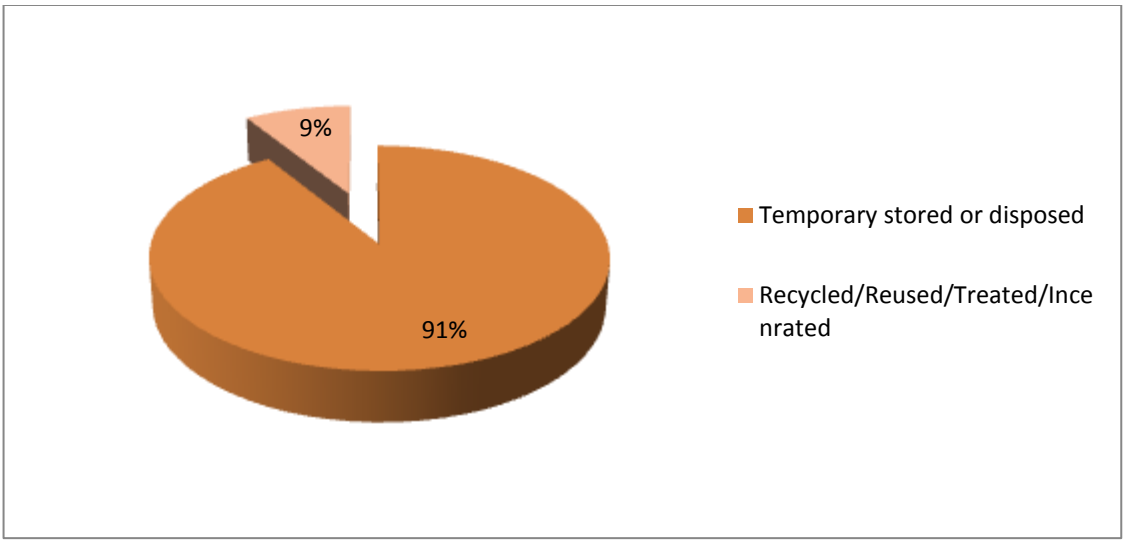


Figure 8. Preferred HW management in Macedonian Industry

A similar trend could be observed not only for waste generators but also for companies authorised for waste collection/treatment. According to data reported to MOEPP in 2012, out of 2790.4 tons of waste oils reported as generated in all sectors, around 203 tons are stored at the generators; 2500 tons are stored at the collection companies, while only 116 tons are exported.

There are also some quantities of chemicals marked as hazardous waste under the custody of different governmental control/inspection bodies. Most of those chemicals are due to various reasons confiscated from Custom offices or MOAFWE Inspection and are consisted mostly of plant protection products, insecticides, rodenticides, fungicides and herbicides. Those quantities are temporary stored until the final option is determined.

Table 4. Confiscated pesticides

Types of products	Confiscated chemicals	
	MOEFWE Inspectorate	Custom office
	[t]	[t]
Plant protection products	6.83	0.876
Insecticides	268.957	0.297
Rodenticides	3.8	
Fungicides	567.719	
Herbicides	507.630	
TOTAL:	1354.940	1.173
GRAND TOTAL:	1356.113	

The quantities of generated PCBs are provided from detailed inventory prepared by MOEPP in cooperation with GEF and UNIDO. Within this survey analysis was performed on transformers, capacitors and waste oil drums contaminated with PCB. It was found that there are 206.65 t of oil contaminated with PCB which is approximately 32 % above the quantity reported by the operators of the installations. PCBs usually originate from ferrous and non-ferrous metallurgy, heat and electricity production, mineral industry, transport, open combustion processes and production of chemicals and consumer goods.

Stored and legacy waste are mostly dominated with thermal waste processes in solid form (estimated to 90%) and much smaller quantities of liquid waste comprised of different waste oil, solvents, coatings and other chemicals. In any case HW quantities presented above must be taken in account for new HWMS development.

Having in mind the data presented above, project team estimates that in last 10 years period around **65.000 tons of different HW is stored at different locations within the country**.

3.2. Generated industrial hazardous waste

Data collected clearly indicate that largest part of hazardous waste come from industrial (manufacturing) sector, although because of the lack of proper reporting system it is very hard to obtain clear picture about the types and quantities. Therefore the project team has taken wide approach collecting data from different sources (IPPC companies survey, MOEPP documentation and databases, State Statistical Office) and in order to assure data consistency our results were compared the data with other relevant documents (NWMP 2008-2014), as much as with data from neighbouring country with similar economic and social development (Serbia, Croatia and Bulgaria). As a form of quality control all data were reviewed in joint sessions between project team and MOEPP officials.

As already mentioned the IPPC application permits were found to be most secure data source and our survey include all (100 %) applications for A permits (total number of companies -106) and around 36 % of applications for B-permits (total number of companies - 52). Based on the detailed documentation review, a comprehensive industry profile/inventory was generated and data about waste sources, types(categories), quantities and management practice were compiled in a single table (given in attachment). In total 11 companies from A category and 6 from B category were excluded from the inventory as they did not report any hazardous waste.

Having in mind extended of data coverage and assuming that IPPC plants are largest (if not exclusive) hazardous waste generators within all industrial sectors, following adjustment were made:

- total HW quantities reported from approximately 36 % of B category plants (totalling 539,85 t/year) were increased 3 times to extend the coverage to all similar plants, thus assuming that B category plants produce about 1619,85 tons of HW per year;
- assuming 100% coverage it is calculated that A category plants contribute to generation of 10941.03 tons of HW per year,
- total waste quantities were calculated as a sum of the quantites given above, increased for 10 % in order to include the waste from the industry not covered with IPPC regulations, thus giving total 14722,91 tons of HW per year produced from industry at national level.

It must be noted that due to different units used in the documentation (such as: tons, liter, m^3 and pieces), additional assumption were made to make the data comparable:

- for liquid wastes:
    - all waste have an average specific density of 1 t/m^3.
- for packaging waste :
    - plastic drums has a weight of 10 kg/pcs ,
    - still containers/drums has 20 kg/pcs,
- waste oil filter's has a weigh of approx. 1 kg/pcs.

Data about HW generation was summarized per waste category and waste source/or type of installation where the waste was generated and given in tables below.

Table 5. Gross quantity of hazardous waste per category

Source of waste	Surveyed Qty. [t/y]	NWMP(08-14) [t/y]
02 WASTES FROM AGRICULTURE, HORTICULTURE, AQUACULTURE, FORESTRY, HUNTING AND FISHING, FOOD PREPARATION AND PROCESSING	**19.8**	
05 WASTES FROM PETROLEUM REFINING, NATURAL GAS PURIFICATION AND PYROLYTIC TREATMENT OF COAL	**264.45**	**391**
06 WASTES FROM INORGANIC CHEMICAL PROCESSES	**628.86**	**227**
07 WASTES FROM ORGANIC CHEMICAL PROCESSES	**19.63**	**467**
08 WASTES FORM THE MANUFACTURE, FORMULATION, SUPPLY AND USE (MFSU) OF COATINGS (PAINTS, VARNISHES AND VITREOUS ENAMELS,) ADHESIVES, SEALANTS AND PRINTING INKS	**23.66**	**12**
09 WASTES FROM THE PHOTOGRAPHIC INDUSTRY	**9.78**	**3**
10 WASTES FROM THERMAL PROCESSES	**10900.93**	**75347**

11 WASTES FROM CHEMICAL SURFACE TREATMENT AND COATING OF METALS AND OTHER MATERIALS; NON-FERROUS HYDRO-METALLURGY	104.58	240
12 WASTES FROM SHAPING AND PHYSICAL AND MECHANICAL SURFACE TREATMENT OF METALS AND PLASTICS	38.98	48
13 OIL WASTES AND WASTES OF LIQUID	1992.97	777
14 WASTE ORGANIC SOLVENTS, REFRIGIRANTS AND PROPELANTS	13.67	
15 WASTE PACKAGING; ABSORBENTS, WIPING CLOTHS, FILTER MATERIALS AND PROTECTIVE CLOTHING NOT OTHERWISE SPECIFIED	109.99	52
16 WASTES NOT OTHERWISE SPECIFIED IN THE LIST	552.46	
17 CONSTRUCTION AND DEMOLITION WASTES (INCLUDING EXCAVATED SOIL FROM CONTAMINATED SITES)	7.29	
18 WASTES FROM HUMAN OR ANIMAL HEALTH CARE AND/OR RELATED RESEARCH	31.19	1000
19 WASTES FROM WASTE MANAGEMENT FACILITIES, OFF-SITE WASTE WATER TREATMENT PLANTS AND THE PREPARATION OF WATER INTENDED FOR HUMAN CONSUMPTION AND WATER FOR INDUSTRIAL USE	3.82	16
TOTAL:	14722.91	78580

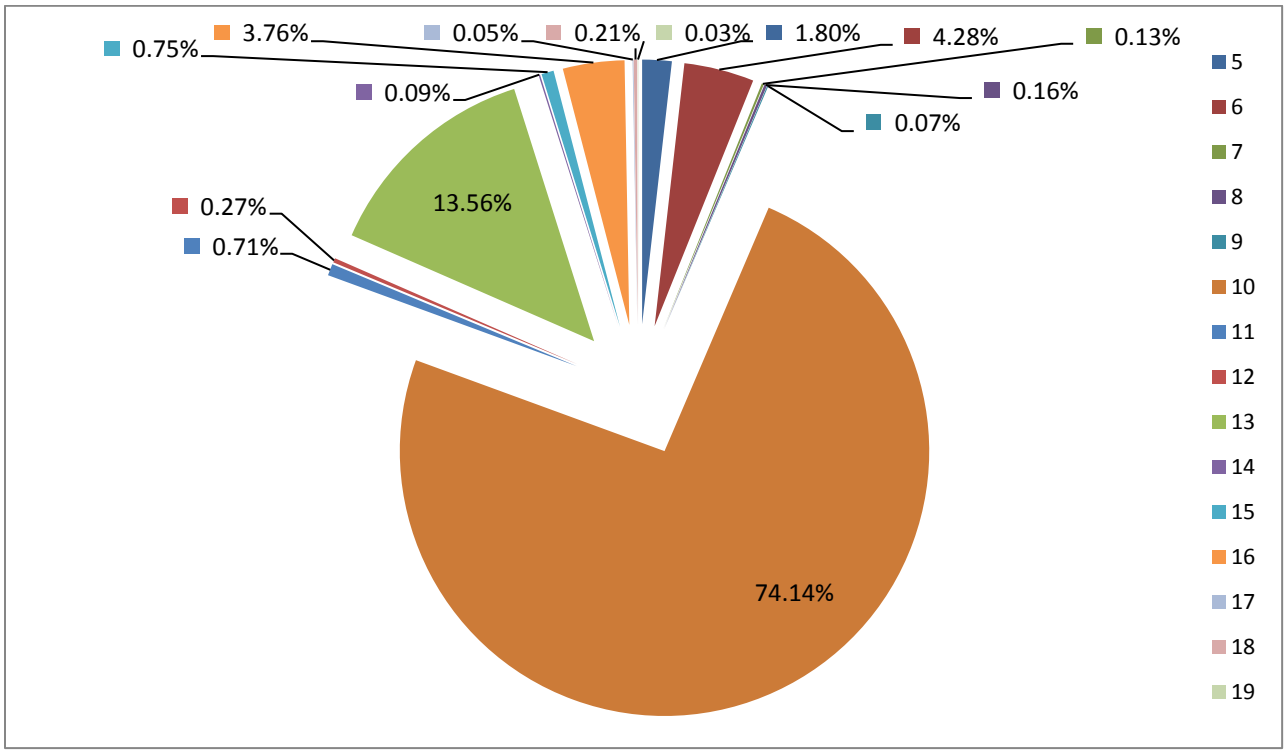
Table 6 Generated hazardous waste per sector[2]

Industry sector	Quantity
	[t/y]
Energy	1100.462
Production and processing of metals	11127.94
Mineral industry	2255.164
Chemistry	136.2093
Waste water treatment	6.662
Other (food, paper & card, use of organic solvents: printing)	96.5195
TOTAL:	14772.91

[2] Calculated by the authors of this Report

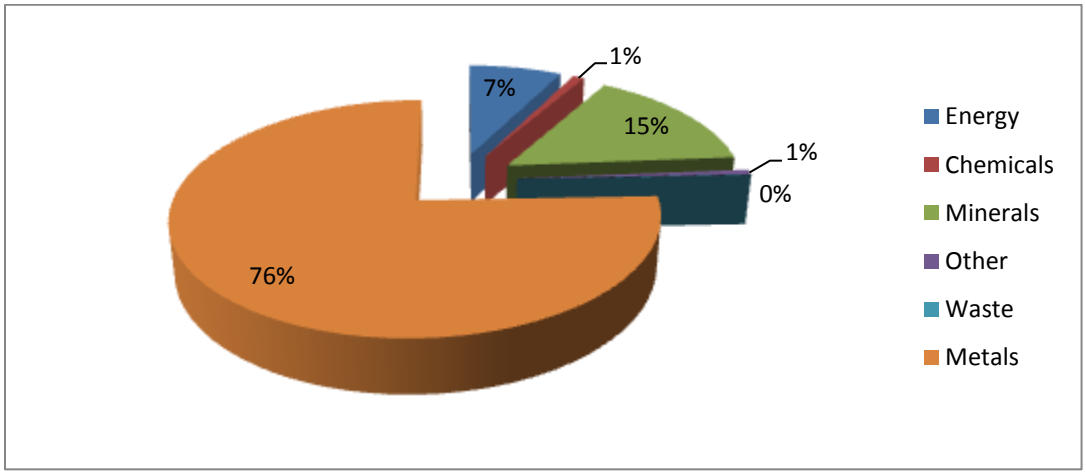
Tables above clearly indicate that wastes from thermal processes comprised largest share of industrial HW in the country (10900 t or 74%), followed by waste oils (1992 t or 14%), waste from inorganic chemical processes (628 t or 4%) and waste batteries (552 t or 4%). Only those 4 groups comprise together more than 96% of total HW generated in the industry.

Figure 9. Industrial HW per waste category



Subsequently, and concerning the source type largest share of HW come from production and processing of metals (76%), followed by the mineral industry (15%) and energy production (7%).

Figure 10. Industrial HW per source



Data presented above shows large discrepancies between the data collected in our survey and data estimated in NWMP, mainly due to inclusion of some sources which in period of NWMP where in operation, but they cease their operation in last few years or in some cases where permanently shoot of. Example for this is large difference in group 10 (waste from thermal processes), where NWMP estimates 75000 tons of waste mostly coming from MHK Zletovo smelter plant (estimation given in NWMP is 70.000 tpy), which stop all operations in 2003 and after few attempts was not restarted at all. A large difference in group 18 (wastes from human or animal health care and/or research) is due to non-inclusion of other medical waste in the stream of HW since this waste stream is separately managed and will not be burden for future HWMS.

For some other groups the NWMP plan gives only a vague explanation about the sources, so no reasonable explanation could be given, although in most cases the differences could be attributed to same cause, sources included in NWMP estimation stop their operations or plans for new production facilities didn't come true.

On the others side, quite good compliance between our survey and NWMP is evident for is some cases like "Makstil", largest single source of HW detected in our survey where data given in the plan and our survey are the same. Similarly, good compliance is also shown at several other waste groups.

In addition to this and in order to assess the data quality, data obtained in our survey were compared against the data reported from our countries from the region including Bulgaria, Serbia and Croatia.

For example Croatia in their NWMP 2007-2015 has estimated HW generation rate between 50.000 and 60.000 tons, dominated by waste from petroleum processing (20.000 t/y), waste oils and emulsions (10.000 t/y), thermal processes residues (10.000 t/y), wastes from metal or plastic surface treatment (10,000 t/y) and wastewater treatment wastes (10,000 t).

Similarly Serbia in their National waste management strategy 2010-2019, reported amount of around 100.000 t/y for HW generated from the industry and around 30.000 t/y of HW generated from the households.

Bulgaria has significantly higher quantities ranging from 500.000 up to 600.000 t/y coming mostly from petrochemical industry, smelters and wastewater treatment plants.

Comparing size of the economies and especially industrial branches in each of the countries included in the comparisons, data found in Macedonia are in expected range.

3.3. Generation of household hazardous waste

The term used to refer to hazardous waste generated in households (HHW) is not clearly defined in EU legislation while there is no specific legislation regulating the management of this waste stream.

Usually household HW fractions include solvents, acids, pesticides, fluorescent tubes and other mercury-containing waste, discarded equipment containing chlorofluorocarbons, oil and fat, paints, inks, adhesives and resins containing dangerous substances, detergents containing dangerous substances, cytotoxic and cytostatic medicines, batteries and accumulators, discarded electrical and electronic equipment and wood containing dangerous substances.

Hazardous waste from individual consumption, according to the European waste list, falls in the group 20 and is categorized as municipal waste (household and similar commercial, industrial and institutional waste) including separately collected fractions. Hazardous fractions in this group are marked with (*) and are as follows:

20 01 13* solvents

20 01 14* acids

20 01 15* alkalines

20 01 17* photochemicals

20 01 19* pesticides

20 01 21* fluorescent tubes and other mercury-containing waste

20 01 23* discarded equipment containing chlorofluorocarbons

20 01 26* oil and fat other than those mentioned in 20 01 25

20 01 27* paint, inks, adhesives and resins containing dangerous substances

20 01 29* detergents containing dangerous substances

20 01 31* cytotoxic and cytostatic medicines

20 01 33* batteries and accumulators included in 16 06 01, 16 06 02 or 16 06 03 and unsorted batteries and accumulators containing these batteries

20 01 35* discarded electrical and electronic equipment other than those mentioned in 20 01 21 and

20 01 37* wood containing dangerous substances.

Some of this wastes are covered with collection schemes (collection of the hazardous waste under the producer responsibility and all producers/importers must participate i.e. provide containers for collection of different types of waste, as much as means for transport, treatment and/or disposal of collected waste. These forms of waste management although introduced due to law enforcing, are still in the early stages and mostly not fully established. Also, for most

collection schemes, reporting system is still not fully functional, preventing possibilities for more precise calculations using mass balance or similar methods.

It must be noted that only a part of the household's hazardous waste are covered with producer's responsibility schemes, including:

- 20 01 21* fluorescent tubes and other mercury-containing waste;
- 20 01 23* discarded equipment containing chlorofluorocarbons;
- 20 01 33* batteries and accumulators included in 16 06 01, 16 06 02 or 16 06 03 and unsorted batteries and accumulators containing these batteries; and
- 20 01 35* discarded electrical and electronic equipment other than those mentioned in 20 01 21.

On the other side there are also hazardous waste types not included in separate waste streams, such as:

- 20 01 13* solvents
- 20 01 14* acids
- 20 01 15* alkalines
- 20 01 17* photochemicals
- 20 01 19* pesticides
- 20 01 26* oil and fat other than those mentioned in 20 01 25
- 20 01 27* paint, inks, adhesives and resins containing dangerous substances
- 20 01 29* detergents containing dangerous substances
- 20 01 31* cytotoxic and cytostatic medicines
- 20 01 37* wood containing dangerous substances.

Municipalities' trough the communal service providers are responsible for the management of the waste groups given above, and they should provide appropriate collection points as much as further waste handling in line with waste management hierarchy. Situation in this case is unfortunately even worse, still focused only on collection and disposal/landfilling of waste. Regional waste management approach is still in very early phases of development and only few regions have waste management plans under development.

Although the management team provided data about different types of materials (paint, oils, oil filters…) placed on the marked, since no data about hazardous waste collected from the households could be obtained, the only option is to estimate quantities using some general parameters, like average income of the inhabitants or general economic conditions (GDP per capita).

Available worldwide data show that the quantity of hazardous waste arising from households represents in average the 0.90±0.34% of municipal solid waste (MSW). In terms of HHW collection per capita, data from EU resulted in an average of 2.46±1.33 kg/capita and estimated arising of HHW generation in EU countries is 0.4-5.3 kg/capita.

The quantity of household hazardous waste generated annually can be roughly assessed using the data for average generation of this type of waste in countries with relatively close GDP like Macedonia. Taking into account the number of inhabitants in the country and the generation rate of 3 kg/ inhabitant/y in Bulgaria, the amount of household hazardous waste generated at national level can be roughly estimated 6.071 t/y. This estimation correspond well with the data provided in NWMS of Serbia, where approx. 30.000 t/y were reported.

3.4. HW management

In general only small part of the hazardous waste is collected and transported in compliance to the current legal requirement. On the other side very often the equipment for collection of waste and level of services is not on a satisfactory level and in compliance with legislation. Usually, collection of hazardous and non-hazardous waste is done without any segregation of these two fractions.

Generally, the hazardous waste generators do not separate their industrial waste, but they mix the different types of hazardous wastes with other, non-hazardous wastes. If some separation is done, then this is primarily driven by market demand i.e. only those types of hazardous wastes are separated that can be sold.

It is very interesting to note that regardless of the waste hierarchy defined in appropriate regulations, preferred management approach for HW in Macedonian industry provided from the IPPC applications is temporary storage or disposal, while very small parts of the waste is reused, recycled, treated or incinerated. It also should be noted that in most cases, waste generators does not have appropriate facilities for temporary storage or landfilling, and this approach could result in significant environmental damage.

Table 7. Management of hazardous waste preferred in Macedonia

Preferred option	Type of waste management	Quantity	
		[t/y]	Share in %
2	Temporary storage	1495.13	10.16
3	Treatment	603.09	4.10
6	Recycling	64.00	0.43
4	Reuse	490.96	3.33
5	Incineration	148.67	1.01
1	Temporary disposal	11921.07	80.97
	TOTAL:	14722.91	100.00

Waste collection, selection and transport is insufficient in a number of areas. Most trucks and waste collection vehicles are very old with low capacity. Mixed industrial and municipal waste, including hazardous fractions waste, is collected from the service beneficiaries.

At the moment in the country there are 9 licensed companies for transport, and 7 companies licenced for storage and treatment of waste electric and electronic equipment and waste batteries and accumulators and 9 companies licensed for storage and treatment of waste oil.

As already explained above, Macedonian industry prefers to keep the hazardous waste generated in their operation on temporary storages within their premises than to invest in proper waste management. Proper treatment of hazardous waste is done only if it is driven by market demand i.e. only those types of hazardous wastes are separated that can be sold. Only a few companies manage hazardous waste in compliance with legislation. Usually those are companies with highly developed corporate responsibility.

There are two incineration facilities in the country, one stationary located in Skopje and one mobile incinerator located in Bitola. Both incinerators are licensed for incineration of medical waste with capacity of 1 t/day for the stationary one and 15 t/day for the mobile unit. It is estimated that about 35% of the total amount of hazardous waste from healthcare institutions in Macedonia is incinerated.

Unlike Macedonia, Bulgaria and Croatia do have established HW treatment and recycling facilities.

Bulgaria have incinerators for medical waste located in some of the bigger hospitals and one incinerator in the Military Medical Academy – Sofia, which is equipped with the necessary

pollution abatement facilities and the new modern installation for incineration of infectious and pathological hospital waste is installed in Sofia have annual capacity of 2800 tons.

The second main group of installations for incineration of waste are located at the main airports in Sofia, Burgas and Varna and at the ports in the last two cities. The condition of these installations is identical to the situation of the installations for incineration of hospital waste. The enterprises of the cement industry show interest for examination of the possibilities for reconstruction and equipment of the existing installations in order to incinerate different types of waste as additional fuel during the production processes.

By the end of 2008 11 landfills for hazardous waste are operating in the country, 8 of which comply with the regulatory requirements for environmental protection. The main part of the hazardous waste landfills in operation are constructed by the enterprises, generating the waste, accepting only their own waste. The exceptions are only the cells for hazardous waste in the regional landfills of Rousse and Sevlievo as well as the hazardous waste cell on the landfill of "KCM – Plovdiv", which will accept certain types of waste from other generators.

There are also recycling installations in the country for different types of hazardous waste such as: metals, lead-acid accumulators and waste oils.

As a result of the existence of market for metal waste within the country and abroad and due to the higher number of companies authorized to carry out activities with such waste, the capacity for recovery is not a limiting factor for the recycling in the country. The capacity of the main enterprises for recovery of steel scrap and cast iron which amounts to about 750 000 tons per year, exceeds the real quantity of the waste collected. There are no enterprises for recovery of scrap from steel alloy/stainless steel and the collected wastes are exported after pre-treatment and sorting. The aluminium, copper and copper alloy wastes are recovered abroad after sorting, baling and/or pre-treatment by pouring.

The existing installations for recovery of waste lead-acid accumulators in the country have capacity at the rate of 23 000 tons per year and they are able to satisfy the country needs.

The existing capacity of the only enterprise authorized for regeneration of waste oils (5 000 tons) does not allows the whole waste quantity generated in the country to be recovered.

In Croatia, technical and technological capacities for collection, storage and treatment of hazardous waste are being developed in accordance with market principles. Certain economic entities have been issued permits for collection, transport and temporary storage of hazardous waste. In addition, there are several smaller specialised facilities in Croatia built for the purpose of recovery/treatment of hazardous waste and there are available capacities within individual industrial installations which are used for recovery/treatment of some type of hazardous waste.

Currently there are 43 companies holding permits for the activities of waste disposal/treatment in Croatia . The method of disposal/treatment of hazardous waste in Croatia is carried out in one of the following ways:

- thermal treatment,
- conditioning by incorporation into brick products,
- solvent regeneration, neutralisation of acids and bases,
- solidification and stabilisation,
- sterilisation/disinfection,
- electrolysis and dilution,

The are several facilities sometimes used for the treatment of hazardous waste:

- power plants with more than 3 MW in capacity (plants for solvent, sludge, oils, etc.);
- heat generating facilities used in the scope of big industrial plants;
- plants for thermal treatment of waste operating as a segment of industrial processes in a bigger system;
- deep boreholes that are exclusively used for the disposal of waste generated through petroleum extraction.

There is one hazardous & packaging waste thermal-treatment plant in Sisak, with the annual capacity of 2000 tons, mainly used for the treatment of pesticides and similar products and one waste plant in Zagreb, with the annual capacity of 10000 tons, was used for thermal treatment of hazardous organic waste but has been out of operation since 2002.

The quantity of about 51,000 tons of waste oils, oiled plastic packaging, filters and emulsions was generated in Croatia in 2003. A smaller portion of these waste oils is disposed of by thermal treatment (co-incineration with fossil fuels) in the facilities of mineral oil manufacturers, in HEP thermal plants, in the cement factory, and in some industrial thermal plants and boiler houses, with thermal capacity of more than 3 MW.

The average quantity of 350 tons/year of mineral oils (transformer, turbine, hydraulic, compressor, cable and motor oils), mostly from HEP plants, were incinerated in thermal plants.

There is also one facility for collection and recycling of oiled water, packaging and filters, and its capacity is 200 l/h.

The thermal treatment of waste is operated in several types of facilities in Croatia:

- installations for the thermal treatment of waste (including power plant fuelled by waste),

- co-incineration of waste with fossil fuels,
- rendering plants (thermal treatment of animal waste from slaughterhouse),
- power plants fuelled by gas generated in landfills.

Installations for the thermal treatment of waste are mostly used for the treatment of hazardous waste. Most waste is thermally treated in the wood-processing industry. This treatment is related to the generation of energy (power plants fuelled by waste). According to the data annually in Croatia is treated 3700 t of hazardous waste by thermal treatment.

4. SPECIAL WASTE STREAMS

4.1. Medical Waste

The Ordinance on Clinical Waste Management lays down the collection, transportation, storage, treatment, recovery and/or disposal of clinical waste, including recovery and/or disposal of wastes generated by treatment, recovery and/or disposal of clinical waste.

The Ordinance determines the system of clinical waste management according to the "polluter pays" principle and in this manner ensures that clinical waste is treated in conformity with the EU Directive on Waste. The Ordinance aims at energy recovery of non-hazardous waste generated by hazardous waste treatment on disinfection and sterilization equipment, due to its high energetic value, although in the country there are only 2 incinerators with no possibilities for energy recovery. It is very important to stress that this waste stream is set to be solved as a separate waste management system through addition of new incinerators (already in process of purchase) with few licenced operators at national level, and this will not be a part of future HW management system.

4.2. Asbestos-containing Wastes

Ordinance on Asbestos-containing Waste Management Methods and Procedures makes it obligatory to waste producers and waste processors to take all necessary measures to ensure that asbestos emissions in the air, the discharge of asbestos and asbestos-containing materials into water and generation of asbestos-containing waste are prevented or minimized in conformity with the Ordinance and special regulations.

There are no plants that use asbestos in the production process and there are few licenced operators licenced for collection and transport of this materials.

4.3. Mining and Mineral Wastes

Management of waste generated by exploitation of mineral raw materials is under jurisdiction of the Ministry of Economy, as the authority responsible for the mining industry sectors and is implemented in the Mining Act and the pertinent enforcement regulations. Those waste are separately stored and treated and will not be a burden of future HWMS. Other types of HW

coming from mining industry (waste oils, chemical packaging…) are included in calculation and will be a part of future HW management scheme.

4.4. Construction and Demolition Waste

Each individual or several local self-government units must determine a site for temporary deposition of construction waste from which all reusable materials will be previously separated. Such temporary sites should be located in a radius of 30-50 kilometres. Temporary deposition of such wastes will be carried out in a transfer station and/or a recycling yard. It is also planned to use existing landfills which will operate until establishment of a WMC, with the aim to use a portion of material recovered from the construction waste managed (daily covers, transport roads and ramps) and from landfill rehabilitation and in this manner reduce the costs of rehabilitation and construction waste management. The recovery of the material collected should be carried out by mobile construction waste recycling plants. Considering the amounts of construction waste generated, the use of quarries may be organized in some cases. Quarries may also be used as possible landfills for construction waste of mineral origin (excavation waste, possibly separated scrap concrete) and as possible locations to place construction waste recycling equipment and facilities.

The existing construction waste will be managed in two ways:

- permanent disposal of total construction waste to the related landfill (e.g. as part of the landfill engineering concept or structure) by rehabilitation of the existing landfill, and
- partial or total disposal of construction waste in the same way as the newly generated construction waste, meaning that it is previously disposed of to temporary landfills or within the framework of plants and facilities (according to the Waste Act in force) used for construction waste recovery or recycling.

Construction waste should be recovered or recycled in full (or to the maximum extent possible), avoiding any permanent deposition to natural environment, as determined by the Waste Act and the Strategy.

4.5. By-products of Animal Origin

As regards by-products of animal origin, control is to be established over dead animals in order to prevent the spread of infectious diseases. All livestock breeding facilities are to be registered with the Ministry of Agriculture, Forestry and Water Management (MAFWM), Department for Veterinary Science, and to be given a veterinarian identification number, and they are responsible for keeping a record of breeding and the number of livestock died. The establishment of an efficient system for the disposal of by-products of animal origin requires the following:

- construction of collecting points for temporary storage of by-products of animal origin at a temperature not exceeding 4°C; and
- introduction of new treatment technologies for by-products of animal origin of category III, using them for the generation of electricity, heat – biogas and high-quality fertilizers.

This waste stream will be a part of future HW management scheme.

4.6. Sludge from Wastewater Purification Plants

Sludge resulting from purification of municipal wastewaters might be considered a municipal waste component. However, sludge management falls within the competence of legal entities that manage wastewater treatment plants rather than authorities responsible for waste management.

Sludge management is to be regulated as part of the water management strategy, because this strategy will define more precisely projected amounts, characteristics and options for final disposal of sludge from municipal wastewater purification plants.

A special ordinance has laid down the methods and conditions for the management of sludge arising from municipal wastewater purification plants when these sludge are used for agricultural purposes.

The construction designs of municipal wastewater purification plants must ensure a complete aerobic (or anaerobic) stabilization of sludges before sending them for deposition on agricultural land or to inert waste landfills.

The quanities of sludge are expected to rise in future (up to 60 t/y in 2035) and will be a part of futire HW management scheme.

4.7. Packaging and Packaging Waste

The recent Ordinance on Packaging and Packaging Waste has set up an integrated system for

packaging and packaging waste management. The Ordinance lays down the packaging and

packaging waste management method, or specifically:

- obligations of manufacturers, importers, packagers and sellers when producing, marketing and using packaging and packaging waste;
- providing manufacturers and consumers with information about essential properties of the product and packaging;
- method of collecting charges for packaging and packaging waste, collection and management of packaging and packaging waste;
- return of used products and packaging respectively for reuse, payment of the charge for recoverable waste after the product has been used; and
- purpose and use of charges paid for packaging and packaging waste.

In accordance with the 'polluter pays' principle, waste disposal costs are borne by manufacturers and importers of packaging.

There are few operational packaging waste schemes and only the packaging of hazardous chemicals will be included in HW management scheme. Estimated quantities are included in this report assessment.

4.8. Waste Tyres

The Ordinance on Waste Tyres Management has determined the disposal method for all tyres discarded in the area of Macedonia and tyres imported either as a single product or mounted on vehicles in Macedonia as a single product or a part of a product.

The Ordinance lays down:

- types and amounts of charges to be paid by persons liable to charges;
- method and time of calculation and payment of charges;
- method of collecting waste tyres and the amount of indemnities payable to licensed waste collectors for the collection of waste tyres; and
- amounts of indemnities payable to entities dealing with the recovery of waste tyres.

In accordance with the 'polluter pays' principle, importers and manufacturers of tyres pay a charge to cover the costs of waste tyre management (collection, temporary storage, disposal and recovery). Persons liable to charges pay a charge for waste tyre management both when importing and vehicles, airplanes and other machines containing tyres as components according to the criteria laid down by the Ordinance.

4.9. End-of-Life Vehicles

The recovery and disposal system prescribed by the Ordinance on End-of-Life Vehicles Management ensures that this type of waste is managed in accordance with the EU Directive on Waste and the EU End-of-Life Vehicles Directive, at the same time applying the 'polluter pays' principle. The Ordinance lays down specific environmental protection measures which aim at setting up a system for collecting end-of-life vehicles for reuse, recycling and other forms of recovery of end-of-life vehicles and their components so as to reduce the disposal of waste and enhance the environmental performance of all economic operators involved in the lifecycle of vehicles, especially those directly involved in treatment of end-of-life vehicles.

The Ordinance on End-of-Life Vehicles Management determines:

- the method of end-of-life vehicles management:
- types and amounts of charges payable by persons liable to payment of charges for end-of-life vehicles;
- method and time of calculation and payment of charges; and
- ban on the marketing of motor vehicles containing hazardous substances.

Although not fully implemented ELV are in most cases included in and separate management scheme only because of the scrap metal value, so implementation of proper management

scheme is very urgent. Hazardous components contained in ELV should be included in HW management scheme and in general way the quantities are added in the estimations.

4.10. Waste Oils

The recent Ordinance on Waste Oils Management determines persons liable to the waste oil charge, types and amounts of charges payable by persons liable to the waste oil charge, method and time of calculation and payment of charges and waste oil management methods. There is an operational waste oil management scheme and several licenced operators already compete on the market. In any case the waste oil represent significant amount of HW which need a treatment and therefore they are included in our calculations, and future HW management scheme should provide options for treatment of this materials.

4.11. Waste Batteries and Accumulators

The Ordinance on the Management of Waste Batteries and Accumulators lays down the method of labelling batteries and accumulators, the method of collecting waste batteries and accumulators, obligations and responsibilities of manufacturers of batteries and accumulators and manufacturers of battery and accumulator components, types and amounts of charges payable by persons liable to charges, method and time of calculation and payment of charges and amounts of indemnities paid to persons licensed for the collection, recovery and recycling of waste batteries and accumulators.

The Ordinance has prescribed the system for the recovery and disposal of waste batteries and accumulators, based on the 'polluter pays' principle, and thus ensured that that waste batteries and accumulators are managed in accordance with the EU Directive on Waste and the Directive on Batteries and Accumulators and Waste Batteries and Accumulators. The Ordinance aims at setting up a system of collection, recovery and high-standard recycling, controlled use and/or disposal of the residues arising from the recovery and recycling of waste batteries and accumulators regardless of their form, volume, weight and material used for their manufacture.

The collection of waste batteries and accumulators is carried out at points of sale and the waste disposal costs are borne by manufacturers and importers.

Having in mind current conditions this waste stream although included in our calculation, accumulators will not be a part of future HM management scheme since there are collection schemes and processing plants already available.

4.12. Electric and Electronic Waste

The Ordinance on Electric and Electronic Waste Management has set up a system for separate collection of electric and electronic waste for its recovery and disposal, environmental protection and human health under the 'polluter pays' principle.

The Ordinance determines:

- persons liable to charges;

- types and amounts of charges payable by persons liable to payment of charges for electric and electronic waste;
- method and time of calculation and payment of charges;
- electric and electronic waste management methods;

The electric and electronic waste disposal costs are borne by manufacturers and importers and the managements schemes are already in place, although in very early stages.

5. ANALYSIS OF TREATMENT OPTIONS

As the policies of enforced self-sufficiency have been abandoned in most of EU Member States as a result of pressures exerted by the open and competitive waste market in the EU it is recommended to strive for greater self-sufficiency in order maximise the treatment/disposal of hazardous waste in Macedonia, where strategically advisable and economically and technically feasible, with policy, environmental and availability-of-outlet benefits.

Based on the data presented above (80 % of HW coming from thermal processes in manufacturing/mineral industry) strategic need for expansion of recovery and treatment capacity is identified.

A number of alternative treatment methods are available for several different hazardous waste streams, including such techniques as: alkaline hydrolysis, molten slag, ball milling, 'PCB Gone', base catalysed dechlorination, plasma arc technologies, catalytic treatment, 'Silver II', 'Cerox', solvated electron technology, gasification, steam detoxification, gas-phase chemical reduction, supercritical water oxidation, molten metal, thermal desorption, molten salt, advanced oxidation

A brief technical description of these technologies is provided in the study.

Chemical methods

Most used chemical methods are:

- *neutralization*,
- *oxidation* (using common oxidising substances such as hydrogen peroxide or calcium hypochlorite);
- *reduction* (used to convert inorganic substances to a less mobile and toxic form);
- *hydrolysis* (decomposition of hazardous organic substances) and
- *precipitation* (particularly useful for converting hazardous heavy metals to a less mobile, insoluble form prior to disposal to a landfill).

Physical methods

Physical methods mostly used for treatment of hazardous waste are:

- *encapsulation* (immobilising hazardous materials by stabilisation and incorporation within a solid matrix such as cement concrete or proprietary organic polymers prior to andfilling) and
- *filtration/Centrifuging/Separation* (physically separating phases containing hazardous substances from other nonhazardous constituents

Biological methods

These involve the use of microorganisms under optimised conditions to mineralise hazardous organic substances.

Thermal Methods

These are the treatment processes which involve the application of heat to convert the waste into less hazardous forms. It also reduces the volume and allows opportunities for the recovery of energy from the waste. The treatment method most commonly used in Europe and North America to destroy hazardous organic wastes, including organochlorines such as polychlorinated biphenyls (PCBs), is high temperature incineration. Incineration is the controlled combustion process which can be used to degrade organic substances. In practice, complete combustion is difficult if not impossible to achieve but for hazardous waste 99.99% or greater destruction or removal is required for the process to be generally acceptable.

The ash resulting from incineration of hazardous waste may itself possess hazardous properties. This is likely to be the case when toxic heavy metals are involved. The ash must therefore be constantly monitored and may require stabilisation and encapsulation before disposal to landfills.

Liquid effluent results where water is used for temperature reduction of gases by quenching, and/or, where wet scrubbers are used for emission control. Some recycling may be incorporated after cooling and chemical treatment, but a quantity of liquid effluent will need to be discharged after appropriate treatment.

Kilns used for the production of cement clinker are designed and operated in a manner that achieves the required parameters for the destruction of hazardous waste, such as time at high temperatures. In many developed countries such kilns are licensed by authorities for the destruction of appropriate hazardous wastes. Such wastes include PCBs, and recently in Japan, waste chlorofluorocarbons (CFCs). An additional advantage from the use of cement clinker kilns is that the alkaline particulates involved act to neutralise acidic combustion products. The general use of cement kilns for hazardous waste destruction in Republic of Macedonia has not gained favour.

A thermal process developed for commercial application in Australia uses the very high temperatures, in excess of 10,000K, which can be attained in arcs formed across high voltage electrodes. This is particularly useful for the destruction of difficult hazardous liquids and gases such as some of the halogenated organics. This process is particularly applicable for the destruction of waste halons and CFCs.

Types of hazardous wastes that can be incinerated based on the assessment done within the mapping process are the following:

- lacquers and paints;
- glues and waxes;
- laboratory chemicals and fine chemicals;
- pesticides;
- sorbent and filter material;
- production and distillation residues;
- rinsing liquids and concentrates;
- acidic wastewater and solvents;
- contaminated packaging or equipment;
- waste containing PCBs;
- oil/water mixtures;
- emulsions and oil trap contents;
- expired pharmaceuticals; and
- infectious waste.

As already mentioned, the largest quantities of hazardous waste (around 74 %) come from thermal processes, followed by waste oils with 14 %, waste from inorganic chemical processes with 4 %, and waste not otherwise specified (mostly batteries and accumulators) with 4 %, other types of waste are put in the group “rest” which represent only 4 % of the generated hazardous waste in the country.

The contribution of hazardous waste originating from different waste group is shown in the Figure 9.

The largest quantities of hazardous waste is solid waste from gas treatment that origin from thermal processes in metallurgy and mineral industry. This waste is generated with the purpose of removing substances from gases released from a thermal process before they are allowed to be emitted to the atmosphere. This could be the removal of acid gases, such as hydrogen

chloride, using an alkaline material, or dusty materials like cement kiln dusts that are removed from the gas stream by, for example, filters or precipitators. Processing of the gas stream is very important for environmental protection. Some of these wastes may contain dioxins and heavy metals which may be captured in the gas treatment residues. In fact, the main quantities are categorized as:

- 10 02 07*- solid wastes from gas treatment containing dangerous substances. This waste origin from iron and steel industry and it can contain heavy metals, dioxins and furans; and
- 10 13 12* - solid wastes from gas treatment containing dangerous substances. This waste origin from the manufacture of cement, lime and plaster and articles and products made from them. This waste may also contain dioxins and furans.

In order to reduce the quantities of generated hazardous waste companies can apply different measures in accordance with the waste management hierarchy such as: prevention and reduction, recycling, recovery and landfill as the last desired option.

Consideration could be given to using less hazardous materials for the removal of acid gases but the disposal or recovery of the alternatives must be taken into account. For example, sodium bicarbonate can be used instead of lime to remove acid gases but the disposal of bicarbonate can be difficult giving rise to carbon dioxide.

Contamination of the material could be minimised by looking at input materials. For example, sorting of waste prior to incineration can minimise the potential for heavy metals to be present in the gas treatment residues. The amount of heavy metal in gas treatment residues is an important factor in further processing and can impede recovery and recycling.

For recovery purposes, it is important to limit the amount of dioxins and furans in the gas treatment waste; however it is also vital to limit the amount of these gases in the atmosphere. This can be achieved and controlled by:

- minimising the ‘chlorine’ content of the input materials. This may reduce dioxin and furan formation, minimising contamination of the gas treatment residues;
- carefully managing the temperatures in parts of the combustion process;
- adding activated carbon to the acid-gas scrubbing lime which removes additional dioxin and furan. This activated carbon and its captured dioxin / furan will be present in the waste gas treatment residues.

Dioxin and furan levels in the gas treatment residues will not make them hazardous but could have an effect on recovery and where possible their formation should be minimised.

Recycling is a form of complete recovery by which waste materials are reprocessed into products that can be used for the original or another purpose. The recycling process needs to

be sufficient to ensure that any contamination is adequately managed so that the material can reach product standard.
Gas treatment residues contain mineral components that can be treated for use in construction. These include compounds of calcium in the form of calcium hydroxide and calcium carbonate, silica, aluminium and iron.

It is unlikely that gas treatment residues can be used as a direct replacement for raw materials in a recovery process without first being treated. However, it may be possible to treat gas treatment residues so that the output of the treatment can be used as raw material replacement. This treatment is considered an interim step towards recovery but only where the waste is strictly intended to be used as a raw material replacement in a recovery process.

The second biggest group according to the quantity of generated hazardous waste with 8.12 % is group 13 Waste oils and waste from liquid fuels. Oil is a hazardous substance that is usually harmful / toxic, carcinogenic or ecotoxic. Oils may also contain metals or other contaminants that may also have hazardous properties. Fuels will probably also be flammable.
The biggest contributors to the quantity of hazardous waste from this group are the following types of waste:

13 01 05* - non-chlorinated emulsions (originating from metallurgy and mineral industry sectors;

13 02 05* - mineral based non-chlorinated engine, gear and lubricating oil (originating from mineral, chemistry and sector other); and

13 02 06* - synthetic engine, gear and lubricating oils (originating from mineral industry and other sector)

These wastes are mainly mineral or synthetic oil based, not emulsions and are not readily biodegradable. They may be mixed together only under permitted conditions, where the mixing improves the opportunity for recycling or energy recovery. The waste may contain water, metals or metal compounds. Their use may have changed the nature of the organic components – for example introducing or increasing the presence of potentially carcinogenic poly-aromatic hydrocarbon (PAH) levels. Measures that can be used for this type of waste are:

- minimization of waste fuels driven by users striving for efficiencies so that they can reduce their costs; changes in engineering and lubricant technology which will resulted in a significantly reduced volumes of waste oils being produced. The move to synthetic oils has also led to oils being produced that are less hazardous;
- there are very few options for fuels or lubricants to be prepared for re-use, such as simply filtration of backup generator diesel oil wastes and put back into the generator;

- it is possible to recycle, regenerate or re-refine lubricants and electrical oils to virgin equivalent quality;
- a fuel waste can be recovered either as a product fuel or as a waste fuel. The waste is fully recovered where: it is converted to product fuel; used as a waste fuel as a fossil fuel substitute; and thermally destroyed using energy recovery.

Intermediate recovery steps include blending of waste, such as oils or other organic wastes, to a specification. Full recovery is only complete when the energy is recovered or the waste is converted to a product.

The third biggest group according to the quantity of generated hazardous waste with 4.79 % is the group 06 Wastes from inorganic chemical process. The main waste type within the group is

06 02 01* - calcium hydroxide

Treatment can be done using precipitation by addition of an alkali, sulfide, coagulant, or other reagent that will bond with dissolved metal ions. Alkali sources include caustic sodium hydroxide (NaOH), hydrated lime ($Ca(OH)_2$), quick lime (CaO), limestone ($CaCO_3$), and magnesium hydroxide ($Mg(OH)_2$). Sulfide reagents used to cause precipitation of contaminants include iron sulfide (FeS), sodium hydrosulfide (NaHS), sodium sulfide (Na_2S), calcium sulfide (CaS), and biogenic sulfide generated in situ by sulfate reduction. Coagulants can include alum $KAl(SO_4)_2$, iron hydroxide ($Fe(OH)_3$), or ferric chloride ($FeCl_3$). Carbonates can also be used in chemical precipitation, including sodium carbonate (Na_2CO_3), calcium carbonate ($CaCO_3$), or CO_2 under pressure.

6. PREDICTION OF FUTURE NEEDS FOR HAZARDOUS WASTE MANAGEMENT AND SUGGESTIONS FOR IMPROVEMENT

Prediction of future needs regarding hazardous waste management in the country will be done based on the influence of the population growth, economic development of the country, demand for and nature of consumer goods, changes in the manufacture methods, new waste treatment methods and changes of the policy for waste management. Results of the future predictions will be presented in following time series 2014/19-2019/24-2024/29-2029/34.

The generation of HW is commonly claimed to be closely related to economic activity and thus the level of production in the different sectors and industries of the economy. Exactly how economic growth patterns, structural changes in the economy and the development in waste intensities interact with the observed total sum of waste is largely unknown. This chapter examines causes behind the increase in hazardous waste amounts generated by Macedonian firms and businesses.

The link between waste generation and the activity in the economy is decomposed and analysed. For this purpose the Log-Mean Divisia Index Method (LMDI) cf. Ang (2005) was used. The decomposition methodology separates the changes in waste amounts into effects related to economic activity, industrial structure and waste intensity, respectively.

Table 8. Decomposed growth factor's

	Qty in tons	Decomposed growth factor in % per year					5 Years Growth %
Energy	**1100.5**	**3.30**	**1.70**	**1.20**	**1.70**	**1.10**	**9.31**
Production and processing of metals	**11127.9**	**2.40**	**2.00**	**0.60**	**0.50**	**0.50**	**6.12**
Mineral industry	**2255.2**	**5.00**	**2.00**	**1.70**	**1.20**	**1.20**	**11.55**
Chemistry	**136.2**	**1.70**	**1.00**	**0.60**	**0.50**	**0.50**	**4.37**
Waste water treatment	**6.7**	**15.00**	**15.00**	**15.00**	**17.00**	**10.00**	**72**
Other (food, paper & card, use of organic solvents: printing)	**96.5**	**3.00**	**2.90**	**2.20**	**1.80**	**1.70**	**12.14**
Households	**6,071.0**	**5.00**	**2.40**	**1.70**	**1.30**	**1.30**	**12.21**

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In the present analysis the LMDI methodology, cf. Ang (2005), is applied to the decomposition of the generation of waste. The aggregate waste production in the economy is the sum of waste from n different sectors (e.g. manufacturing, construction, services, etc.) where the waste generation is measured in tons and data is available for some time period.

Assuming a multiplicative decomposition is appropriate, the total waste generation in period t can be split into three components (time period suppressed in the notation):

$$W = \sum_i W_i = \sum_i Y \frac{Y_i}{Y} \frac{W_i}{Y_i} = \sum_i Y S_i I_i$$

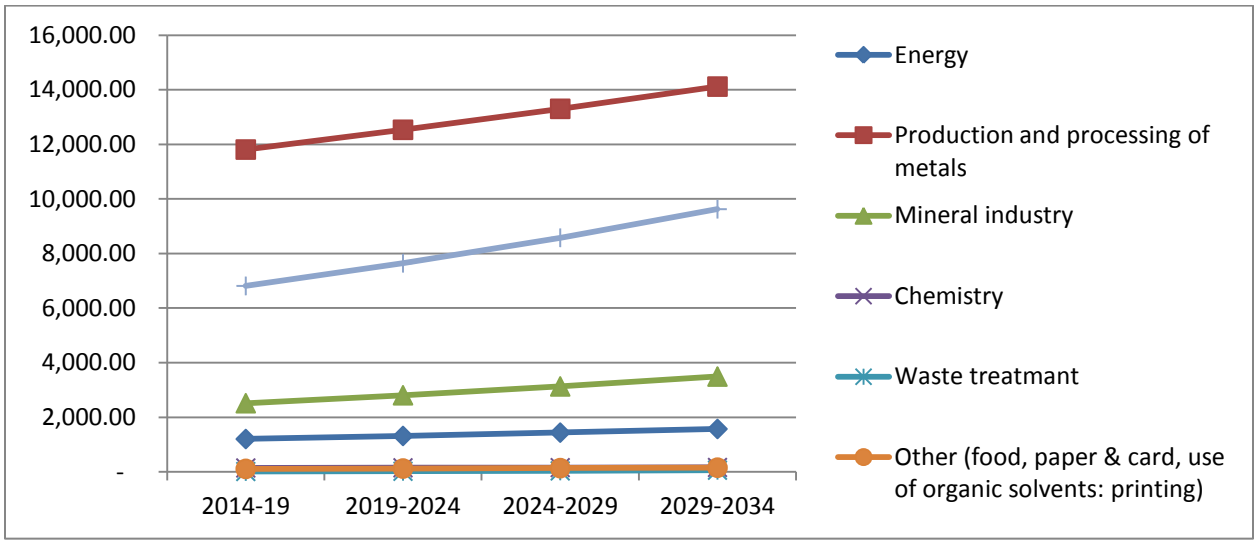
Wi: Volume of waste generated in industry i in period t (measured in tons)

Yi: GDP of sector i in period t (measured in constant prices)

Si: the share of sector i of the total economy (Y) in period t (i.e. the structural component)

In the empirical analysis we use a sample data from SSO. The waste data found in our survey has been merged with detailed national accounts data extracted from SSO. The empirical application is related to data for the three main sectors in the national economy as well as a detailed analysis of eight subsectors in the manufacturing industry covering the time span 2014 - 2034.

Figure 11. Estimated HW growth



The results indicate that the intensity effect is the main contributor to the increasing amounts of waste generated in Macedonia, with average increase over all sectors of 37,12 % (excluding waste treatment), and ranging between 19% for chemical industry and up to 58 % for households hazardous waste. It is estimated that waste for waste water plans will significantly increase in next years (up to700% in next 30 years).

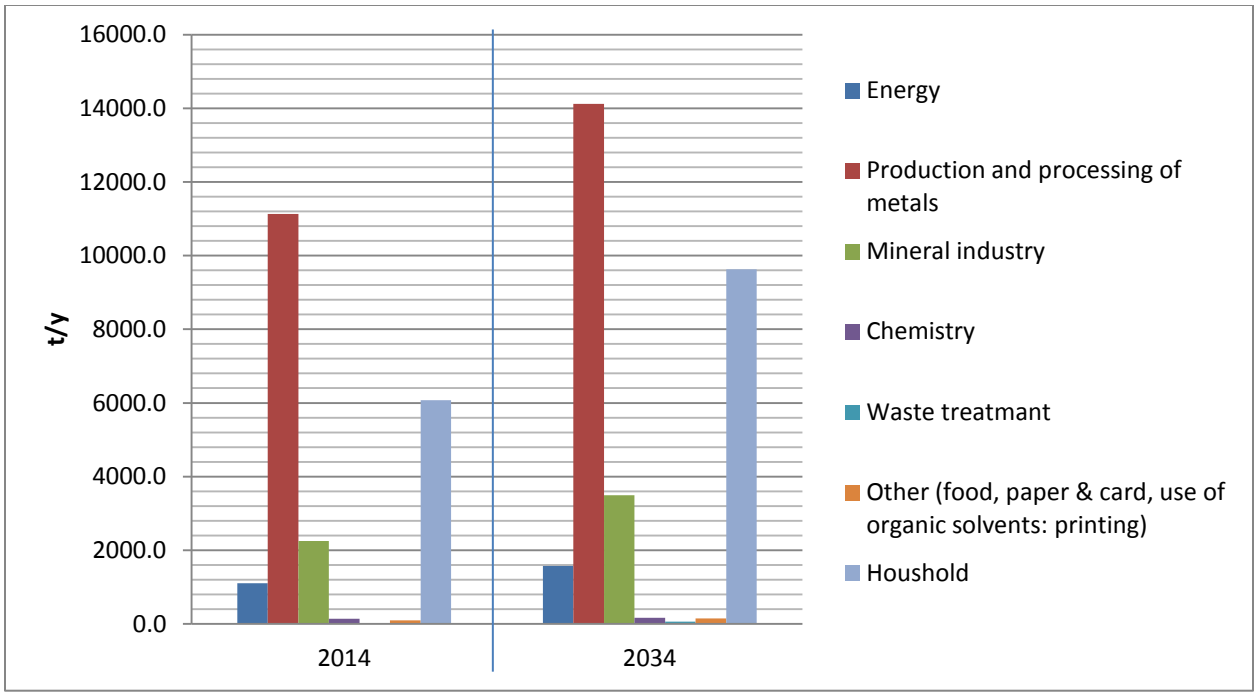


Figure 12. HW growth prediction

7. CONCLUSIONS AND RECOMMENDATIONS

Findings in the study clearly indicate lack of well develop management systems, institutional capacities and regulation enforcement.

Present situation of the hazardous waste management from can be characterized as sub-standard in terms of human and financial resources, as well as ineffective in terms of monitoring and enforcement of the legislation. All these factors result in many detrimental effects on the human health as well as on the environment.

The need for proper hazardous waste management is closely connected with restructuring of the production processes responsible for waste generation, as much as implementation of regional waste management plans.

Having in mind the hazardous waste types and quantities, it is clear that waste quantities are far to small to afford environmental and economically feasible treatment of all hazardous waste types, especially in the light that the policies of enforced self-sufficiency have been abandoned in most of EU Member States as a result of pressures exerted by the open and competitive waste market in the EU. However there is a need to provide treatment/disposal options for some hazardous waste types, where strategically advisable and economically and technically feasible, with policy, environmental and availability-of-outlet benefits.

Based on the data presented above (80 % of HW coming from thermal processes in manufacturing/mineral industry) strategic need for providing of recovery and treatment capacity is identified and therefore authors recommend to change the regulations and provide hazardous waste landfills development by the enterprises, generating the waste, and accepting only their own waste (in general limited to thermal waste only) and designed fully in line with applying regulations for such facilities. Similar solutions are already implemented in Slovenia, Bulgaria and can provide better handling of already large quantities of such waste types.

Some of the combustible waste types could be treated in advanced incinerators (already in process of construction) planed with some regional waste management facilities.

Wastes that cannot be treated at national level should be solved through inclusion of regional waste management schemes.

In our opinion development of efficient and complete (wide coverage) reporting system for all waste streams and especially HW is very important for development of any future HWMS, and this should be one of first task to be tackled in future efforts.

Detailed analysis of recommended solutions including costs estimations and feasibility will be a part of the second stage of the study, as further analysis are needed in order to compare and select most appropriate options for HWM on the national level.

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