CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Engineering

ANALYSIS OF THE WASTE MANAGEMENT IN THE SELECTED REGION OR MUNICIPALITY

Diploma thesis

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Thesis title

Analysis of the Waste Management in the Selected Region or Municipality

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Objectives of thesis

Analysis of current current situation in chousen region. Design of changes in collection system.

Methodology

Analysis of the current situation of waste management. Based on the results of the analysis design possible changes in waste management.

The proposed extent of the thesis

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Keywords

mixed waste, separated waste, collecting system

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Statement of Authorship:

I declare that I have used no other sources and aids other than those indicated in Diploma Thesis on Analysis of the waste management in selected region or Municipality. All passages quoted from publications or paraphrased from these sources are indicated as such, i.e. cited and/or attributed. This thesis was not submitted in any form for another degree or diploma at any university or other institution of tertiary education. I recognize that I commendation of Diploma Thesis and I agree with publication of the thesis according law č. 111/1998 Sb., about Collage and change of attached further laws.

In Prague, 4th April 2015 Signature…….....

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Analysis of the waste management in selected region or municipality

Abstract:

In this diploma thesis an analysis of waste management of Nový Bor has been conducted. Firstly there is literal overview which states different definitions of municipal waste according to variant sources. Further part deals with waste management issue in global scale, and there are shown countries according to their income with relevant waste generation. Thereafter Germany is presented and its achievements as well as the Czech Republic with chosen information related to waste management. At the end of first section company EKO-KOM is described and generally methods for collection of waste. Second part contains information about Nový Bor and extended information related to its waste management. Own analysis firstly examines production of municipal solid waste in Nový Bor and compares it with production in Česká Lípa and Czech Republic; further the detailed analysis examines waste separation. Secondly the analysis assesses economic management of waste management in city Nový Bor, this is systematically splitted into three parts: waste management costing, incomes of waste management and resulting costs. There is performed an investigation of bag collection system via questionnaire; it displays results the investigation. The conclusion is about evaluation of results and possible actions.

Keywords: Mixed waste, separate waste, collection system, waste management, recycling

Analýza odpadového hospodářství ve vybraném region nebo obci

Souhrn:

V diplomové práci je provedena analýza odpadového hospodářství Nového Boru. Prvně je provedena literární rešerše, která uvádí různé definice komunálního odpadu podle rozdílných zdrojů. Dále je pojednáváno o odpadovém hospodářství v globálním měřítku a jsou zde také představeny země podle příjmu s odpovídající produkcí odpadu. Poté je představeno Německo a jeho úspěchy v oblasti odpadového hospodářství, stejně jako vybrané informace o České republice, které jsou relevantní k odpadovému hospodářství. Na konci první části je popsána společnost EKO-KOM a metody sběru odpadu. Druhá část práce obsahuje informace o Novém Boru a širší záběr informací vztažených k vlastnímu odpadovému hospodářství města. Vlastní analýza prvotně hodnotí produkci směsného komunálního odpadu města Nový Bor a porovnává ji s produkcí města Česká Lípa a Českou republikou. Další část analýzy detailně hodnotí separaci odpadu v Novém Boru. Druhá část analýzy se věnuje ekonomice odpadového hospodářství Nového Boru, a ta je systematicky rozdělena do tří částí: náklady a příjmy odpadového hospodářství a výsledné náklady. Dále byl proveden průzkum pytlového sběru separovaného odpadu prostřednictvím dotazníku, práce ukazuje výsledky šetření a pojednává o nich. Závěr práce hodnotí výsledky a ukazuje možná řešení.

Klíčová slova: směsný odpad, tříděný odpad, sběrný systém, odpadové hospodářství, recyklace

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1 Introduction

Waste management is relatively young sector, which has carried curtain problems concerning especially budget. Every municipality has to face problems like balance between fee for person and additional payment of municipality for municipal waste disposal. However municipality charges the fee in certain intervals, there might occur some difficulties, which may be lead to uncover costs for waste disposal. This uncovered costs are usually paid by municipality, where is only up to waste department to find way to manage it.

In case of municipality Nový Bor is following problem. Once per year municipality charges fee 500 CZK per person with permanent living permit (inhabitant of municipality) for disposal of municipal waste. The fee for MSW disposal is unchanged since year 2008 till 2014; there has been problem with budgeting where income from the fees has not covered whole payment for waste disposal. Municipality additionally pays for waste disposal from city budget.

In year 2008 municipality Nový Bor has adopted bag system for collection (BCS) recyclable waste (plastic, paper and since year 2012 tiny electrical appliances). BCS gives to habitants of Nový Bor possibility to join into the program and participate on collection of SW. Collected SW is sorted to plastic bags with respect to kind of waste, on each bag is attached barcode, maximum allowed weigh of one a bag is 10 kg. Each physical person who joins into the program receive private barcode, whereby waste is matched with certain person, which is necessary for update balance of collected waste on each single account and the city website. Every first Monday in month collector must place the bags on dustbin spot, where bags are gathered.

Nový Bor has cooperated with company EKO-KOM a.s. in program for separation of waste, the municipality has gotten reward for collection of SW. The rewards helps to improve WM budget of Nový Bor. Resulting impact is decrease of additional payment by municipality, improving collection of SW, strengthen reuse of materials and help to inhabitants to save some money.

2 Literal overview

Waste management is pretty new discipline, which came up with increasing size of cities and desire for waste disposal solutions. In history people had of course problems concerning waste disposal, but weight of the problem was smaller, particularly because there were no plastic bottles, plastic bags and every single peace of food was not packed in huge plastic cover as it is happening nowadays.

2.1 Different definitions of municipal solid waste

Municipal waste may be defined in different ways and meaning might be seemingly similar. National laws play important rule, which stipulates for instance whether waste from entrepreneurship is considered as municipal waste, or not.

By Waste Act No. 185/2001 from the Czech Republic

Municipal waste means all waste generated in the territory of a municipality is connected with activities of legal entities or natural persons and which is stipulated as municipal waste in the statutory instrument, with except of waste produced by legal entities or natural person authorized. [Waste Act 185/2001, 2001]

By Organization for Economic Co-operation and Development (OECD)

Municipal waste is collected and treated by, or for municipalities. It covers waste from households, including bulky waste, similar waste from commerce and trade, office buildings, institutions and small businesses, yard and garden, street sweepings, contents of litter containers, and market cleansing. Waste from municipal sewage networks and treatment, as well as municipal construction and demolition is excluded. [HOORNWEG, 2012]

By Pan American Health Organization (PAHO)

Solid or semi-solid waste generated in population centers including domestic and, commercial wastes, as well as those originated by the small-scale industries and institutions (including hospital and clinics); market street sweeping, and from public cleansing. [HOORNWEG, 2012]

By Intergovernmental Panel on Climate Changes (IPCC)

The IPCC includes the following in MSW: food waste; garden (yard) and park waste; paper and cardboard; wood; textiles; nappies (disposable diapers); rubber and leather; plastics; metal; glass (and pottery and china); and other (e.g., ash, dirt, dust, soil, electronic waste). [HOORNWEG, 2012]

2.2 Global production of waste is growing

Urbanization is still evolving process, the amount of municipal waste MSW is one of most important by-product of urbanization lifestyle, and is growing even faster than process of urbanization. Ten years ago there were 2.9 billion urban habitants and it was estimated that they generated 0.64 kg MSW per person per day. Nowadays it is estimated that amount is about 3 billion urban habitants who generate approximately 1.2 kg MSW per person per day. Therefore we can consider waste management as crucial issue for ever-single government of a city around the World. Generation of waste is so rapid that estimation for 2025 are alarming, about 1.42 kg MSW per person per day. This will require higher level of WM organization and also different approach to product and package design. [HOORNWEG, 2012] Furthermore human kind faces energetic problems where more electricity and more heating is needed. Meanwhile there is not much left. According to Czech Waste Act 185/2001 "The hierarchy of waste management" from "Section 9a", Firstly, within waste management framework the following hierarchy of waste management has to be respected:

a) Waste prevention
b) Preparation for re-use of waste
c) Recycling of waste
d) Another utilization of waste, for instance: Energetic utilization
e) Waste disposal – landfilling

If WM is not possible practice according to the pattern above, it may be performed differently, but life cycle assessment of impacts (including waste generation and disposal) must prove that the alternative is appropriate. [Waste Act 185/2001, 2001] Regardless this directive in many places in the Czech Republic, and as well around the World energetic utilization is neglected. Meanwhile waste is in big scale buried into land. Around 70 % of MSW generated in the Czech Republic is still landfilled. [Aleksic, 2013] Seemingly in the Czech Republic there is still stuff to work-on, because there are not so common stages like

pretreatment and follow-up reuse of MSW or energetic utilization of waste. Incineration of MSW may be used for heating of city developments as well as for generation of electricity. MSW has great heating potential which varies from Low Heating Value (LHV) between 8 and 12 $\mathrm{GJ} * \mathrm{tone}^{-1}$ to Upper Heating Value (UHV) 18 and 20 $\mathrm{GJ} * \mathrm{tone}^{-1}$, where the LHV corresponds to approximately 42 % of the fuel value of bituminous coal (23.9 $\mathrm{GJ} * \mathrm{tonne}^{-1}$). This demonstrates that even if material recovery is not economically feasible, still energy recovery from waste can bring environmental and economical benefits. [Habid, Schmidt and Chritensen, 2013]

2.3 Importance of MW for government of municipality

Municipal solid waste management is the most important service that a city provides, and also is the largest single budget item for cities. Also solid waste management is one of the most important functions of a city government. It can be said that WM is key utility function of a city, which assures clean environment, regardless public health and "image" of a city that depends on it. This unmanaged function (uncollected solid waste) can easily lead to serious health issues, with both direct effect on child health and indirect choking drains and channels leading to water born diseases and even floods – most likely in developing countries. [Wilson et al., 2015] Cities are fully self responsible for MSW and way of disposal. A city that cannot effectively manage its waste is rarely able to manage more complex services such as health, education, or transportation. Poorly managed waste has essential impact on health of habitants, local and global environment and economy such an as money are spent for useless waste treatment. Poor WM causes to higher GHG emission, over high cost for waste disposal, damage to water quality – ground and surface water, etc. [HOORNWEG, 2012] This irresponsible behavior might lead to huge bills for and irreversible changes of the Earth for future generations.

2.4 Generated waste according income

Countries might be sorted according different parameters, but in case of MSW it is relevant to do it according to income. This is because the higher income means the higher outcome logically; therefore countries with low income do not generate too much waste because easily citizens who live there cannot afford buy to many things. But they fumble with poor WM, which leads to terrible impacts. Such country has not organized system, but reuse

is very common. Opposite to low income countries are high-income countries, where belongs the Czech Republic as well. Such countries have relatively high-income and generally generate more waste. Also system is differently organized, programs emphasize 3R – reduce, reuse, recycle. There are huge differences between the groups in whole scale for example: collection, recycling, composting, incineration landfilling/dumping costs. [HOORNWEG, 2012] Also Sivakumar and Sugirtharan [2010] reported that "solid waste generation depends on the economy of the people and level of income of the family or individual. Previous studies have shown that for every Indian, an increase an income by Rs. 1000 results in an increase of solid waste generation by one kilogram per month." This is frequent result of observation; whereby with an increase of economic growth the waste generation increases in equal manure. There is no difference in economic growth and waste generation between developed and developing countries. [Sivakumar and Sugirtharan, 2010]

List of countries belonging to high-income category

Barbados, Belgium, Brunei Darussalam, Canada, Croatia, Cyprus, **Czech Republic**, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong – China, Hungary, Iceland, Ireland, Israel, Italy, Japan, South Korea, Kuwait, Luxembourg, Macao – China, Malta, Monaco, Netherlands, New Zealand, Norway, Oman, Portugal, Qatar, Saudi Arabia, Singapore, Slovak Republic, Slovakia, Spain, Sweden, Switzerland, Trinidad and Tobago, United Emirates, United Kingdom, United States. [HOORNWEG, 2012]

2.4.1 Typical solid WM practice by high income level (definition):

Source reduction

Organized education programs emphasize the three 'R's'– reduce, reuse, and recycle. More producer responsibility & focus on product design. [HOORNWEG, 2012]

Collection

Collection rate greater than 90%. Compactor trucks and highly mechanized vehicles and transfer stations are common. Waste volume is a key consideration, and aging collection workers are often a consideration in system design. [HOORNWEG, 2012]

Recycling

Recyclable material collection services and high technology sorting and processing facilities are common and regulated. Increasing attention towards long-term markets. Overall recycling rates are higher than low and middle income. Informal recycling still exists (e.g. aluminum can collection, repurchase of scrap materials) Extended product responsibility common.

Composting

Becoming more popular at both backyard and large-scale facilities. Waste stream has a smaller portion of compostable than low- and middle-income countries. More source segregation makes composting easier. Anaerobic digestion is increasing in popularity (especially in Europe). Odor control critical.[HOORNWEG, 2012]

Incineration

It is prevalent in areas with high land costs and low availability of land (e.g., islands). Most incinerators have some form of environmental controls and some type of energy recovery system. Governments regulate and monitor emissions. About three (or more) times higher the cost per ton than landfilling. This system of incineration is very common in Denmark. [HOORNWEG, 2012]

Landfilling/Dumping

Sanitary landfills with a combination of liners, leak detection, leachate collection systems, and gas collection and treatment systems. Frequent problems concerning opens landfills are neighboring residents. Post closure use of sites increasingly important, e.g. golf courses and parks. [HOORNWEG,2012]

2.4.2 Definition of Generators and types of Solid Waste

Solid waste is made of many types of waste and it may be sorted according to source. Each source of waste has typical generator, see table below.

Table 1: Definition of Generators and types of Solid Waste

Source	Typical Waste generator	Types of solid Wastes
Residential	Single and multifamily dwellings	Food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, metals, ashes, special wastes (e.g., bulky items, consumer electronics, white goods, batteries, oil, tires), and household hazardous wastes (e.g., paints, aerosols, gas tanks, waste containing mercury, motor oil, cleaning agents), e-wastes (e.g., computers, phones, TVs)
Industrial	Light and heavy manufacturing, fabrication, construction sites, power and chemical plants (excluding specific process wastes if the municipality does not oversee their collection)	Housekeeping wastes, packaging, food wastes, construction and demolition materials, hazardous wastes, ashes, special wastes
Commercial	Stores, hotels, restaurants, markets, office buildings	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes, e-wastes
Institutional	Schools, hospitals (non-medical waste), prisons, government buildings, airports	Same as commercial
Construction and demolition (C&D)	New construction sites, road repair, renovation sites, demolition of buildings	Wood, steel, concrete, dirt, bricks, tiles
▪ **All of the above should be included as municipal solid waste. Industrial, commercial, and institutional (ICI) wastes are often grouped together and usually represent more than 50% of MSW. C&D waste is often treated separately: if well managed it can be disposed separately.** ▪ **The items below are usually considered MSW if the municipality oversees their collection and disposal.**		
Process	Heavy and light manufacturing, refineries, chemical plants, power plants, mineral extraction and processing	Industrial process wastes, scrap materials, off-specification products, slag, tailings
Medical Waste	Hospitals, nursing homes, clinics	Infectious wastes (bandages, gloves, cultures, swabs, blood and body fluids), hazardous wastes (sharps, instruments, chemicals), radioactive waste from cancer therapies, pharmaceutical waste
Agricultural	Crops, orchards, vineyards, dairies, feedlots, farms	Spoiled food wastes, agricultural wastes (e.g., rice husks, cotton stalks, coconut shells, coffee waste), hazardous wastes (e.g., pesticides)

Source: [HOORNWEG, 2012]

2.5 Germany

Germany was chosen as a successful country upon waste management area, particularly because there has been achieved EU goal concerning reuse 50 % of MSW before 2006, whereas the Czech Republic must fulfill this recycling target by year 2020. [Fisher, 2013] Waste management of Germany should inspire and guide the Czech Republic to meet the EU targets and enhance WM – one of the most important sector of ever municipality.

2.5.1 Country description

Germany is European country located in west part of Europe with neighboring countries Denmark, Poland, Czech Republic, Austria, Switzerland, France, Luxembourg, Belgium, and Netherland. It is a member of EU, full name is the Federal Republic of Germany and capital city is Berlin; in 2011 in Germany lived 82.1 million people. Occupied area of Germany is 357 168 km^2. [Germany country profile, 2012] Germany is consisting of sixteen federal states (called Bundesländer). [Fisher, 2013]

2.5.2 Development of Germany

For year 2005 had been set targets concerning emissions of reducing greenhouse gases, pollution of ground and surface water and also preserving country itself for future generations. [Municipal solid waste report, 2006] Responsibilities are shared between Government, the Federal states and local authorities. The National Ministry of environment acts as authority there, which deals with making strategies, overseas relations and strategic planning and mostly regulations to national laws. Regulations concern means, rules and requirements itself how to dispose waste. Waste management plans of each single federal state are individual and dependent on their authorities. [Fisher, 2013] One of the biggest problem before 2005 was dumping untreated waste at landfills, which had brought huge risk of environmental pollution. Early 2005 about 200 landfills had been closed because they had not complied with the new standards. This conventional landfilling has been considered as major source of greenhouse gas methane, where accounted emissions were 25% of total emissions of Germany. The number is obtained as CO_2 potential, where for instance CH_4 is 21 times more potent than CO_2. [Municipal solid waste report, 2006] In 2006 Germany successfully met the targets, which were set for year 2020. One of these targets regards reuse 50 % of MSW, where in 2001 were recycled 48 % of MSW and 62 % in year 2010. Problem

concerning biodegradable waste disposing were resolved in 2006 – target for year 2005. Latest initiative introduces advanced so-called recycling bins for increasing recycling plastic and metals from households; also mandatory separate collection of bio-waste. These measures should lessen "aftercare" and bills for future generations. [Fisher, 2013]

2.6 Czech Republic

The Czech Republic is country where waste management had been almost neglected until year 1991, but many things happened since then; however still around 70% of MSW generated in the Czech Republic is landfilled. [Aleksic, 2013] Hence the Czech Republic should be inspired by some of developed countries, where WM is more advanced.

Two streams influence development of the country, however as a mainstream can be considered European Union legislate which set the pace for all 28 member states. Second stream is Ministry of Environment, which has control and guideline function over the local subjects. [Waste Management, 2015]

2.6.1 Country description

The Czech Republic is country located in center of Europe, is member of EU, but has not accepted Euro currency yet. Its neighbors are Germany, Poland, Slovakia, and Austria. Capital of the Czech Republic is Prague with 1 259 079 habitants and increasing. [CZSO (1), 2015] In the Czech Republic lives over 10.5 million habitants [CZSO (2), 2015], occupied area is 79 000 km^2 which is 4.5 times smaller than the area of Germany.

2.6.2 Legislation about waste management

Waste management is relatively young but dynamically developing sector of the National Economy. Developed countries have started care about waste management in last 20 – 30 years. Until year 1991 in Czech Republic there has been no control of waste on legislative level, after 1991 first waste act was established. In year 2001 Waste Act 185/2001 came into force, its essential principle is prevention of waste and it also defines waste management. Furthermore the Act defines prevention and disposal of waste and preserving of environment. [Waste management, 2014]

Main strategic document governing WM is the Waste Management Plan of the Czech Republic, the plan is set for a period of ten years. Old waste management plan was in charge

since 2003 until 2013 [Aleksic, 2013], nevertheless in December 22, 2014 after comments procedure that lasted half a year Government of the Czech Republic approved new Waste Management Plan for period 2015 – 2024. [Ministry of Environment of the Czech Republic, 2014] Binding part of the plan for waste management of the Czech Republic is mandatory basis for processing of plans for WM of economics regions and also is mandatory for decision-making and other activities of relevant government agencies, regions and municipalities regarding waste management. New agreed goals for MSW in further years are following:

First target is adopt sorting of waste for at least paper, plastic, glass and iron until year 2015 [Prime Minister – Minister of Ministry of Environment of the Czech Republic, 2014]; first target is considered to fulfill according to EKO-KOM announcement which reports that: 20 233 companies manufacturing or importing packaged goods currently offer their consumers a recovery network for recycling packaging within the scope of their statutory obligations. These companies cooperate with 6 057 Czech municipalities, which have in total 10 457 754 habitants (99 % of the whole population) using the EKO-KOM system. [EKO-KOM (2), 2015]

Second target is to increase reuse of (at least) commodities as paper, plastic, glass and iron by 50 % of MSW's weight; these objectives include only MSW from household or other streams of waste which must appear similarly as waste from households. Particular values for certain years are showed in table 2 (below), there this plan has been suggested to manage and achieve second target – step by step. [Prime Minister – Minister of Ministry of Environment of the Czech Republic, 2014]

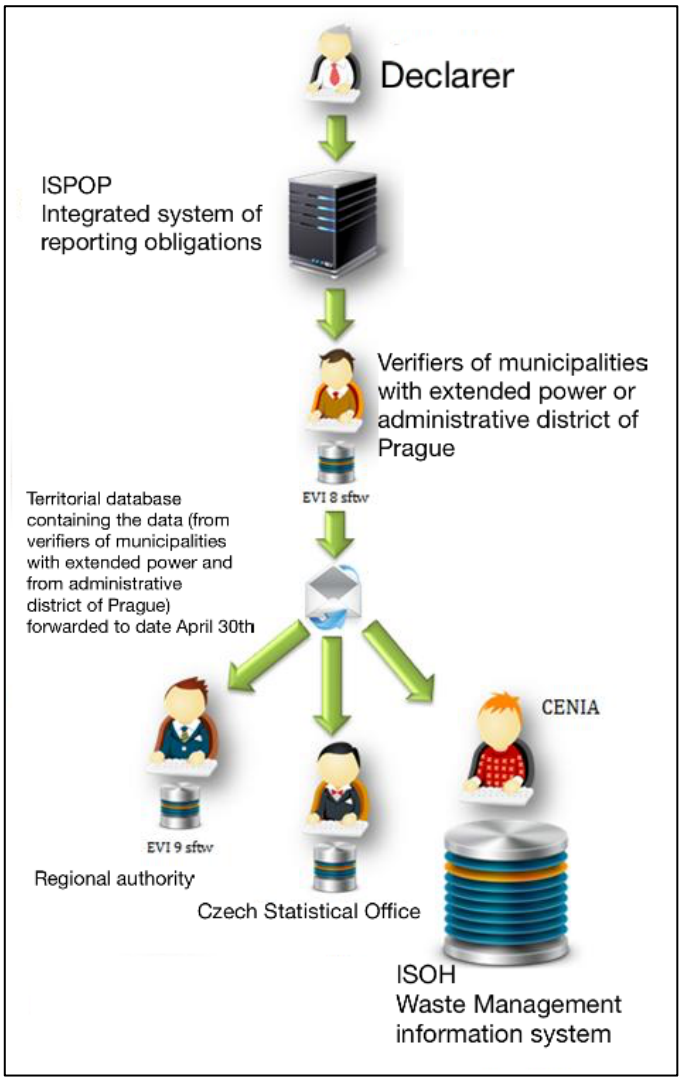
Table 2: Proposal for second target (increase of MSW reuse)

Year	Target
2016	46 %
2018	48 %
2020	50 %

Source: [Prime Minister – Minister of Ministry of Environment of the Czech Republic, 2014]

Nowadays the Czech Republic is using system declaration of waste: Information system of Waste Management (Informační systém odpadového hospodářství – ISOH). It is nationwide system maintaining data regarding production and handling with a waste, further information concerning facilities for waste treatment and waste disposal relevant to Waste Act 185/2001. Ever entity (declarer) is obligated declares produced amount of waste there. [Information system of Waste Management, 2015] (See picture below)

Figure 1: Diagram of waste date declaring



Source: [Information system of Waste Management, 2015]

2.6.3 Waste act 185/2001

This is in accordance with the law of the European Community and regulates certain points. First are the rules on the prevention of waste production and on the waste management in compliance with environmental protection, human health protection and sustainable

development aspects. Second are rights and obligations of persons in the waste management sector. Third is competence of public administration authorities.

The act shall apply to the management of any waste, except to forbidden waste stated in Waste Act 185/2001, which is for instance waste water, waste from mining activities, radioactive waste, human corpses, etc. [Czech Republic (2). 2001] Complete list of forbidden waste can be found in Waste Act 185/2001.

2.6.4 Law about packaging - Package Act 477/2001

Persons (physic and legal entities) producing or introducing packages into circulation (import, deliver, fill to the Czech Republic or sell) have according to the law take-back and reuse of package waste duties. [Czech Republic (3), 2001] The Act defines a package and gives obligations to producers and resellers; following parts are chosen from the content of the Act.

Definition of package

Package is defined as any product made up by any material, which is designed for caring, protection, handling, transportation or presentation product that is aimed to consumer (habitant) or another end-consumer. [Czech Republic (3), 2001]

Ensure take-back and reuse of package waste (section 10 and 12)

Package waste take-back system helps in sustainable and feasible way to take back used packages with purpose reuse, recycle or dispose package waste. Recovery ensures that a waste from packaging introduced onto the market or into circulation is reused or recover in adequate rate – determined in appendix no. 3. of the Act [Czech Republic (3), 2001]

List of subjects (Section 14)

Any subject introducing packaging or packaged product into the market or into circulation, is required to file draft to for registration in the List of Subjects required to recover packaging waste within 60 days of the day this obligation arises. [Czech Republic (3), 2001]

Records (Section 15)

Subjects registered in the List of Subjects (Section 14) are required to: keep regular records; announce information to the Ministry of the Environmental by 15th February; keep record materials for at least 5 years; demonstrate transparency and accuracy of data. [Czech Republic (3), 2001]

Registration and record fee (Section 30)

The registration fee in the value of 800 CZK is paid for registration in the List (Section 14) and a record fee in the same value is also paid for maintaining record in this List in subsequent calendar years, always for elapsed calendar year by 15th February of the following year. [Czech Republic (3), 2001]

Terms and conditions for introducing packaging onto the market (Section 4)

Limited the content of heavy metals and dangerous substances in packaging. An obligation for subjects introducing packaging and packing products onto the market. [Czech Republic (3), 2001]

Prevention (Section 3)

Minimize packaging volume and weight. Meanwhile adhering to the requirements placed on the package product. This is an obligation for subjects introducing packaging onto the market. [Czech Republic (3), 2001]

Identification of packaging (Section 6)

The Packaging Act does not give the obligation of identifying packaging introduced onto the market or into circulation. However, if you decide to identify the material, which the packaging was manufactured from, you are required to identify it in compliance with European Community law. It means in accordance with provisions of Section 6 of Packaging Act. [Czech Republic (3), 2001]

2.7 EKO-KOM, a.s.

This is authorized company dealing with packages and providing also compliance of take-back and recovery of packaging waste.

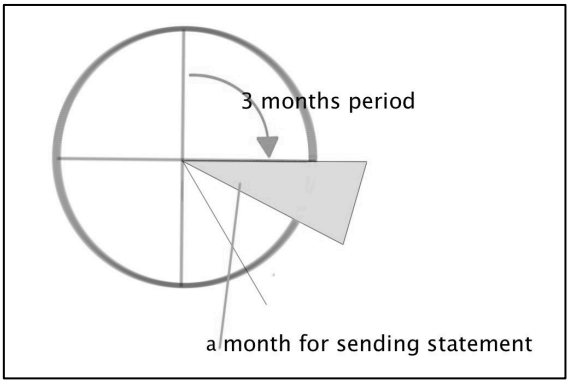
2.7.1 About the company

In year 1997 EKO-KOM, a.s. was founded by industrial enterprises producing packaging goods. This nonprofit company operates nationwide system. The system assures sorting, recycling and utilization of packaging waste with respect European standards.

The system is based on cooperation of industrial enterprises, cities and municipalities. Whereby it assures that used packages are sorted by consumer, then gathered, perfectly sorted and then reused as rough material or eventually incinerated for energetic purpose. EKO-KOM must assure cleanness of separated waste, which subsequently assures continuous sales of reusable waste on European and Worldwide level. [EKO-KOM (2), 2014]

Nowadays all municipalities of the Czech Republic have been enrolled in EKO-KOM system. This system commits involved parties (municipalities) to register quantity of collected waste (mixed and separated) over period in area of the municipality and subareas belonging to the municipality. Further importance which have to be included in the report are number and sizes of used containers and frequency of empting of containers, information about persons or entities who had disposed waste, facilities where waste was reused. This report is required on quarterly basis (see the model below – figure 2), where deadline is after three months period. Submitter (municipality, company) has to submit report until this time. [EKO-KOM (3), 2014] The report is base for receipt financial award. Every region has own manager who cares about municipalities/companies within the region. The report might be send to regional manager by municipality or authorized company (waste manager) which assures this kind of service, in such case is report called collective statement. Report/collective statement are processed electronically, current system has used MS Excel, which provides simplicity and feasibility to operate this system in every municipality/company. This report/collective statement is one of conditions for EKO-KOM accreditation. Manager processes reports/collective statements and sends back foundation for invoicing financial reward to municipality/company (entity); regional manager calculates financial reward EKO-KOM, entities assure invoicing themselves. When entity receives the foudation for invoicing, it can immediately invoice for elapsed period (there months). Municipality receives the financial reward for her efforts such as improving collection system, recycling and support, etc. Received money has to be used for WM purposes of municipality. [EKO-KOM (4), 2014]

Figure 2: Model of statement system, where each quarter presents 3 months period after which report/statement must be sent within a month



2.7.2 The Green Dot

The Green Dot is the trademark; placed The Green Dot on packaging means that the obligatory entity pays a financial amount to the packaging recovery to organization for take-back, sorting and recovery of packaging in accordance to Directive 94/62/EC. [EKO-KOM (5), 2015] Following picture presents the Green Dot logo, this can be marked only on products or packaging which are distributed in the Czech Republic and only with acceptance of EKO-KOM, a.s. which is the only authorized company in the Czech Republic. *[EKO-KOM (5), 2015]*

Figure 3: Logo of the Green Dot

Source: [EKO-KOM (5), 2015]

This trademark can be used only within Czech territory and therefore exported products and packages must not be marked with it. In 7th September year 2000 company EKO-KOM,a.s. gained license for using trademark the Green Dot by PRO EUROPE organization. It was acknowledgement that EKO-KOM fulfills requirements concerning systems for reuse of package's waste in scope of EU directives. Furthermore trademark must not be utilized in

any other way and also accompanied by any text that would put it into context with package properties – particularly in relation with environment protection. *[EKO-KOM (5), 2015]*

2.8 Methodology of waste collection

Handling with municipal waste is already difficult task nowadays; this task very often combines different methods, their types and further customizations in framework of individual stages of the process. [SLAVÍK, 2004]

2.8.1 Technical equipment of collection

Widespread collection of waste is via containers and caddies, however for some kinds of waste collection might be supported by bag collection system. Choice of container type strongly depends on kind of collected waste, type of residential area where waste is collected and likely local conditions. [SMO, 2008]

There is also an important right choice of container size especially upon municipal solid waste collection whereby further generation of MSW is influenced. Because if there are more containers with more space than it is necessary, it leads to excessive waste generation, in contrast insufficient space leads to founding black (illegal) dumps. Good choice of container size is cost reducing; for instance costs for collection MSW for 110 liters dustbins are 2–3 times higher than for 1100 liters containers. However utilization of certain containers for certain residential area cannot be changed, each type is defined to each kind of building.

For collection of MSW are used container sizes: 70, 110, 240 and 1100 liters. Further for collection of separate waste are used following container sizes: 120, 240, 1100, 1300, 1500, 2000 and 2500 litters. The bag collection system (BCS) is realized by plastic bags with volume from 40 to 120 liters. [SLAVÍK, 2004]

2.8.2 Collection of sorted waste

Success of sorted waste collection relies on sophisticated collection network, where people start interest in waste sorting if containers are in convenient distance; otherwise waste is mixed together and ends in municipal waste dustbin. It has been verified that if citizen has to walk the distance to the nearest container that overcomes 400 m, then only 5 % of population will sorts the waste. The delivery distance cannot exceed 150 m to nearest container if it is desired for at least 65 % of the population to sort the waste. Nowadays in the Czech Republic the average delivery distance is about 101 m, collection network is made up

by 241 thousands containers for sorting plastic, paper, beverage carton and glass waste. The collection network is additionally supplied via bag collection system, collection yards, etc. [EKO-KOM (2), 2014]

2.8.3 Waste manager

Collected waste is gathered and removed by certain company (waste manager) with authorization to deal with waste. In the Czech Republic many different companies perform WM services, two and more companies might perform services in same region regardless distribution or location of municipalities. Even two adjoining cities in one district may use different companies for WM services.

Good example is Nový Bor and Česká Lípa in Czech Republic, they are adjoining cities from same region and same district, and they are relatively close to each other (only 10 km). Nový Bor has contract with company COMPAG CZ, s.r.o. [QCM, 2014] and Česká Lípa with Marius Pedersen a.s. [Bínová, 2015]. Chosen authorized company depends on preferences of municipality and budget feasibility with respect service scope of the company, however regular process is announcement of public offer.

3 Aim and methodology of diploma thesis

This part explains course of actions leading to results, formulas and their unknowns. Data, which are used in following articles regarding Nový Bor city were obtained from the municipality office of Nový Bor from Mgr. Petr Škop.

Objectives of the work are conduction of analysis of Nový Bor waste management and relevant calculations of costs. Last part of the analysis is investigation about awareness of residents about the bag collection system in Nový Bor. The investigation is based on the questionnaire, which is presented in the appendix of this work. Furthermore results obtained from questionnaires were processed into outputs; conclusion gives overview about the issue and advises way to go.

In investigated city is determined current state of WM; there is also compared amount of generated waste for the period 2008 – 2014. For each kind of waste in certain year is calculated average amount of waste per person in kilos and percentage changes.

(1) Calculation of specific amount of waste

$$SPA = \frac{TAW * 1000}{NH}$$

Where:

SPA… specific amount of waste $[kg \times person^{-1} \times year^{-1}]$

TAW… amount of waste [t]

NP... number of habitants

(2) Calculation comparing amount of waste between single years

$$YYCH = \frac{SPA - (SPA^{n-1})}{SPA^{n-1}} \times 100\ [\%]$$

Where:

YYCH… year-on-year change in production of waste [%]

SPA… specific amount of waste $[kg \times person^{-1} \times year^{-1}]$

SPA^{n-1}… specific amount of waste in previous year $[kg \times person^{-1} \times year^{-1}]$

(3) Calculation of comparison with referential year

$$CHRY = \frac{SPA - (SPA^{r})}{SPA^{r}} \times 100\ [\%]$$

Where:

CHRY… change of waste production from referential year

SPA… specific amount of waste $[kg \times person^{-1} \times year^{-1}]$

SPA^{r}… specific amount of waste in referential year $[kg \times person^{-1} \times year^{-1}]$

(4) Calculation of chosen costs

$$CC = TC - CWS$$

Where:

CC… chosen costs of the WM $[CZK \times year^{-1}]$

TC… total costs of WM $[CZK \times year^{-1}]$

CWS… cost for waste separation $[CZK \times year^{-1}]$

(5) Calculation of average operational cost

$$AOC = \frac{TC}{NH}$$

Where:

AOC… average operational cost of WM [$CZK \times person \times year^{-1}$]

TC… total costs of WM [$CZK \times year^{-1}$]

NH… number of habitants

(6) Calculation of real average cost

$$RAC = \frac{CC}{NH}$$

Where:

RAC… real average cost [$CZK \times person \times year^{-1}$]

CC… chosen costs of WM [$CZK \times year^{-1}$]

NH… number of habitants

(7) Calculation of net costs

$$NC = \sum cost - \sum incomes$$

Where:

NC… net cost (costs after deducting incomes) [$CZK \times year^{-1}$]

$\sum cost$… all known cost entering into WM [$CZK \times year^{-1}$]

$\sum incomes$… all known incomes entering into WM [$CZK \times year^{-1}$]

4 Description of present waste management in Nový Bor

Legislation and future procedures are going to follow new waste management plan of The Czech Republic, which came into force in the beginning of 2015; the WM plan directly follow European directives 2008/98/EC on waste. Waste management of Nový Bor is governed by Municipalitily Act No.128/2000 Coll. and also by Waste Act No. 185/2001 Coll.

Nový Bor is the producer of MSW thus all obligations of a waste generator apply upon it. Generation of MSW on many places and routine collection of MSW via specific means define the city as waste generator, hence the city has to have waste manager (company), which is currently company COMPAG CZ, a.s. This company manages cleanness of the city at the stipulated price and period; thereby the city passes its responsibility to the waste manger.

4.1 Present status of the city

Nový Bor is located in north part of district Česká Lípa. In January 1st 2014 in the city have lived 13 144 registered habitants [Škop, 2015], this number tends to increase. The city is partially located upon protected landscape area; hence they take waste management very seriously. Occupied area of the city is 20 089 ha.

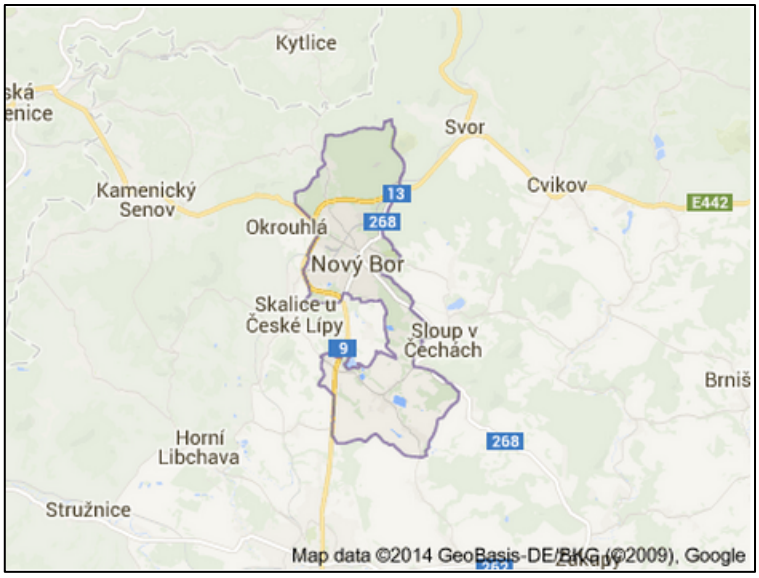
4.1.1 Description of the city

The city is part of Liberec region, which is located in northwest part of district Česká Lípa. The district is located on borderline of Czech Central Highland and Lužické Mountains, these are close to region Ústí nad Labem and Germany.

City development had been closely connected with glass industry. In close area of the city there are many small glass workshops, where production of blown glass, painted glass, grinded glass and grooved glass is located. The city has mountain characteristic with specific climatic conditions. Year average temperatures vary from 7 to 5 °C, precipitation is high as well. Year average of precipitations reaches 800–1000 mm. Forests cover significant part of the area. Only in higher locations are preserved residuals of mixed woods and bushes. Vegetation of local environment has high diversity with lowlands and highlands. Tourists visit the city for its terrain and beautiful landscape in summer and winter season. Typical sports, which pass of here, are hiking, skiing, biking, and motocross and particularly international orienteering race. For hiking there are many marked hiking paths there. Area of

the city is on borderline of two protected areas, CHKO Lužické Mountains area (protected landscape area) and Czech Central highland. These two protected areas were founded in year 1976. Mount Klíč high 760 meters is protected area as well. Nový Bor is municipality with extended powers, which governs 16 municipalities with overall 25 910 habitants and 20 089 ha of occupied area. [ISEC, 2005]

Figure 4: Location of Nový Bor city

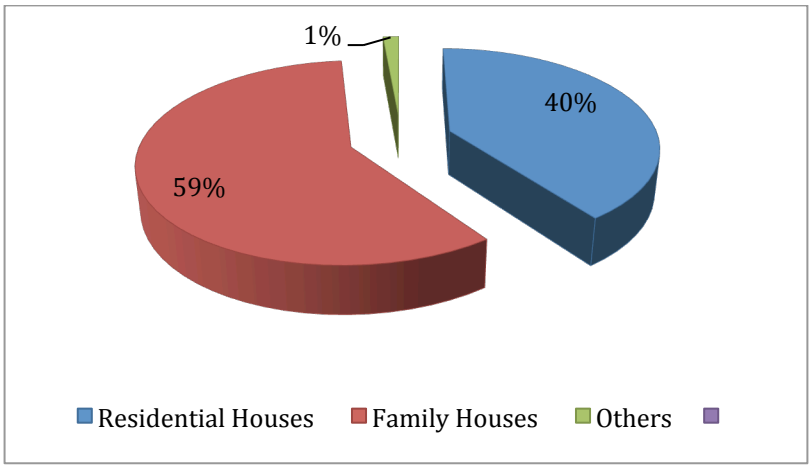


Source: Google maps

4.1.2 Distribution of dwellings in the city

Dwellings in Nový Bor are segregated into two main parts: 4 926 people live at residential houses and 7 227 people live at family houses and 174 are classified as others. Others may be hostel, dormitory or homeless. In Nový Bor live overall 12 327 habitants. Distribution in percentage is residential houses 40 %, family houses 58.6 % and others 1.4 %. Complete statistic table with date sheet from census from 2001 is in appendix. [CZSO (3), 2015]

Figure 5: Dwelling distribution of habitants in Nový Bor



Source: [CZSO (3), 2015]

4.1.3 Present status of containers in the city

The municipality has several types of containers, which is possible split into two groups: municipal waste and separate waste. There are several sizes of containers; number of containers is from 2014. Spots with separate waste are called "nest", where 69 nests are spread throughout the city to provide short delivery distance to everyone. Each nest contains containers for separate collection of paper, plastic, glass, and (beverage) cartons. Table 3 located below displays state of containers in January 1, 2014. Municipal solid waste and sorted waste is usually collected from containers once a week, whereby there are provided empty containers and smooth run of the city. This is based on an agreement with disposal company – COMPAG CZ, a.s. If there are crowded containers, then city office extends number of containers in certain place. However number of containers has persisted unchanged for long time. [Škop, 2015]

Table 3: Containers status in Nový Bor in January 1, 2014

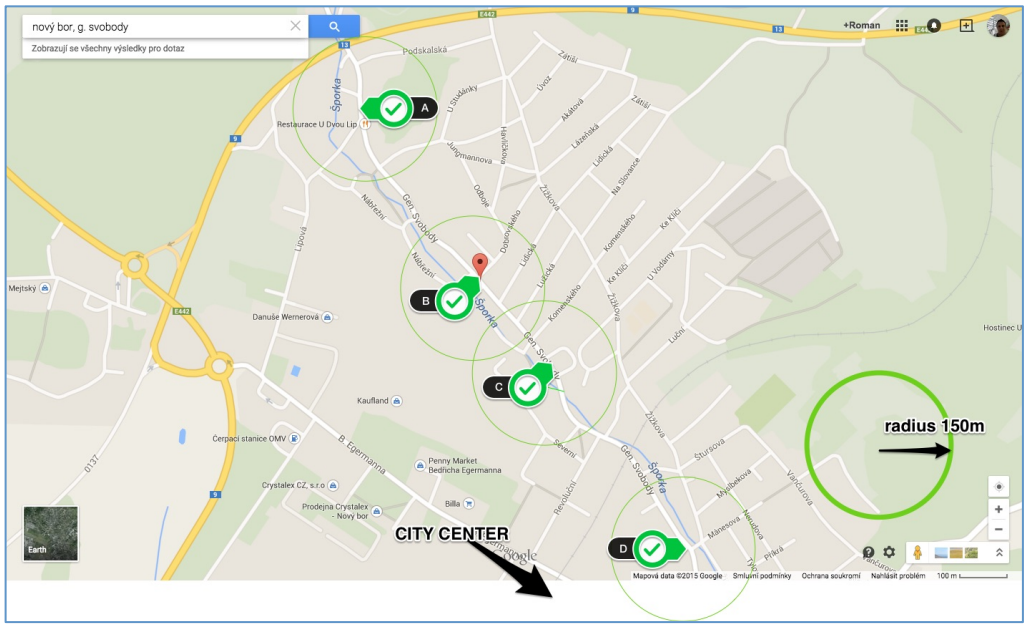
	Type of container	Pieces of containers
Sorted waste	Paper	68
	Plastic	81
	Colored glass	67
	White glass	15
	Beverage cartons	60
Municipal waste	120 L containers	1773
	240 L containers	264
	1100 L containers	208

Source: [Škop, 2015]

Following picture in Figure 6 shows placement of containers in chosen street in Nový Bor, this is an example of city approach towards the WM issue, where satisfaction of human comfort and achievement of decent results are leading criteria, thereby containers for sorted waste must be set as close as possible to citizen homes. This is very important variable if a municipality wants to achieve decent efficiency of waste sorting. In the Czech Republic an average distance between a home and the containers is approximately 101 m. [EKO-KOM (2), 2014]

On the picture 6 there is G. Svobody Street, Nový Bor displayed, there are pointed containers spots, green circle present radius 150 m in scale of the map. There can be observed that some places in the street are out of the acceptable distance. Distance in such places might be about 175 m, which is according the research little far and due to its efficiency of waste sorting may decreases. Pictures of containers from each spot "nest" are displayed on next pages, so appearance of each of them.

Figure 6: Map displaying placement of containers for sorted waste located in G. Svobody Street, Nový Bor in January 1, 2014



Source: Google maps

Figure 7: Photo of containers in nest - A -

Source: Google maps

Figure 8: Photo of containers in nest - B -

Source: Google maps

Figure 9: Photo of containers in nest - C -

Source: Google maps

Figure 10: Photo of containers in nest - A -

Source: Google maps

Number of some containers has been extended; they are mainly containers for plastic waste where plastic waste has highest volume beside weight. Furthermore ongoing trends are packaging everything into dozen layers of plastic foil or plastic caddies; thereby generation of waste soars as well as following necessity of more containers.

4.2 Waste management of Nový Bor

Every municipality has to have plan for waste management with pointed priorities and selected approach to the one of the most important issues.

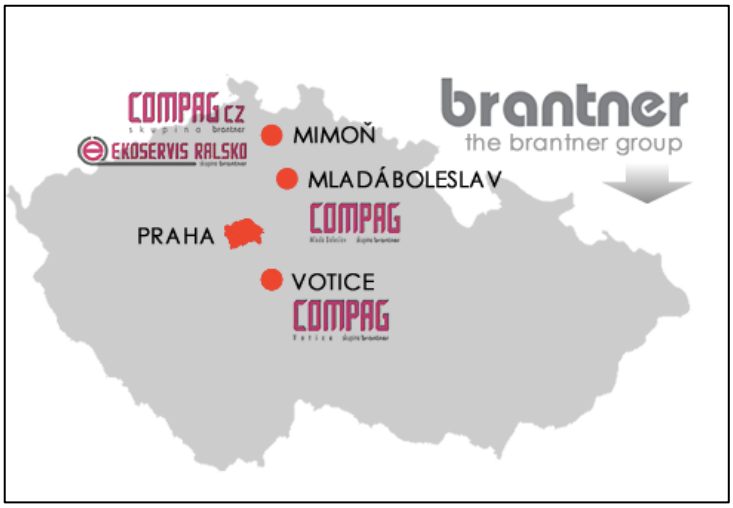
Waste management plan

Waste management plan of a waste generator is obligatory for the generator activities. Waste management plan has to be made for at least 5 years and it has to be changed upon change of conditions that were taken into account for the plan making. The change of plan has to be done within 3 months. [POH Nový Bor, 2005]

4.2.1 COMPAG CZ, s.r.o.

COMPAG is sister company of parent company Brantner Walter GmbH which was established by Walter Brantner senior in 1936. Brantner Walter GmbH had been originally a transport company. Modern history of the company started in 1960, as Walter Brantner junior was leading it. He is the owner of whole company as well. His company started dealing with waste management in 1976. The company ensures own logistic, nevertheless it has established end-processing of waste as ecologic disposal and recycling of waste. COMPAG for example established and operates the landfill. Another example is latest full-automatic sorting line for waste in Europe, which is also operated by this company. [COMPAG, 2014] On the picture 11 the activity of the company in Czech Republic is shown. The company has certification of Quality management BS EN ISO 9001:2008, Environmental management BS EN ISO 14001:2004 and Occupational Health and Safety BS OHSAS 18001:2007. [COMPAG CZ, 2014] These certifications ensure good quality and professional approach in process of WM services.

Figure 11: Activity of COMPAG CZ, s.r.o. in the Czech Republic



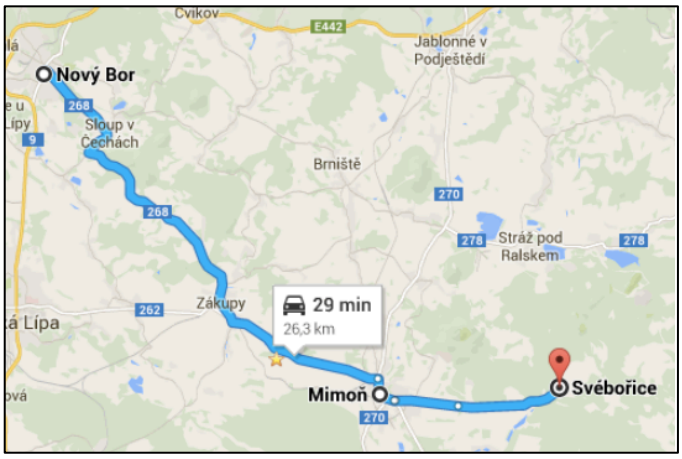
Source: [COMPAG, 2014]

Nový Bor has contract with COMPAG CZ, s.r.o. Mimoň for collection and disposal of municipal waste. [Škop, 2015] COMPAG has performed municipal waste collection and transportation, waste sorting; useful part of waste is sent to recycling, all MSW generated is disposed on landfill. COMPAG has had contrast with EKOSERVIS Ralsko, s.r.o. which has landfill Svébořice. There is disposed MSW from Nový Bor. [COMPAG CZ, 2014]

Although Nový Bor had conflict with COMPAG concerning higher fees for waste disposal [MANĚNOVÁ, 2014], yet the city gave responsibility for waste disposal for next period. In July 7th 2014 COMPAG CZ, s.r.o. won public competition whereby it got commission for WM services in Nový Bor. [QCM, 2014] Advantages of COMPAG are nearest landfill from the city (See map below), lowest budget offer, fulfillment of all requirements of Nový Bor.

Contra: COMPAG disposes waste from Nový Bor only on the landfill, which seems to be wrong, even though incinerator in Liberec (company TERMIZO a.s.) is only 10 km farther than the landfill (via main roads 35 km). Due to WM being a business as any other, the price for disposal on landfill is around 700 CZK/t and about 2000 CZK/t in incinerator. [Slavík, 2004] Furthermore disposing in incinerator carries many other obligation, for example the contract according to which WM company is obligated to deliver determined amount of waste, if it does not satisfy then the company has to pay for missing amount of waste (fuel) to incinerator, because now incinerator may run out fuel. These prices for waste disposal and possible sanction discourage many companies. [Škop, 2015]

Figure 12: Shortest distance between municipality Nový Bor and landfill Svébořice



Source: Google maps

4.2.2 Collection yard of Nový Bor

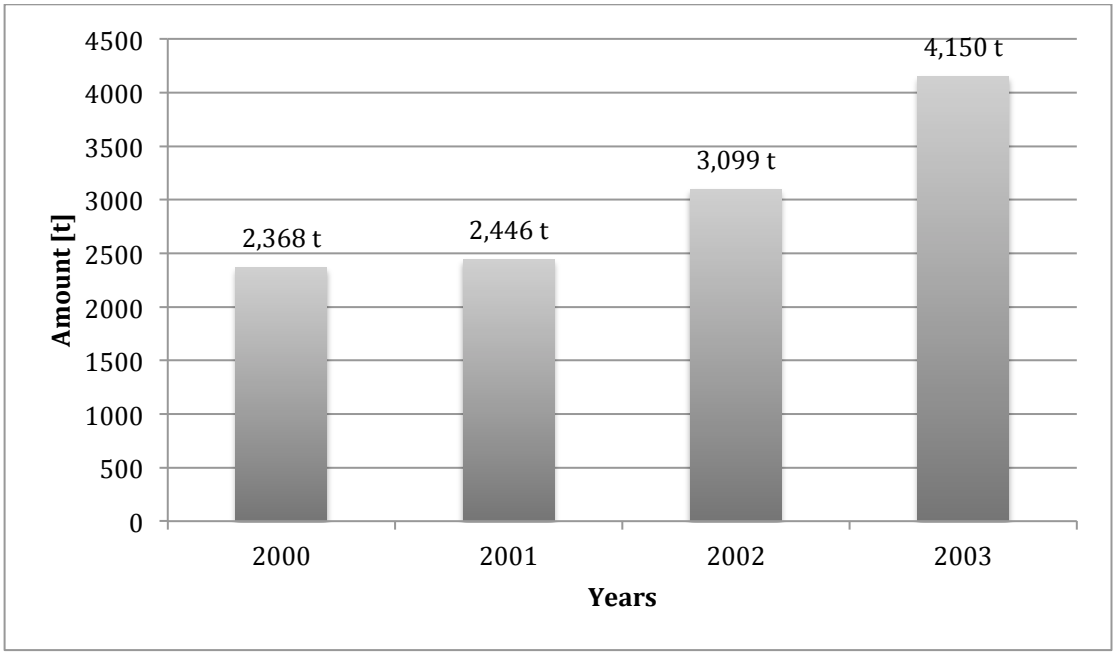
This is site that is defined for gathering selected types of waste. The place is equipped with various kinds of collection equipment (different types of containers, collecting caddies, etc.). Upon collection yard it is possible to gather more types of wastes including dangerous waste. The term collection yard is not defined in Waste Management legislative. [Municipal waste (1), 2015] The collection yard in Nový Bor is situated in Wolkerova 346 Street, with opening three times per week (Monday, Wednesday and Saturday). Collection yard operator is company COMPAG CZ, a.s. Habitants of Noby Bor can dispose waste for a free in collection yard, but they have to submit themselves with an ID card and prove their citizenship of the municipality. They can dispose for a free: sorted, bulky, dangerous and construction waste, although the amount of construction and dangerous waste is limited to 100 kg per person per year. Larger amount or un-called (another) kind of waste is charged according to current valid pricelist. [Collection yard in Nový Bor, 2015]

4.2.3 The city approach to waste management issue

Nový Bor keeps basic principles about waste treatment: prevention, reuse, recycling and landfilling. [POH Nový Bor, 2005] However energetic utilization is still neglected there. These principles of waste treatment are according to European directive 75/442/ES from year 2008. [Waste is Energy, 2015] It is good to figure out that waste management is one of most important issue, although it may be inconvenient. Between years 2000 and 2003 production of mixed municipal waste had increased by 40 %, see figure 13. There is apparently problem

with missing energetic utilization of waste causes to landfilling. According to data obtained in 2003 there is landfilled 87 % of municipal waste and only 13 % is secondary used (recycling or reused) [POH Nový Bor, 2005], and in 2014 share of separated waste soared un 20 % and production of MSW dropped on 80 %. There is no energetic utilization of a waste, this is considered as lack in attitude of the city's WM. Though this lack is not only municipality or regional scale, but mostly nationwide. [Aleksic, 2013] This problem concerning waste disposal arises from the fact that landfilling is way cheaper than incinerator and company with WM services is a regular business as any other. [Slavík, 2014]

Figure 13: Production of mixed municipal waste (in tones) between years 2000 and 2003



Source: [POH Nový Bor, 2005]

4.3 Motivation program for increase waste sorting via bag collection system (BCS)

Since year 2007 waste sorting system "bag gathering" is running, where everyone who has interest can participate in the program. First step is to go to department of technical services to sign up and pick up the stickers with barcode; stickers identify each registered person and commodity. For gathering waste it is possible to use whichever plastic bag; bags may be bought in a store or in COMPAG CZ s.r.o. BCS has been introduced for three types of waste (commodities): plastic, paper and tiny electronic appliances (electro). However participation in the system is completely voluntary, if one decides to participate and contribute to better treatment of waste, unloaded landfills and make some extra money, it is entirely up to him and is welcome. This system has been matching with success and more

people use it every year. [ŠKOP, 2015] This system has found popularity especially in pensioners, because they do not need to carry heavy waste to containers on the street. They can simply collect waste in bags at home and once at month put the bags "behind the door". It is first Monday in month and it is necessary to place bags with stickers (rather "back up" with transparent duct tape) beside street garbage containers. Volunteers participating in BCS get paid at end of year, nevertheless they do not get the money physically to hands but "earned" reward is deducted from their Fee for MSW services in the next year. In total collector of waste can get on the "zero" fee which means that the collector will not pay anything for waste disposal. Collectors can monitor current state of their accounts (amount of collected waste) on the city web www.novy-bor.cz or at the city office. Weight of each collected commodity is summarized over a year; each commodity has certain price per kilo – See table 4. [Škop, 2015]

Table 4: Rewards for kilo of commodity according local directive number 2/2014

Commodity	Price [CZK/kg]
Plastic	1.50
Paper	0.40
Tiny appliance	0.50

Source: [Škop, 2014]

5 Own analysis

In this chapter the analysis of single items of municipal waste was made. There were observed values of collected waste over the time period 2008 – 2014; another monitored values were year-on-year changes or changes related to referential year (2008) which show more precisely development of waste generation. Calculations conducted in this part of thesis are presented in the chapter methodology and are marked with numbers in comas: (1), (2) and (3), etc.

Kind of dwelling might influences production of sorted waste

In Nový Bor lived 13 144 habitants in 2014 [Škop, 2015]. Nevertheless 58.6 % habitants have lived at family houses [CZSO (3), 2015], hence there is significant probability that part of generated MSW may be incinerated at home, whereby amount of collected MSW would be affected by that. It is most likely during heating period in winter, when people use paper for lighting fire in boiler and fireplace using either plastic or other waste for heating itself. These phenomena have been observed for several years, sometimes the odor from chimneys is so intensive that it irritates the nose and force cough. For this reason containers may be less filled than outside the heating season.

5.1 Comparison of production of mixed MSW between Nový Bor, Česká Lípa and the Czech Republic

This part displays complete data regarding amount of mixed MSW generated in Česká Lípa and relevant population in given years; these numbers are recalculated to obtain specific amount of waste per person according calculation (1). Further there are compared specific amounts of waste between Nový Bor, Česká Lípa and Czech average.

As it has been mentioned that Nový Bor is a city located in district Česká Lípa, where Česká Lípa is 10 km far from Nový Bor; in 2014 Česká Lípa has 2.8 times more habitants than Nový Bor. Specific criteria why Nový Bor is compared with Česká Lípa are following:

- Both cities are located in the same region
- Short distance from one to another
- Similar city size in order shortest distance from Nový Bor to compare cities
- Nový Bor utilizes bag collection system, whereas Česká Lípa does not

- Different waste managers (companies) – Nový Bor has COMPAG CZ, s.r.o, whereas Česká Lípa has Marius Pedersen a.s.

Amount of collected mixed MSW in Česká Lípa

Data displayed below in table 5 were obtained from department of Management of Technical Services, City Hall of Česká Lípa. Unfortunately data 2008 and 2009 were not available, but still the data created comparable and consistent data series. According to table 5 it can be stated that production of mixed MSW has decreased harmonically and continually; there were mild grows in 2012 and 2013 but nothing significant. Last growth from 2013 dropped by 3.48 % in 2014; it can be concluded that highest production had been in 2010 and lowest in 2014 and it still tends decrease. For calculation in table 5 were used formulas (1), (2) and (3).

Table 5: Collection of municipal (mixed) waste in Česká Lípa

Year	Number of habitants	Amount [t]	Specific amount $\mathbf{kg \times per.^{-1} \times year^{-1}}$	Year-on-year [%]	From 2008 [%]
2010	38 088	6 310,49	165,68	0,00	0,00
2011	37 817	6 010,71	158,94	-4,07	-4,07
2012	37 573	6 063,89	161,39	1,54	-2,59
2013	37 446	6 068,52	162,06	0,42	-2,19
2014	37 534	5 871,09	156,42	-3,48	-5,59

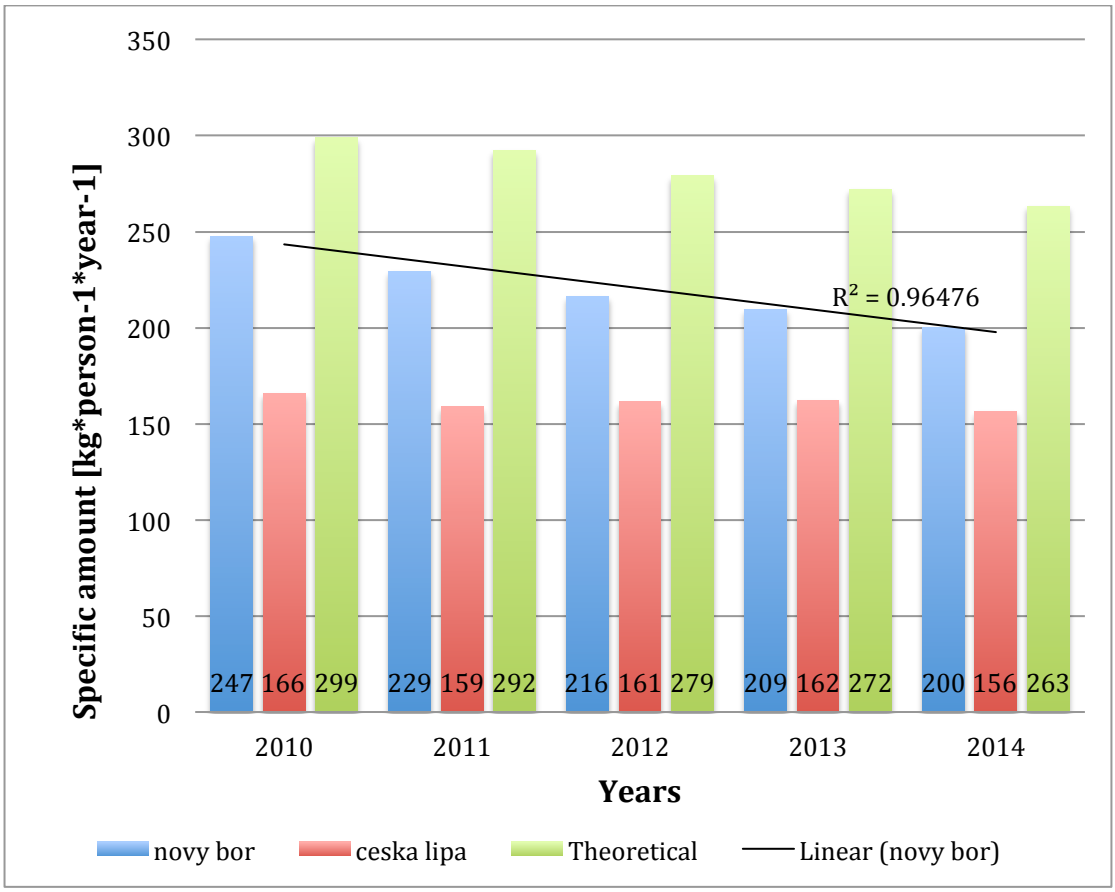
Source: [Bínová, 2015]

Comparison of mixed MSW production of three subjects at once

At the graph below (Figure 14) are presented three subjects: Nový Bor, Česká Lípa and average amount of waste in the Czech Republic; the amounts are expressed as specific amount of waste (1). The data shows course of last 5 years, and give overview about the production of waste in Nový Bor on district scale, as well as nationwide scale.

There can be seen that the waste production in Nový Bor is almost onto midpoint between the highest and the lowest value of MSW production. Generation of the waste has constantly decreased in the entire watched period and it should still goes down according trend line. Nový Bor has had higher MSW production than Česká Lípa apparently due to character of the city and prevailing number of family houses, which gives the city character between “Mixed development of cities” and “Rural development” according table 6.

Figure 14: Comparison of specific amount o mixed MSW



Source: Nový Bor [Škop, 2015], Česká Lípa [Bínová, 2015], Theoretical: http://issar.cenia.cz/issar/page.php?id=1730

Table 6 shows specific amount of MSW in certain housing developments, but it does not include waste (commercial waste) similar to household waste, amount of the waste that is estimated to 50 – 60 % of entire production of MSW (households and other waste similar like that) in "Urban development" and on 20 – 30 % in "Rural development". [Municipal waste (2), 2015]

Table 6: Indicator of specific amount of waste from households (separate waste included, but without commercial waste)

Type of building	Specific amount of waste			
	$kg \times per.^{-1} \times week^{-1}$			$kg \times per.^{-1} \times year^{-1}$
	Average	MIN value	MAX value	Average
Housing estates of large cities	**3,0**	3,9	1,4	**156**
Housing estates smaller towns	**2,5**	3,2	2,3	**130**
Mixed development of cities	**3,0**	3,4	2,5	**156**
Rural development	**3,8**	4,7	3,0	**198**

Source: [Municipal waste (2), 2015]

5.2 Amount of collected MSW in Nový Bor

These data were obtained from the city office; further used calculations are (1), (2) and (3) and they are presented in the methodology part of the thesis. Following part presents data concerning amount of collected waste, each subpart shows exact type of MSW (commodity) throughout observed period (2008 – 2014). Some data series are accompanied by graphical outputs.

5.2.1 Mixed municipal solid waste

In the table below course of mixed solid waste yield within 2008 and 2014 from municipality Nový Bor is given. The table 7 shows the average amount of household waste production per registered person over the past years and the resulting changes.

Table 7 Collection of municipal (mixed) waste in Nový Bor

Year	Number of habitants	Amount [t]	Specific amount $kg \times per.^{-1} \times year^{-1}$	Year-on-year [%]	From 2008 [%]
2008	11 380	2 569.54	225.80	0.00	0.00
2009	11 383	2 958.62	259.92	15.11	15.11
2010	11 434	2 828.85	247.41	-4.81	9.57
2011	12 329	2 828.67	229.43	-7.27	1.6
2012	12 831	2 775.5	216.31	-5.72	-4.2
2013	12 892	2 699.34	209.38	-3.20	-7.27
2014	13 144	2 633.46	200.35	-4.31	-11.27

Source: [Škop, 2014]

The known target of WM is to reduce production of MSW and increase share of recycled material. As can be seen the highest amount of generated waste was in year 2009,

when spefic amount of waste was 225.80 $\mathrm{kg} * \mathrm{person}^{-1} * \mathrm{year}^{-1}$ and growth by 15.14 % beside the referential year; this year had been peak in the observed time period because since 2010 has been observed mild decline of the generated waste.

5.2.2 Iron collected in the collection yard

Iron scrap is collected at the collection year, which is run by COMPAG CZ, s.r.o. and furthermore the city has contract with company Kovošrot a.s. which runs the Scrap Materials, where people can bring iron, copper, aluminum and other scrap materials. This company is connected into collection system led by the city.

In following table 8 the course of iron scrap collection during past seven years is shown. According to average amount it is obvious that year 2010 till 2012 were very strong, particularly year 2010 which is strongest within observed years, it is because in 2010 repurchasing prices in Scrap Materials were highest in past dozen years, web server www.vykupzeleza.cz (Purchase of iron) mentioned that people delivered double amount of scrap materials (in average) oppose to previous years. It happened because generally repurchases of scrap material had not paid much for commodities, whereby people were losing interest in. Thereupon repurchases of scrap material reacted and stimulated people via higher prices per kg. [Purchase of iron, 2015] This course of actions is apparent from table 5.

Table 8: Iron collected in the collection yard

Year	Number of habitants	Amount [t]	Specific amount $\mathbf{kg \times per.^{-1} \times year^{-1}}$	Year-on-year [%]	From 2008 [%]
2008	11 380	1 009.30	88.69	0.00	0.00
2009	11 383	870.00	76.43	-13.82	-13.82
2010	11 434	1 175.20	102.78	34.48	15.89
2011	12 329	1 191.40	96.63	-5.98	8.96
2012	12 831	1 053.74	82.13	-15.01	-7.40
2013	12 892	790.70	61.33	-25.32	-30.85
2014	13 144	797.60	60.68	-1.06	-31.58

Source: [Škop, 2014]

5.2.3 Collection of sorted waste

Sorted waste is very important item of a municipality, which has to be managed properly. Nowadays all municipalities of the Czech Republic are involved in EKO-KOM system for waste separation. Municipalities also have to meet targets concerning material reuse from municipal solid waste.

In the following part data collected from Nový Bor are shown, which were used for extended calculations presented in the methodology. There has been considered approximately 50 % of residents collect sorted waste, however it tends to rise up as people get used to separate waste and exerts effort to deliver sorted waste into containers.

Further fact, which should be taken into account, is that more than half of habitants of Nový Bor live in family houses, which are heated up most likely individually. This individual heating is executed by: fireplaces, stoves or boilers, which heats house via central heating system (radiators). Nevertheless there is very common use of paper for ignition of fire, regardless some individuals even use paper and other commodities like plastic for heating itself. This phenomena is noticeable especially during heating period, when the inversion happens and smoke sticks close to the land whereby emitted odor from incineration such substances is strongly felt in the air. This incineration of recyclable commodities causes containers are almost empty during heating period, this might be significant particularly because the city is located in cooler region which is surrounded by hills with average height 500 m above sea level.

It can be summarized that the city would had have higher outputs from waste sorting and better air quality if it used for instance central heating system for whole city via one incineration plant as is used for example in Odense, Denmark.

5.2.3.1 Carton waste collected via stable containers

This is mostly beverage carton like boxes from milk or juice. This is not too big amount because the usage of these packages does not produce so much, still lot of them finishes in trashcans with mixed MSW. It may be because people are still getting used to sorting, essential and strongest commodities are the most obvious to everyone – glass, paper and plastic. However according to the numbers in column “Change from 2008” it can be concluded that introduction of carton collection among Czech community seems to be very successful. In 2008 average amount per person had been 0.36 kg after six years original amount rose by 156.47 %, moreover this process has been almost uniformly rising except for small deviations in years 2010 till 2012.

Table 9: Collection of carton via stable containers

Year	Number of subjects	Amount [t]	Specific amount $\mathbf{kg \times per.^{-1} \times year^{-1}}$	Year-on-year [%]	From 2008 [%]
2008	11 380	4.10	0,36	0.00	0.00
2009	11 383	8.48	0,74	106.77	106.77
2010	11 434	8.20	0,72	-3.73	99.06
2011	12 329	8.30	0,67	-6.13	86.86
2012	12 831	8.40	0,65	-2.75	81.71
2013	12 892	10.28	0,80	21.90	121.50
2014	13 144	12.14	0,92	15.79	156.47

Source: [Škop, 2014]

5.2.3.2 Paper waste collected via stable containers

In table 10 placed below are the data concerning paper waste collection within seven years is displayed. At the glance it can be registered that year 2010 has been strongest, the increase of paper production was nationwide. As it is mentioned in the part above regarding collection of iron: in 2010 prices of collected commodities soared up because companies needed stimulate people wiliness to bring more paper. In this year repurchasing price of paper was about 2 CZK/kg, which has been highest in past dozen years. [Purchase of iron, 2015] Hence can be noticed that production of paper rose by 25.53 % oppose to beginning year 2008. Further development slightly went down, and might be attributed to rising prices of fuels; this problem is mentioned in the introduction of Sorted waste.

Table 10: Collection of papers via stable containers in Nový Bor

Year	Number of habitants	Amount [t]	Specific amount $\mathbf{kg \times per.^{-1} \times year^{-1}}$	Year-on-year [%]	From 2008 [%]
2008	11 380	338.60	29.75	0.00	0.00
2009	11 383	330.70	29.05	-2.36	-2.36
2010	11 434	417.00	36.47	25.53	22.57
2011	12 329	405.50	32.89	-9.82	10.54
2012	12 831	444.98	34.68	5.44	16.56
2013	12 892	407.90	31.64	-8.77	6.34
2014	13 144	351.15	26.72	-15.56	-10.21

Source: [Škop, 2014]

5.2.3.3 Plastic waste collected via stable containers

This part presents data concerning plastic waste collected via stable containers, the course is fluctuating within whole range; there has been strongest year 2011 with almost twelve kilos per person. Contrary to the peak from 2011 is year 2009, which has been lowest within observed period, collected amount per person, was below 9 kg. According to the

statistic research amount of collected sorted waste stagnates in 2012 and 2013; 10 kg is considered as long-term nationwide average. [Veselá, 2014] Nevertheless it can be concluded that the production of Nový Bor is more or less stable and varies around 10 kilos per person per year.

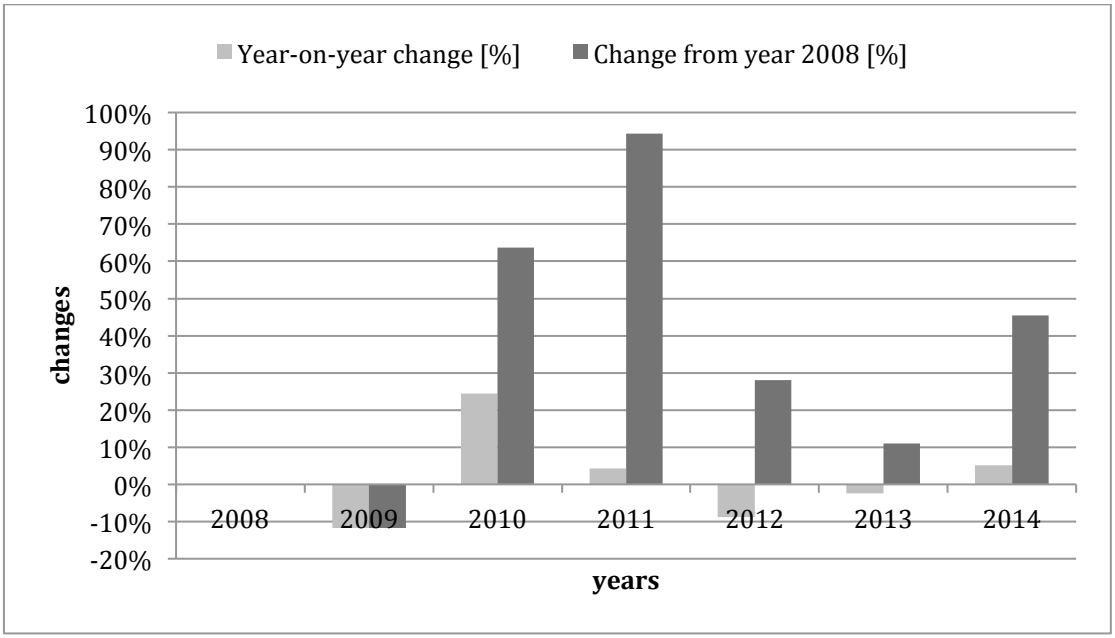
Table 11: Collection of plastic via stable containers in Nový Bor

Year	Number of habitants	Amount [t]	Specific amount $kg \times per.^{-1} \times year^{-1}$	Year-on-year [%]	From 2008 [%]
2008	11 380	115.40	10.14	0.00	0,00
2009	11 383	101.80	8.94	-11.81	-11,81
2010	11 434	127.20	11.12	24.39	63,63
2011	12 329	143.00	11.60	4.26	94,28
2012	12 831	135.66	10.57	-8.84	27,98
2013	12 892	132.93	10.31	-2.48	11,03
2014	13 144	142.51	10.84	5.15	45,37

Source: [Škop, 2014]

The chart below graphically displays data from table 9; year 2008 is considered as starting point, due to it has no column upon the graph.

Figure 15: Development of plastic waste collection in Nový Bor from year 2008 till 2014



Source: [Škop, 2014]

5.2.3.4 Glass waste collected via stable containers

Table 12 displays data concerning white glass and presents differences of it and colored glass, which are shown in table 13. It can be concluded that there is not too much white glass

to separate or people are too comfy and they rather mix all kinds together, like they have done with mixed MSW. Estimation is human comfort.

However from another angle of view and closer look at the tables, there can be seen almost equal changes between white and colored glass from year 2010, almost continues decrease of white glass and soaring tend of colored glass. This phenomena may be explained as more goods than used to be are selling in colored glass, also there can be observed that waste separation tends grow in whole range. However bars, pubs and restaurants are one of biggest contributors of glass bottles, glass scraps and other glass waste, which is usually colored glass.

Table 12: Collection of white glass via stable containers in Nový Bor

Year	Number of subjects	Amount [t]	Specific amount $\mathbf{kg \times per.^{-1} \times year^{-1}}$	Year-on-year [%]	From 2008 [%]
2008	11 380	17.60	1.55	0.00	0.00
2009	11 383	30.90	2.71	75.52	75.52
2010	11 434	16.44	1.44	-47.03	-7.03
2011	12 329	11.97	0.97	-32.48	-37.22
2012	12 831	12.32	0.96	-1.10	-37.92
2013	12 892	11.67	0.91	-5.72	-41.47
2014	13 144	12.89	0.98	8.34	-36.59

Source: [Škop, 2014]

Table 13: Collection of colored glass via stable containers in Nový Bor

Year	Number of subjects	Amount [t]	Specific amount $\mathbf{kg \times per.^{-1} \times year^{-1}}$	Year-on-year [%]	From 2008 [%]
2008	11 380	92.7	92.70	0.00	0.00
2009	11 383	99.20	99.20	6.98	6.98
2010	11 434	100.39	100.39	0.75	7.78
2011	12 329	100.11	100.11	-7.52	-0.32
2012	12 831	147.704	147.70	41.77	41.32
2013	12 892	123.103	123.10	-17.05	17.22
2014	13 144	130.57	130.57	4.03	21.95

Source: [Škop, 2014]

5.2.4 The bag collection system for separate waste in Nový Bor

Following part is devoted to data regarding relatively new collection system, which is realized via home collecting into bags marked by barcodes. Whereas the system is not so widespread and is used only in few municipalities, it can be considered as unique tool; tool extending separation and collection of municipal waste generated by households. This system

was settled in Nový Bor in year 2008 and following tables displays entire course of the system since the beginning until 2014.

Subjects might be individuals as well as families with one family member as representative; number of subjects is multiplied by 3.8 for practical calculation to figure out how many people are involved in the system in real. It is obvious that one person cannot collect for instance about 50 kilos of plastic waste within one year.

Further issue, which has to be taken into account, is that number of subjects is registered as total number of all subjects, the city office has not had registered single numbers of subjects for each commodity. It is so because it is not economically feasible and present system does not desire it.

5.2.4.1 Paper waste collected via BCS

Table 14 shows total amount of the commodity collected in each year, but more important is specific amount of commodity per year according to percentage highest production per person has been in 2013.

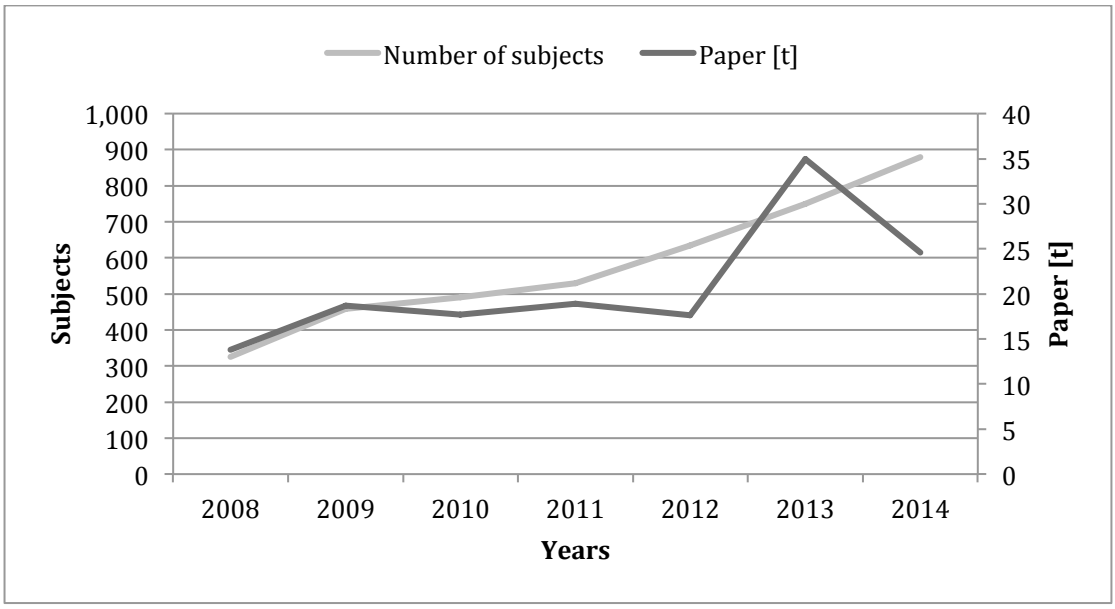
Table 14: Paper waste collected via BCS in Nový Bor

Year	Number of subjects	Amount [t]	Specific amount $\mathbf{kg \times per.^{-1} \times year^{-1}}$	Year-on-year [%]	From 2008 [%]
2008	325	13.80	42.46	0.00	0.00
2009	458	18.70	40.83	-3.84	-3.84
2010	491	17.70	36.05	-11.71	-15.10
2011	529	18.90	35.73	-0.89	-15.86
2012	635	17.60	27.72	-22.42	-34.73
2013	750	35.00	46.67	68.37	9.90
2014	880	24.57	27.92	-40.17	-34.25

Source: [Škop, 2014]

Although percentage expression tends to decrease, number of participants soars up and oppose referential year 2008 the previous year 2014 was more than doubled.

Figure 16: Graph displays data from table 14



Source: [Škop, 2014]

5.2.4.2 Plastic waste collected via BCS

In table 15 are displayed data regarding amounts of collected plastic waste via BCS, at the glance can be noticed progressing number of subjects starting in 2008 with 325 subjects and heading to nine hundred subjects in year 2015. This is considered as successful installation of such system; the thing which charms people to collect admirable amount of plastic waste is apparently solid price 1.50 CZK per kilo, which is highest repurchase price oppose to paper waste or scrap of tiny electrical appliances, on the other hand plastic waste is much lighter than paper.

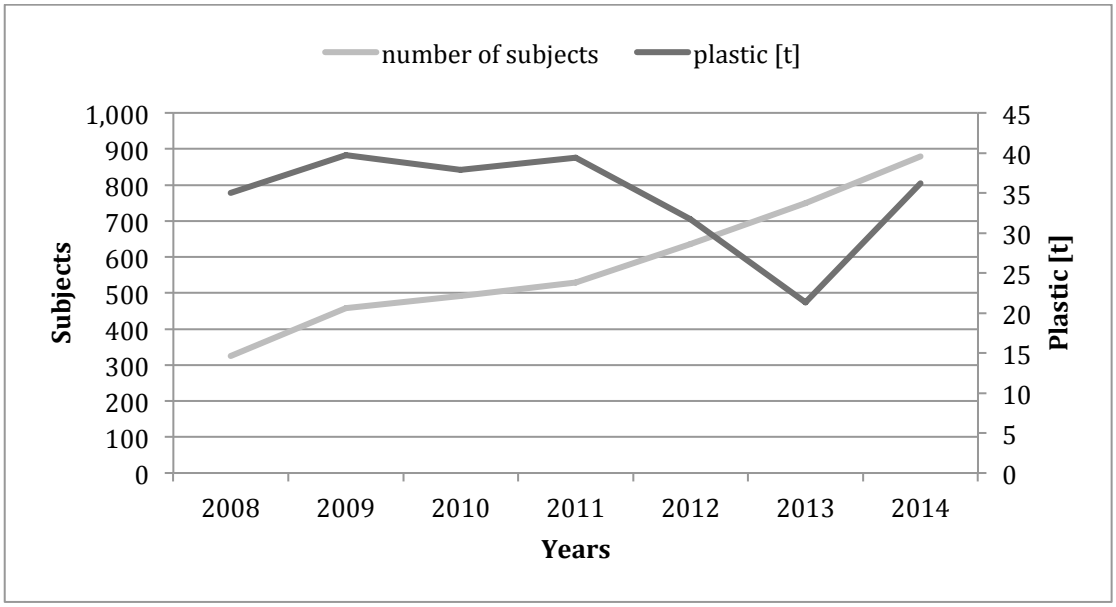
Table 15: Plastic waste collected via BCS

Year	Number of subjects	Amount [t]	Specific amount $\mathbf{kg \times per.^{-1} \times year^{-1}}$	Year-on-year [%]	From 2008 [%]
2008	325	35.00	107.69	0.00	0.00
2009	458	39.70	86.68	-24.24	-19.51
2010	491	37.90	77.19	-12.30	-28.32
2011	529	39.40	74.48	-3.64	-30.84
2012	635	31.70	49.92	-49.20	-53.64
2013	750	21.30	28.40	-75.78	-73.63
2014	880	36.19	41.13	30.95	-61,81

Source: [Škop, 2014]

Although number of subjects rapidly increases on the contrary the average weight of bag decreases. The drop of weight has been observed until year 2013 when it stopped and started growing again. Similar course can be observed in graph presenting collection of plastic waste via fixed containers, where continues fall was until 2013 and then it stopped and soar up to 2014. However plastic waste collected is lower because the production of municipal solid waste is lower. In 2008 production of MSW was approximately 225 kg per person but in 2014 only 200 kg.

Figure 17: Graph displaying data from table 15



Source: [Škop, 2014]

5.2.4.3 Scrap of tiny electrical appliances collected via BCS

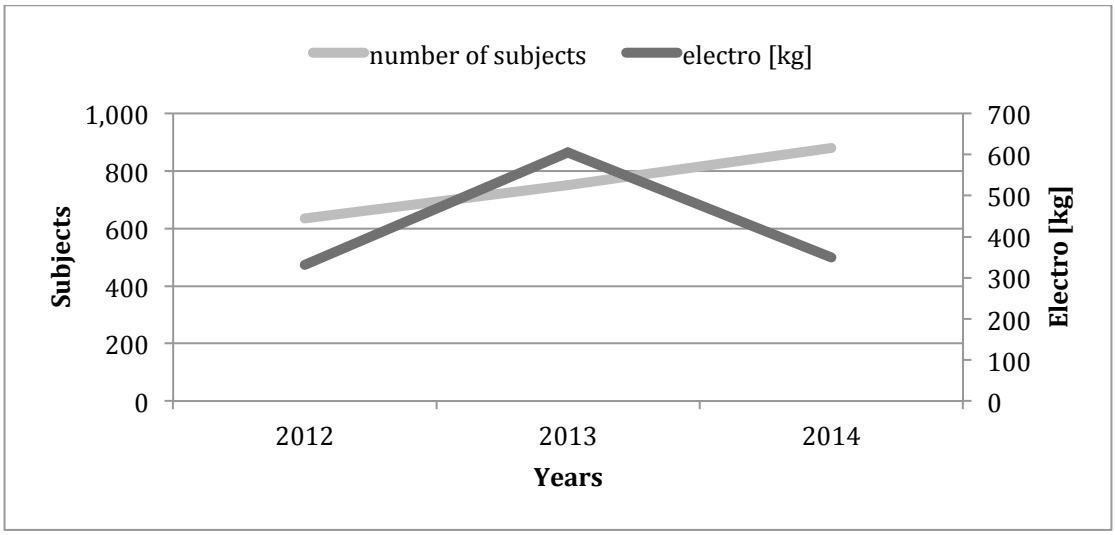
This segment was implemented three years ago so there is not much knowledge about it, though according to the graph (figure 16) in 2012 people apparently got to know about collection of this commodity. In next year 2013 number of active collectors increased and collected amount was on the peak with 0,81 kg per person per year; latest monitored year 2014 was even lower than year 2008, because people gave away all gathered stuffs from home. Development of the production may either steady or vary, but it will depend on the people, how they will accumulate and dispose of old electrics appliances. Here it is necessary to figure out that people do not like throwing away expensively acquired stuffs, hence the process of disposal of old electronics takes some time.

Table 16: Scrap of tiny electrical appliances collected via BCS in Nový Bor

Year	Number of subjects	Amount [t]	Specific amount $\mathbf{kg \times per.^{-1} \times year^{-1}}$	Year-on-year [%]	From 2008 [%]
2012	635	0.33	0.52	0.00	0.00
2013	750	0.61	0.81	54.64	54.64
2014	880	0.35	0.40	-50.84	-23.98

Source: [Škop, 2014]

Figure 18: Graph displays data from table 16



Source: [Škop, 2014]

5.3 Summary

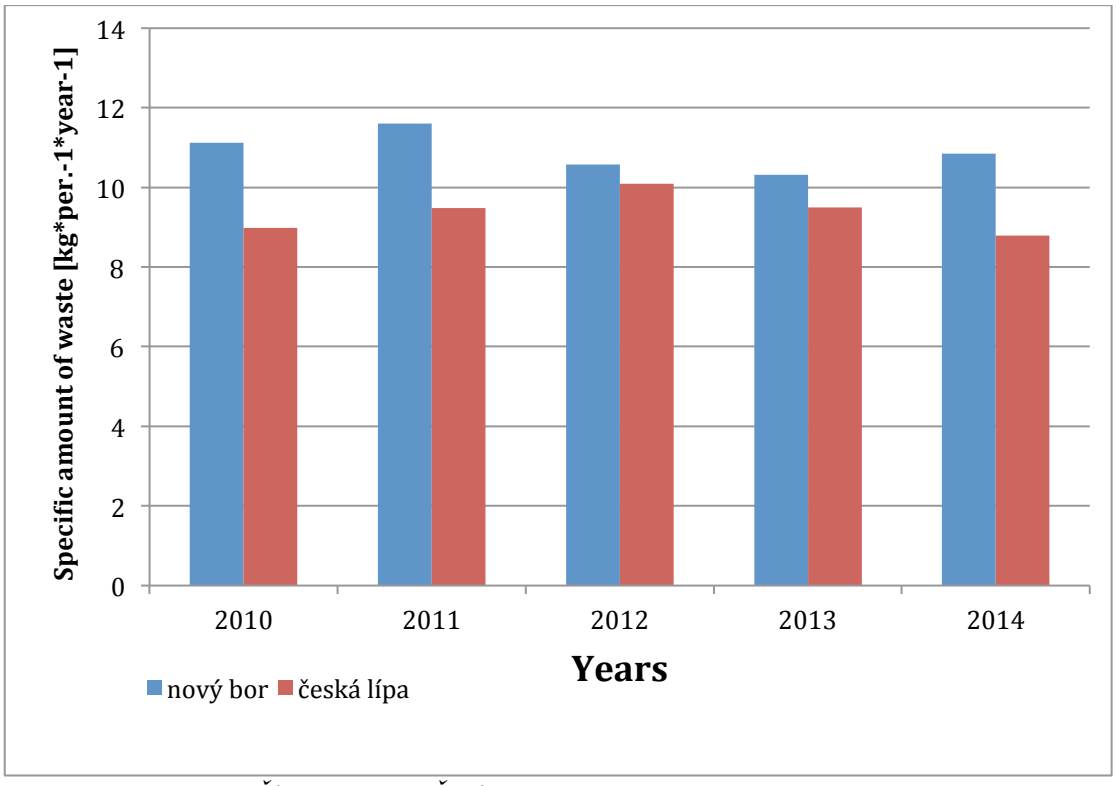
Results of this part are focused on the most delicate items that have to be changed rapidly as reduction, recycling and energetic utilization of MSW generation. These three items press Czech Republic via latest WMP to reach new goals in the next couple of years. Second importance to discuss is production of commodity plastic because in Nový Bor was fall with lowest point in 2013, hence here was conducted analysis which compare Nový Bor results with Česká Lípa. Last important results to discuss were obtained from part concerning bag collection system in Nový Bor, whether worth it or not.

Mixed MSW generation in Nový Bor has tended to decrease; this decline in MSW generation is constant, and it is apparently still going to fall. In the future lower waste generation might be due to weakening purchasing power of habitants, because this region is still struggling with high rate of unemployment and substandard wages. However Česká Lípa

has production of MWS even lower, but it is seemingly due to different character of the city, nevertheless in result Nový Bor stands well.

Production of separated plastic waste has different progress in both cities, where in Nový Bor the production course has almost the shape parabola of upward, whereas in Česká Lípa is the shape of production line is vice versa. In contrast MSW generation where lower number means better, in this case are admirable higher numbers which Nový Bor has achieved. The production has not dropped below 10 kilos per person per year in watched period, even in years 2012 and 2013 which are evaluated as weaker. In contrast of Nový Bor, Česká Lípa has reached 10 kilos in observed period only once, then gradually decrease again.

Figure 19: Production of sorted plastic waste only from stable containers



Source: Nový Bor [Škop, 2015], Česká Lípa [Bínová, 2015]

Is BCS worth it? This could be a frequent question of many authorities contemplating whether to install it or not. According to the analysis of Nový Bor and experiences from another Czech municipalities, it can be recommended as functional system which worth it. EKO-KOM stated: in year 2013 ever Czech sorted out in average 39.7 kg of waste – mentioned paper, plastic, glass and carton. [EKO–KOM (1), 2013] According to the

conducted analyses, in year 2014 every inhabitant of Nový Bor sorted out in average 49.4 kg of the waste via stable containers (without bag collection system); however 54 kg via both systems (stable + BCS). In fact the BCS of Nový Bor is pretty young and people are still getting used to it, but BCS has progressively soared up from about 300 subjects in the beginning to currently almost 900 subjects. Expression subject is because usually only one member of family is registered upon the City Hall, but seeming entire family participates. In conclusion it should be mentioned that about 30 % of population is already involved into BCS.

6 Economic assessment of Waste Management

This part is splitted into three parts, first part deals with costs, second part with incomes and last part shows costs after deducting incomes and also how much the city has to additionally pay for the WM in real.

6.1 Waste Management costing

Firstly total cost are shown, furthermore the cost of Nový Bor are compared with Česká Lípa and the Czech Republic average; There are formulas used which are displayed in methodology. Secondly chosen costs are described which enter into the fee for waste collection that residents must pay.

6.1.1 Total costs of Waste Management in year 2012

Total costs of a municipality are all costs, which are necessary to assure run of waste management in a municipality. In table 17 are some items which may be unclear, the item called municipal waste includes Collection Saturdays in adjacent villages; that means big container is placed in village in a date known in advance, so people can get rid of things they do not need, this is usually bulky waste. Item waste management includes services as cleaning, gathering and carting of sweeping of litter from the streets. In following table are displayed data, which present total costs of Nový Bor in year 2012. It is important to realize difference between "total" and "chosen costs", "chosen costs" are "total cost" minus costs for waste separation (Sorted waste, Sorted waste via BCS); exact calculation is (4).

Table 17: Total costs of Nový Bor for WM's services in year 2012

Item	Expanses [$\mathbf{CZK * year^{-1}}$]
Trash cans	293 287
Municipal waste – others	47 512
Collection yard	1 791 284
Sorted waste	*1 013 567*
Containers	27 320
Liquidation of black landfills	217 176
Sorted waste via BCS	*313 336*
Carting of dustbins and containers	4 671 323
Waste Management	60 000
Biowaste	188 876
Sum	**8 609 432**
Cost per capita	**671**

Source: [Škop, 2014]

In Česká Lípa lived 37 017 Czech residents and 1 379 foreigners – habitants of the Czech Republic. For foreigners there are several types of stays, merely the Police of the Czech Republic register them. There were about 800 foreigners with permanent residence who were obligated to pay the fee. Resulting number is approximately 37 800 payers in year 2012. Total cost of waste management was 37,002,439 CZK after dividing total cost for WM by the population released average operational cost of WM 979 CZK per capita! [Bínová, 2015] In year 2006 AOC of the Czech Republic was 747 ± 82 CZK per capita and in 2009 it was 902.7 CZK. [SMO, 2008] According to the facts that AOC of Nový Bor is equal to 672 CZK in year 2012, it can be concluded that the financial management of WM of Nový Bor is set up very well; mainly because its low AOC is even lower than Czech average from year 2007, further it is stable fee for MSW collection that has not been changed for entire observed period (years 2008 – 2015).

6.1.2 Chosen waste management costs according local municipal fee

Table 18 displays municipal waste costs, these costs touch the local fee for collection of MSW and are used for assessment of the fee. However the items "sorted waste" and "sorted waste via BCS" are the only difference between "Chosen MW costs" and "Total WM costs".

The table below displays expanses during year 2012 and 2013; in 2012 in Nový Bor lived 12 831 residents and in 2013 there lived 12 892 residents. Based on these facts real costs per capita can be calculated (6).

Table 18: Chosen MW costs of Nový Bor

	Expanses [$\mathbf{CZK * year^{-1}}$]	
Item	**2012**	**2013**
Trash cans	293 287	292 474
Municipal waste – other	47 512	62 607
Collection yard	1 791 284	1 791 284
Containers	27 320	34 588
Liquidation of black landfills	217 176	137 433
Carting of dustbins and containers	4 671 323	4 719 031
Waste Management	60 000	48 400
Biowaste	188 876	213 846
Sum	**7 296 778**	**7 299 663**

Source: [Škop, 2014]

Table 19: Real cost per resident of Nový Bor

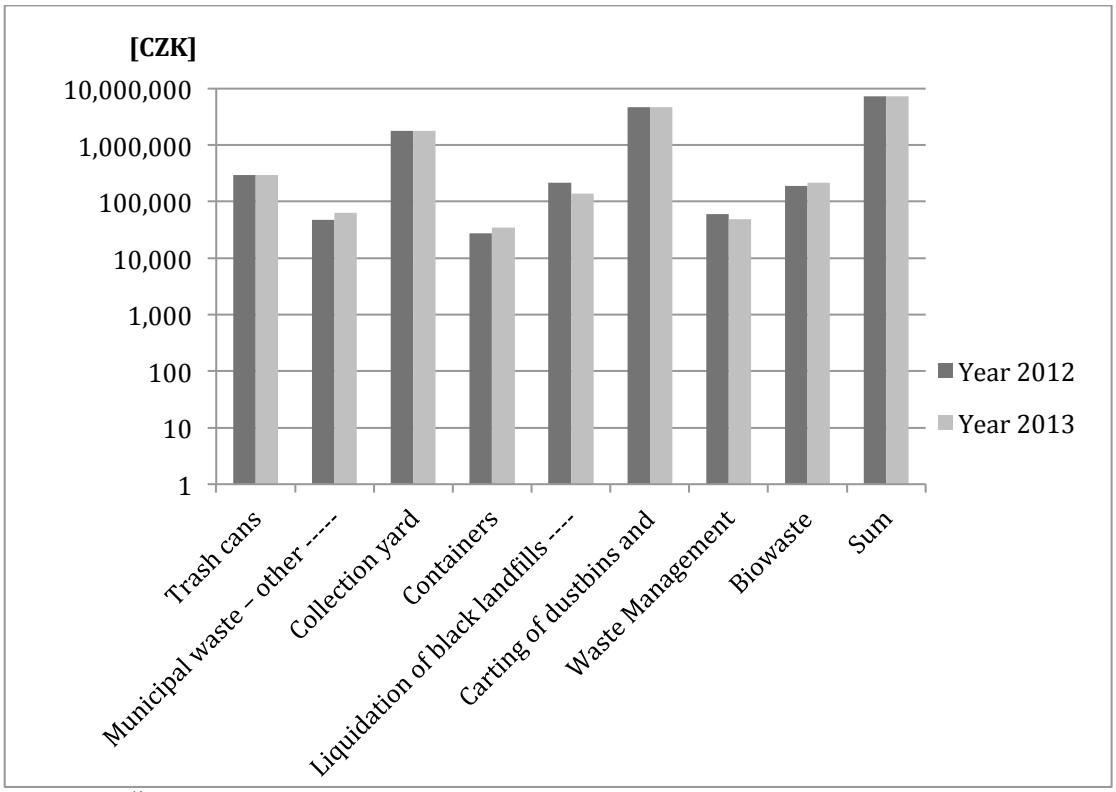
Year	Number of registered residents	Real costs $[\mathbf{CZK \times resident^{-1} \times year^{-1}}]$
2012	12 831	568.70
2013	12 892	566.20

Source: [Škop, 2014]

Real cost per capita is little higher than final amount paid by the city, the city hall diminishes this amount via WM incomes, and this final cost is shown in third part of chapter 6. According to table 19 is possible imagine WM cost per capita and also it is interesting, because in 2013 costs of municipality went down by 2.50 CZK per capita per year and furthermore $2.50 \times 12\,892 = 12\,892$ CZK in total.

The chart below displays data from table 15 and uses logarithmic scale on the vertical axes. There is clear to see that development of all items between years 2012 and 2013; liquidation of black landfills went down in second year, which indicates better attitude of habitants than in the previous years. However four columns are almost unchanged, trash cans, collection yard and carting of dustbins and containers. Although there was an increase in carting costs, but it was most likely due to the increase of fuels prices, because carting of dustbins and containers require tracks, which cruise the municipality once a week to assure empting all containers. Whereas collection yard is static place where people are coming to dispose of their waste, this is the opposite of previous two services.

Figure 20: Chosen costs of Nový Bor within 2 years



Source: [Škop, 2014]

6.1.3 Costs of sorted waste

Collection of sorted waste has become second most important cost item of waste management in the last few years. These usable components are especially paper, plastic, glass and carton. The collection had share 13.1 – 26.5 % from whole WM costs of municipalities of the Czech Republic in 2012. [Vrbová , 2012]

6.1.3.1 Costs of separated waste via stable containers

These costs also are not taken into account in local fee charges system for collection, transport, sorting, use and disposal of municipal waste under the Act of Local Fees. Rent of containers, handling, removal, carting and other, all these costs are creating final number called costs for separate waste via stable containers. These services cost about one million CZK annually; costs for year 2012 are displayed in table 17.

6.1.3.2 Costs for separated waste via bag collection system

The bag collection system seems to be very advantageous where sorting waste into bags enhances economic situation of the municipality and also helps the habitants to save some money for waste disposal, because they have got discount upon the fee for MSW disposal.

Particularly good is extended city's interest about the most touching topic nowadays – waste sorting. Cities with proactive attitude to waste separation get financial rewards from EKO-KOM; such a reward for Nový Bor is about one million CZK. This money has to be used only for operating and development of waste management.

Table 20 shows the data concerning operational costs of BCS; it is necessary to consider that the city has employed people who have to conduct community work to perform BCS service. Therefore city has reduced its costs for manpower, this solution might fit for any municipality in Czech Republic and cause it to solve two problems at once. It employs people who are punished by court and helps to municipality withstand ongoing economic pressure. This BCS is evaluated as economically feasible and efficient for municipality with prevailing family houses or medium residential houses.

Table 20: Main average costs of the municipality for BCS

Item	Price [CZK $*$ year^{-1}]
Acquiring plastic bags	25 000
Print out barcodes	4 000
Collection of bags (carting)	300 000
Total	**329 000**

Source: [Škop, 2014]

Nový Bor spends 25,000 CZK for the plastic bags, every participant gets first 10 bags for collection gratis. Barcodes cost includes cost for material necessary for printing barcodes (sticky papers, colors and other). Bag collection costs are mostly for operation of the collecting vehicles.

Table 21 shows money paid away by the municipality to participants of BCS, these rewards have been paid away via rebate from the Local fee charges system for collection, transport, sorting, use and disposal of municipal waste under the Act of Local Fees.

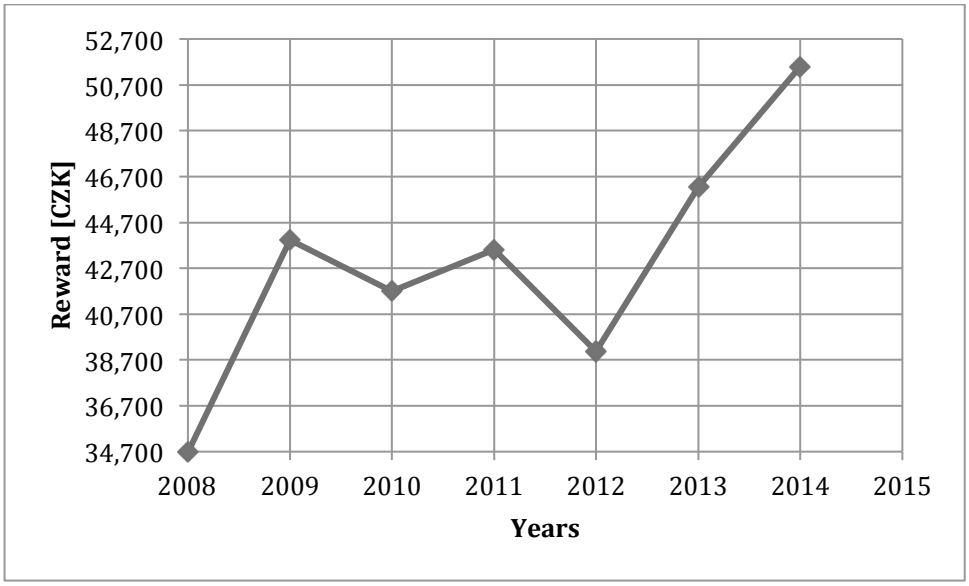
Table 21: The money paid by city office to volunteers for collections of sorted waste via bag system and barcodes, numbers are expressed in CZK

Year	2008	2009	2010	2011	2012	2013	2014
Paper [CZK]	14,000	15,880	15,160	15,160	12,680	14,000	14,477
Plastic [CZK]	20,700	28,050	26,550	28,350	26,400	31,950	36,854
Electro [CZK]	–	–	–	–	–	303	175
SUM [CZK]	**34,700**	**43,930**	**41,710**	**43,510**	**39,080**	**46,252**	**51,504**

Source: [Škop, 2014]

Chart figure 18 graphically presents table 21; the reward is directly proportional to production because repurchasing prices have not been changed since beginning of the BCS.

Figure 21: Graph describing total reward paid to participating volunteers in bag collection system



Source: [Škop, 2014]

6.2 Incomes of Waste Management

This part is devoted to money generation where can be considered three main sources: first from the Local fee charges for municipal solid waste collection, second from collection of sorted waste via fixed containers and third collection of sorted waste via bag system with bar codes. There is really important to set up sufficient Local Fee system payment to prevent future problems with enforcement debts, especially if it is considered that this item is mainstream of money to Waste Management of the city; by the way in recent year 2014 total amount obtained from the Fee was $13{,}144 \times 500 \; = \; 6{,}572{,}000 \; CZK$.

6.2.1 Rewards from EKO-KOM

Citizens sort waste and place it into correct containers. This waste is aimed to second usage and therefore the city hall gets paid for it from EKO-KOM. The amount of reward is based on weight and cleanness. In following table 22 data obtained from the city office are presented, where displayed data is since year 2008 till 2014. Present data in table below is in Czech currency [CZK]; table is made up from six items where first five are commodities. Last item "bonus" is kind of extra money to support city effort and willingness to separate waste. This item includes money for instance for sorting waste, package take-back, and density of container's net (good placement) and etc.

Table 22: Profit from EKOKOM, numbers are in CZK

Years	2008	2009	2010	2011	2012	2013	2014
Glass [CZK]	86,000	127,000	172,113	173,110	224,047	192,471	165,106
Plastic [CZK]	588,000	550,000	649,842	713,583	647,941	632,047	689,654
Iron [CZK]	31,000	61,000	105,772	107,233	204,215	153,238	145,770
Paper [CZK]	147,000	206,000	212,850	174,559	166,768	184,918	274,292
Carton [CZK]	14,000	30,000	29,581	29,887	30,265	37,036	46,964
Bonus [CZK]	328,000	378,000	446,833	390,700	386,824	385,714	312,211
Total [CZK]	**1,194,000**	**1,352,000**	**1,616,991**	**1,589,072**	**1,660,060**	**1,585,424**	**1,633,997**

Source: [Škop, 2014]

The profit from glass as well as the profit from iron is visible to be highest in 2012 and poorest in 2008, as well as profit from iron. Plastic had strongest year in 2011 and weakest in 2009 but a bit smaller than 2008. Paper and carton had been lowest at 2008 and reached highest amount in 2014. It can be concluded that 2008 as initial year had been lowest and with upcoming time each commodity tends to progress.

Following table displays sum of each year from previous table, and two production indicators. First expresses 2008 as hundred percent and compares rises and drops with it. Second indicator shows year on year changes

Table 23: Percentage changes in total profit in period 2008 – 2014

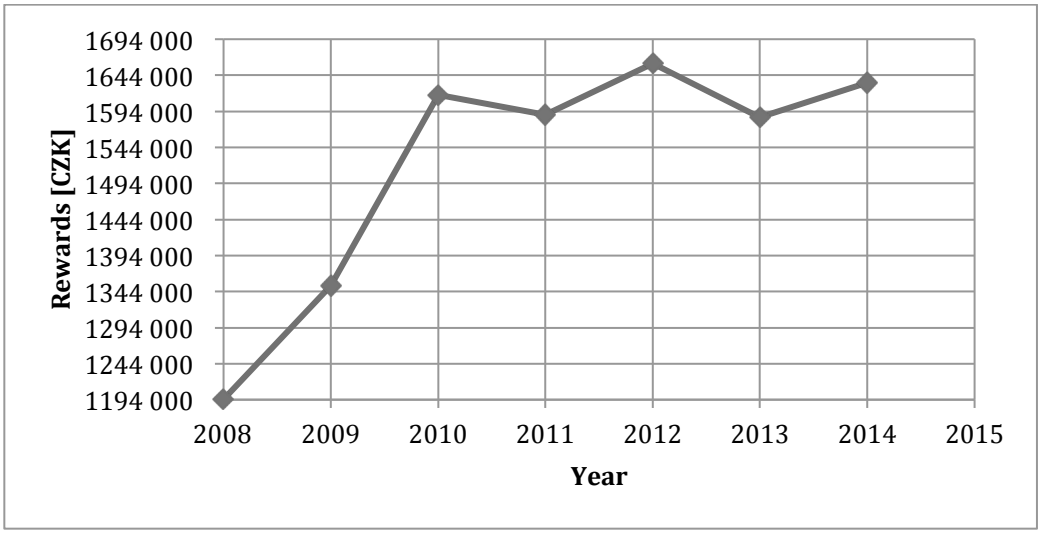
Year	2008	2009	2010	2011	2012	2013	2014
SUM [CZK]	**1,194,000**	**1,352,000**	**1,616,991**	**1,589,072**	**1,660,060**	**1,585,424**	**1,633,997**
From 2008 [%]	0.00	13.23	35.43	33.09	39.03	32.78	36.85
Year-on-Year [%]	0.00	13.23	19.60	-1.73	4.47	-4.50	3.06

Source: [Škop, 2014]

According to the first indicator "From 2008" the progress is visible in whole range, although in the second half was not growing, in first three years production had grown up nicely. This phenomenon may be explained as rising interest of citizens in waste sorting and positive and proactive city's approach. Furthermore second Year-on-year indicator shows only two red numbers, first drop –1.73 % was in year 2011 and second drop –4.5 % was in year 2013. This development might be concluded as fluctuating from 2010 to 2014, nevertheless according to last five years it keeps stable stream of money into the city cash desk. Meanwhile the waste sorting supports EU targets about waste reuse and minimizes damping.

At the Figure 9 is graphically displayed the development of received reward from EKO-KOM. The municipal approach is evaluated as positive approach toward sorted waste issue and it proves that it helps to improve budget of the Nový Bor.

Figure 22: Graph displaying SUM of profit via rewards from EKO-KOM over the observed period



Source: [Škop, 2014]

However it is necessary not forget that city office has to pay back to company Kovošrot a.s. according to the agreement of joining into the collection system of the city. Kovošrot a.s. earlier called Severočeské sběrné suroviny (North Czech Republic scrap materials) is company dealing with iron scrap. In table below are displayed amounts paid back to Kovošrot a.s.

Table 24: Money paid back to Kovošrot a.s. for join into the city collection system

Year	Payment [CZK]
2008	40 000
2009	44 000
2010	76 169
2011	67 564

Source: [Škop, 2014]

6.2.2 Local fee for municipal solid waste collection

Nový Bor has several sources of income, which are necessary for keeping city clean and trashcans and containers empty, there is also talking about operation of the city Waste Management. Main source of money for covering these services is from the local fee $500\ \mathrm{CZK}\times\mathrm{resident}^{-1}\times\mathrm{year}^{-1}$.

Nový Bor has distribution of costs as is showed in part Chosen costs, where the Fee for MSW services is obtained based on Act of Local Fees. However in the Czech Republic there are three options how to set up MSW removal fee, first option is according to Waste Act 185/2001 and second one based on the Act of Local Fees – ordinance of municipality or regional city office, moreover it is called in full name: local fee charges system for collection, transport, sorting, use and disposal of municipal waste under the Act of Local Fees. Third option is contractual payment collection system for municipal waste within the meaning of § 17 Sec. 5 of the Waste Act. [Stanovisko odboru dozoru a kontroly veřejné správy Ministerstva vnitra, 2009]

Despite global rising prices, Nový Bor has held the local fee for MSW services stable for many years, even when the municipality pays additional payment on each resident. This additional payment is displayed in table 25.

Table 25: local fee charges system for collection, transport, sorting, use and disposal of municipal waste under the Act of Local Fees; Nový Bor in 2015

Year	Number of registered residents	Real costs [$\mathbf{CZK \times resident^{-1} year^{-1}}$]	Fee [CZK]	Additional payment [CZK]
2012	12 831	568.70	500	68.70
2013	12 892	566.20	500	66.20

Source: [Škop, 2014]

6.3 Cost after deducting incomes

Cost after deducting incomes of the city was obtained as: all known costs minus all known incomes belonging to WM, the calculation was conducted according to formula (7). Table 26 shows all involved items and result; in Nový Bor lived 12 831 habitants in year 2012. The amount paid back (money paid back to Kovošrot a.s. from in year 2012) was missing in the datasheet, and then professional estimation was made for purpose complete calculation. Single items are previously explained; final total cost paid by the city is 657 201 CZK, this amount the city had to pay for operation entire WM sector in year 2012. Resulting cost paid by city is 51 CZK per resident per year. This was final and real amount (after deduction all relevant costs from all relevant incomes) paid by the city.

Table 26: Assumption cost after deduction incomes

COSTS	
ITEM	**PRICE** [**CZK**×population^{-1}**year**$^{-1}$]
Trash cans	293 287
Municipal waste – others	47 512
Collection yard	1 791 284
Sorted waste	1 013 567
Containers	27 320
Liquidation of black landfills	217 176
Sorted waste via BCS	313 336
Carting of dustbins and containers	4 671 323
Waste Management	60 000
Biowaste	188 876
Money paid from BCS to people	39 080
Money paid back to Kovošrot	70 000
TOTAL	**8 732 761**
INCOMES	
Profit from EKOKOM	1 660 060
Income from fees from residents	6 415 500
TOTAL	**8 075 560**
COST MINUS INCOME	
Final cost paid by city	**657 201**
Final cost paid by city per person	**51**

Source: [Škop, 2015]

6.4 Summary

There are also circumstances concerning the number of habitants, which affect revenue of the city office. Approximately 8% of inhabitants do not pay the fee for MSW disposal; they are so called problematic people and enforce the money from them is hardly feasible or it is not economically feasible for the city hall of Nový Bor. They are people like gypsies or people living on "edge" and other maladjusted people. This group includes about 1000 individuals and keeps stable number, but such group might cause to loss of half a million CZK per year! This possible loss of income magnifies the final cost (paid by city per resident) from 51 CZK to 90 CZK. However

7 Investigation of bag collection system – questionnaire

There was made questionnaire with objectives to research if residents are aware about the BCS of how many people are participating in the BCS and if they are satisfied with it. For questionnaire were used following criteria: necessity to live in Nový Bor and age; furthermore closed question were used. Used questions are presented in table 27; whole questionnaire is attached in the appendixes of this thesis.

Table 27: Extruded questions from the questionnaire used in Nový Bor

1/	Are you inhabitant of Nového Boru?
2/	Do you know about motivation program for collection of sorted waste (BCS)?
3/	Are you direct participant in the program (BCS)?
4/	Are you happy with the present system (BCS)?

Source: Source: Own investigation

There was conducted questionnaire for two groups with following age distribution (18–30 years) and (31–55 years), whereas people (55+ years) are considered as common collectors however they are not included; the investigation was focused on actively working part of population, which should be environmentally educated to preserve their landscape.

7.1 Age category (18-30 years)

The age category (18–30 years) was conducted around Glass School Nový Bor, asked people were mostly students of last year of study and teachers of the school; this place had been chosen because it is an educational place, where awareness about sorting waste is supposed be decent. However results were not so impressive, seemingly habitants in age range (18–30 years) do not know much about BCS. Primary problem may be considering awareness, because only 14 in 25 asked people knew about BCS, and in percentage 45 % of habitants do not know about the system, but particularly young people do not know it at all. There is another alarming number – only half of people who know about the BCS actually use it, this means less than 30 % in total. Regardless these numbers, the satisfaction with system reported 100 % of people who use the system so 7 in 7 people are happy with it. Data mentioned above are displayed in table 28 and figure 23 displays graphic output.

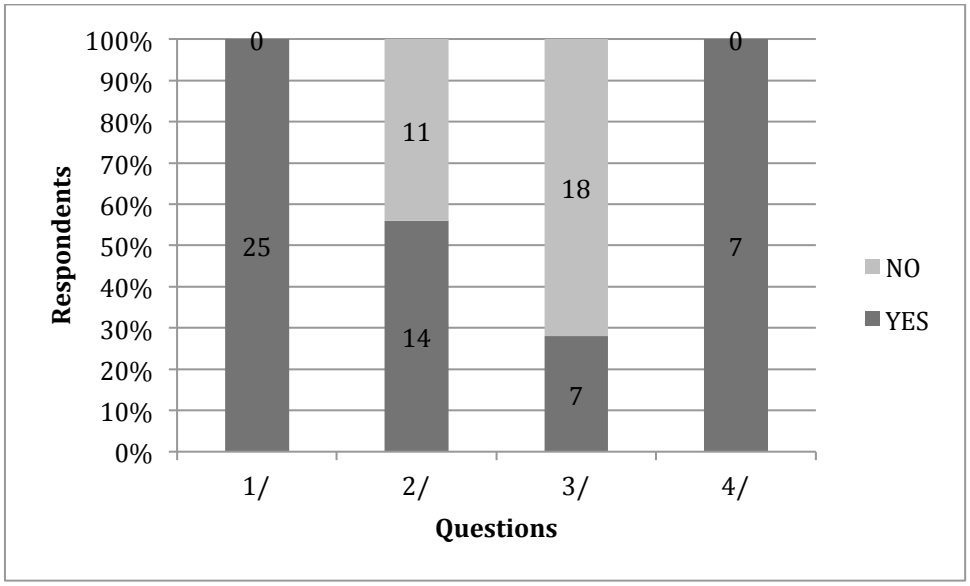
Table 28: Questionnaire results upon age category (18–30 years)

	Age category (18–30 years)	
Answer	YES	NO
1/ question	25	0
2/ question	14	11
3/ question	7	18
4/ question	7	0

Source: Source: Own investigation

Following chart uses vertical axes presenting number of respondents in percentage, certain number of respondents can be found in each column, there are light and dark sides and each number is for certain answer. On the horizontal axes are questions, which are numbered, same as in the questionnaire.

Figure 23: Graphic output of table 24



Source: Source: Own investigation

7.2 Age category (31–55 years)

Investigation of this age category was conducted in company Crystalex CZ, s.r.o. and around shopping place where stays Kaufland (grocery). Crystalex is plant producing glasses and other glass products, which are exported into more than 60 countries and carry trademark Bohemia Crystal, nowadays it is largest glass producer in the Czech Republic.

People working at the factory are mostly within investigated range, however it was not possible to ask all employees, asked people were workers working beside production line and

other laborers. Rest of randomly asked people around the shopping place were apparently people with lower income, they consider BCS as eminent to them. Table below shows answers obtained from interviewed people, system in table and further graph is the same as for the previous age group.

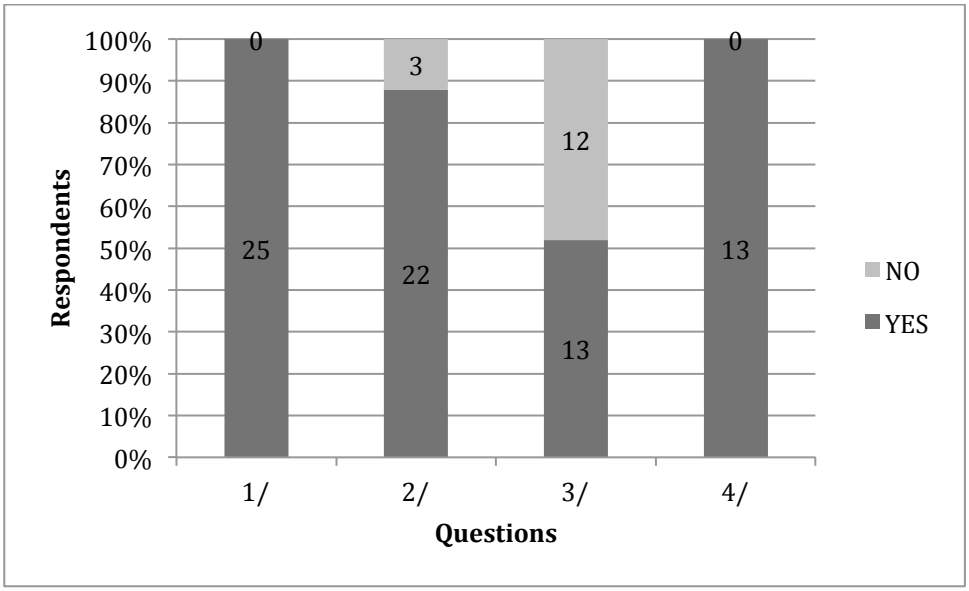
Table 29: Questionnaire results upon age category (31–55 years)

	Age category (18–30 years)	
Answer	YES	NO
1/ question	25	0
2/ question	22	3
3/ question	13	12
4/ question	13	0

Source: Source: Own investigation

At the glance the difference between first and second group is visible – see figure 21, in second question 22 respondents answered positively; in percentage almost 90 % of asked people know about BCS. Whereas 13 respondents, which is more than 50 %, answered that they use BCS, and 100 % respondents using BCS are satisfied with it.

Figure 24: Graphic output of table 25



Source: Own investigation

7.3 Summery

It can be observed that younger people do not know about system and also can be expected that the information, which they know might not be correct; this matter should be reformed. This may be realized via newsletters, posters in supermarkets and other public places, or as enclosure of the municipal newspaper; all these means would improve utilization of BCS system, amplify production of collected commodities and significantly contribute to lift up the city economy.

Third question was performed with following result: first group (18 – 30 years) with 28 % and second group (31 – 55 years) with 52 %; these numbers are explained that younger people paradoxically do not care too much about environment as older generations, the problem can be seen as well in home financial management, where older generation – people about 40 years old are more wise and use BCS as simple mean to separate waste, behave considerately toward environment and simultaneously reduce family expenses.

The last question was about satisfaction with the current system, this field can be considered as satisfactory because both groups reported 100 % satisfaction.

This last result shows that system has been installed well, there are only obstacles concerning awareness of people about the system. Another problem is that people are not used to use BCS, because it is still young and some people need time to get used to it.

8 Conclusion

Objective of the thesis was to analyze the waste management in Nový Bor; the analysis is made of the processing and evaluation of information from various sources. Further the work is performed on comparison of MSW production in Nový Bor. This production is systematically separated between mixed MSW and sorted waste as commodities with second life span.

It was investigated that the average amount of mixed MSW is approximately 200 $\mathrm{kg \times person^{-1} \times year^{-1}}$ in Nový Bor in 2014, this is 24 % lower than the Czech average from identical year (263 $\mathrm{kg \times person^{-1} \times year^{-1}}$). It is most likely due to character of the city, more than half city developments are family houses (58.6 %) it is possible that some part of the amount of waste is incinerated in stove or fireplace at home and thus is not registered. On the other hand costs for liquidation of black landfills fell in year 2013 compared to 2012 by 36.7 %; this indicates that people dispose less waste illegally. Also households pay for dustbins and containers as for volume, there is no difference if it is empty or completely full, consequently they do not need to incinerate waste to reduce their expenses, but papers are very often used for fire ignition in stoves. However upon the comparison of sorted waste production in 2014, Nový Bor had better results than is Czech average (39.7 $\mathrm{kg \times person^{-1} \times year^{-1}}$), average resident of Nový Bor separated +24.4 % more waste via stable containers (49.5 $\mathrm{kg \times person^{-1} \times year^{-1}}$) and +11.6 % via BCS; it is 54 $\mathrm{kg \times person^{-1} \times year^{-1}}$ in total. According information from Mgr. Škop approximately 50 % of population separate waste via stable containers, and about 30 % of population participate in BCS. However real number of people involved in BCS is difficult to estimate, because usually only one member of family is registered. Current number of volunteers in BCS is slightly below 900. Volunteers are not considered persons, but subjects (family representatives), hence the number must be multiplied by 3.8 to represent number of members behind (one subject).

Although landfilling should be (according the hierarchy of handling with waste) last choice of how to dispose of waste, approximately 80 % of MSW from Nový Bor is landfilled and energetic utilization is totally neglected. Recycling and reuse materials are represented by 20 % of total amount generated, in conclusion actually 100 % of mixed MSW is disposed on the landfill Svébořice. Nový Bor is via main roads 35 km far from landfill in Svébořice and incinerator in Liberec 44 km, however distance does not matter. The city does not care about the way of disposing the waste but is required by law to have a waste manager (company)

who will look after WM services. Generally how waste will be disposed depends more or less on price, price of disposal MSW by landfill is about 700 CZK/t and in incinerator about 2000 CZK/t. Since the WM is business its managers search for cheapest means how to handle with waste, moreover if such company like COMPAG decides to dispose of waste in incinerator, than it has to sign an agreement where it commits where a certain amount of waste (fuel) will be delivered. But if happens that the company does not deliver whole amount of waste that was signed, then they have to pay the missing amount, because now incinerator runs out of fuel. This is the biggest obstacle for some companies and reason why they decide rather for landfilling than for incineration of waste. This is apparently not up to city hall of Nový Bor but rather a task for government to support better utilization and correct the disposal of a waste, otherwise future generation will be scared to dig hole in the garden, collect mushrooms in the forest and what is most alarming is possible damage of ground and surface waters.

Mgr. Škop reported that cleanness of separate waste via BCS is much cleaner than separate waste collected via stable containers "nests" which are spread all over the city. Difference between these kinds of collection is a dozen orders; impurity of sorted waste collected via stable containers varies around 20 – 40 % and BCS up to 10 %. Similar numbers were obtained in other municipalities of the Czech Republic, which have installed collection of sorted waste via bags as well. Reason why waste in bags is cleaner than in containers is simple; collection via stable containers is anonymous. Meanwhile via BCS people have to be registered, people do get pay for collected waste, waste is not mixed and stay segregated in a single bag which average weight is about 4.5 kg. Additionally municipalities get paid more from EKO–KOM for separation of waste via bags than stable containers.

There was conducted an investigation about BCS, where people were asked via questionnaires. Only 56 % of asked people in age category (18 – 30 years) knew about BCS in contrast to older generation (31 – 55 years) where 88 % of them knew about it. Municipality should provide more information to habitants via newspapers, newsletters or events at schools, which will educate young population on how to treat a waste. In total 42 % of respondents from both groups together (21 of 50) use BCS, this number is only matter of habituation; satisfactory is 100% of people who actively use BCS are happy with it.

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10 Lists

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11 List of abbreviations

AOS	Average operational cost of waste management
BCS	Bag Collection System
C&D	Construction and Demolition Materials
CHKO	Protected Landscape Area
EU	European Union
GHG	Green House Gases
IPCC	Intergovernmental Panel on Climate Changes
MSW	Municipal Solid Waste
OECD	Organization for Economic Co-operation and Development
PAHO	By Pan American Health Organization
SW	Separate waste
WM	Waste Management
WMP	Waste Management plan

12 Appendixes

Appendix 1: Questionnaire applied in Nový Bor

Dotazník: sáčkový sběr tříděného odpadu ve městě Nový Bor			
		ano	ne
1/	Jste občanem/kou Nového Boru?		
2/	Víte o motivačním programu pro občany v separaci odpadu?		
3/	Jste přímým/mou účastníkem/nicí motivačního programu v separaci odpadu?		
4/	Jste spokojen/a se stávajícím systémem motivačního program?		

//Zvolenou odpověď označím křížkem ☒, vždy zaškrtávám jen jednu zvolenou odpověď
//jestli-že se mě otázka netýká, proškrtnu možné odpovědi souvislou vodorovnou čarou ☐☐☐
//Jedná se o anonymní dotazník, sloužící pro analýzu stávajícího systému			

Appendix 2: Translation of questionnaire applied in Nový Bor

Questionnaire: bag collection of sorted waste in municipality Nový Bor			
		Yes	No
1/	Are you inhabitant of Nového Boru?		
2/	Do you know about motivation program for collection of sorted waste (BCS)?		
3/	Are you direct participant in the program (BCS)?		
4/	Are you happy with the present system (BCS)?		

//Chosen answer marked with cross ☒, always mark only one chosen answer
//If a answer is not relevant/related/touching to you, cross out a boxes ☐☐☐
//This is anonymous questionnaire and is used for the analysis the present system			

Appendix 3: Distribution of dwellings in Nový Bor

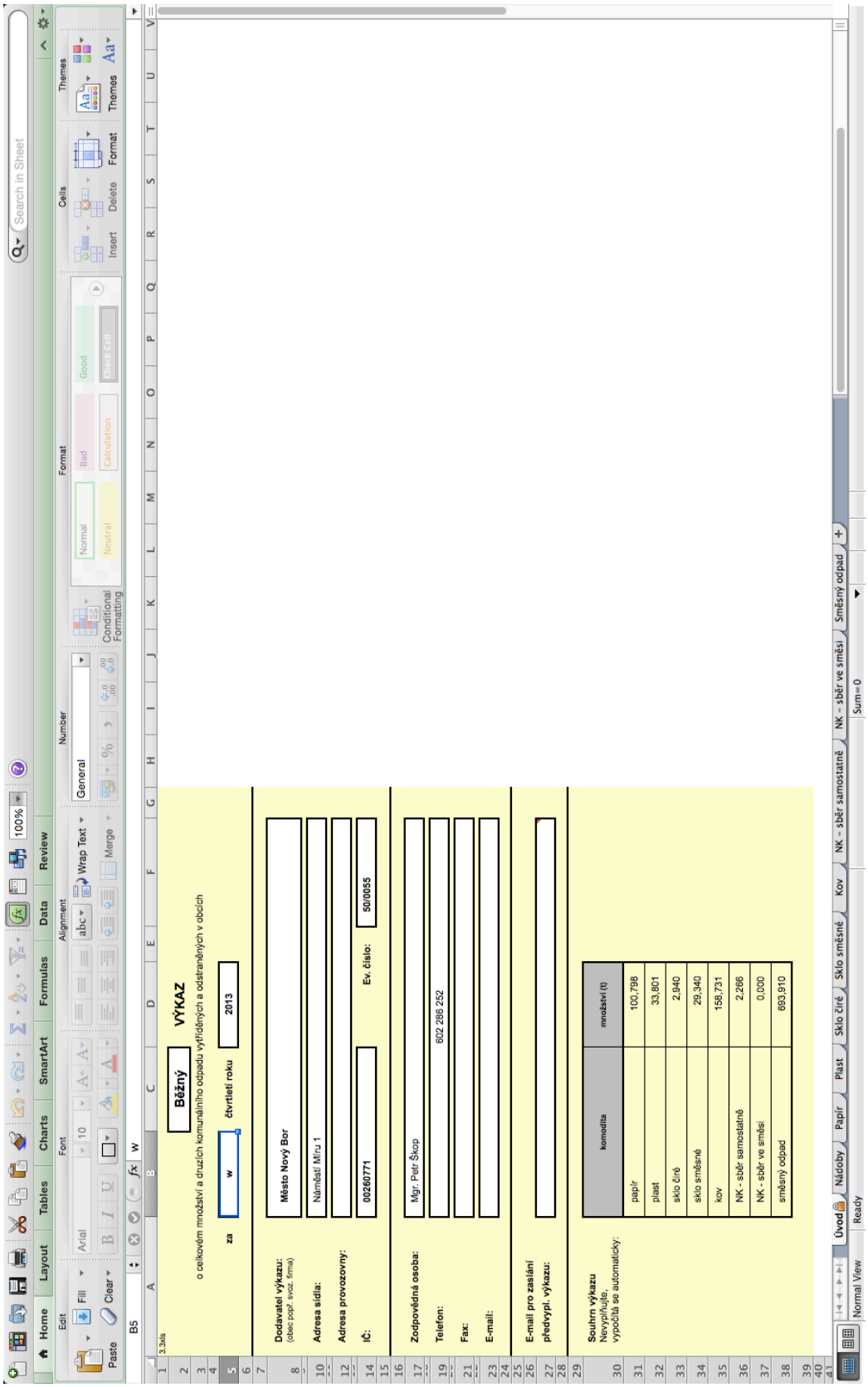
Tab. č. 253 Domy a obydlí mimo bytový fond podle obydlenosti, počtu bytů a trvale bydlících osob a podle druhu domu

Nový Bor

Druh domu	Trvale obydlené domy s byty				Neobydlené domy s byty		Ubytovací zařízení bez bytů		Domy		Bydlící osoby			
	celkem	v nich počet bytů			celkem	v nich bytů	trvale obydlené	ne-obydlené	celkem	v nich bytů	v bytech	v za-řízeních	jinde	celkem
		trvale obydlené	ne-obydlené	celkem										
Rodinné domy celkem	1419	1686	37	1723	193	201	x	x	1612	1924	4917	-	9	4926
v tom:														
rodinné domy samostatné	1137	1385	35	1420	193	201	x	x	1330	1621	3923	-	6	3929
rodinné domy dvojdomky	50	62	2	64	-	-	x	x	50	64	178	-	-	178
rodinné domy řadové	232	239	-	239	-	-	x	x	232	239	816	-	3	819
Bytové domy celkem	272	2993	113	3106	3	11	x	x	275	3117	7165	-	62	7227
Ostatní budovy celkem	42	65	5	70	7	8	5	-	54	78	153	11	10	174
v tom:														
Ubyt. zařízení k trv. nebo dlouhod. ubytování														
svobodárny, společné domovy, ubytovny	4	7	-	7	-	-	1	-	5	7	21	10	1	32
studentské koleje	-	-	-	-	-	-	-	-	-	-	-	-	-	-
domovy mládeže, internáty	2	3	-	3	-	-	-	-	2	3	7	-	-	7
dětské domovy	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ostatní zařízení pro děti a mládež	1	1	-	1	-	-	-	-	1	1	2	-	-	2
domovy důchodců	-	-	-	-	-	-	-	-	-	-	-	-	-	-
penziony pro důchodce	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ústavy pro tělesně a mentálně postižené	-	-	-	-	-	-	-	-	-	-	-	-	-	-
kláštery, konventy	-	-	-	-	-	-	-	-	-	-	-	-	-	-
celkem	7	11	-	11	-	-	1	-	8	11	30	10	1	41
Lůžková léčebná a lázeňská zařízení														
nemocnice a ostatní lůžková a léčebná zařízení	-	-	-	-	-	-	-	x	-	-	-	-	-	-
lázeňské ústavy	-	-	-	-	-	-	-	x	-	-	-	-	-	-
celkem	-	-	-	-	-	-	-	x	-	-	-	-	-	-
Ostatní ubytovací zařízení														
hotely, motely, penziony, ubytovací hostince	3	4	-	4	1	1	-	x	4	5	10	-	-	10
turistické chaty a ubytovny, rekr. a ubyt. zařízení	-	-	-	-	2	2	1	x	3	2	-	1	-	1
uprchlické tábory, humanitární střediska	-	-	-	-	-	-	-	x	-	-	-	-	-	-
celkem	3	4	-	4	3	3	1	x	7	7	10	1	-	11
Provozní budovy	32	50	5	55	4	5	3	x	39	60	113	-	9	122
Domovní fond úhrnem	1733	4744	155	4899	203	220	5	-	1941	5119	12235	11	81	12327
Trvale bydlící osoby v objektech mimo bytový fond	x	x	x	x	x	x	x	x	x	x	x	x	15	15
v tom:														
mobilní (pohyblivé) obydlí	x	x	x	x	x	x	x	x	x	x	x	x	-	-
nouzové obydlí	x	x	x	x	x	x	x	x	x	x	x	x	-	-
rekreační chata, chalupa	x	x	x	x	x	x	x	x	x	x	x	x	15	15

Source:[CZSO (3), 2001]

Appendix 4: Illustration of quarterly statement emitted by the municipality for EKO-KOM



VÝKAZ

Běžný

o celkovém množství a druzích komunálního odpadu vytříděných a odstraněných v obcích

za: w čtvrtletí roku: 2013

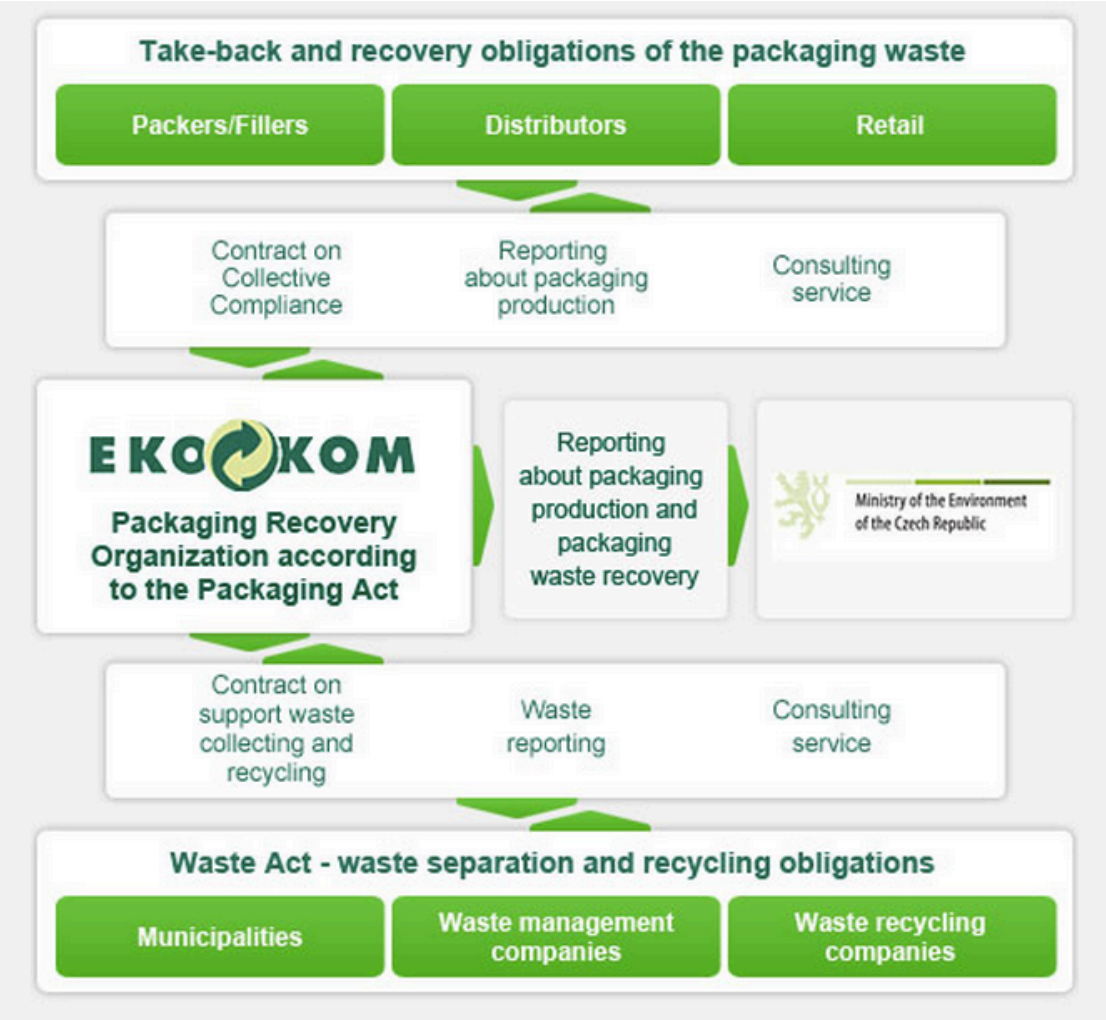
Dodavatel výkazu: (obec popř. svoz. firma)	Město Nový Bor
Adresa sídla:	Náměstí Míru 1
Adresa provozovny:	
IČ: 00260771	Ev. číslo: 50/0055
Zodpovědná osoba:	Mgr. Petr Škop
Telefon:	602 286 252
Fax:	
E-mail:	
E-mail pro zaslání předvypl. výkazu:	

Souhrn výkazu
Nevyplňujte, vypočítá se automaticky:

komodita	množství (t)
papír	100,798
plast	33,801
sklo čiré	2,940
sklo směsné	29,340
kov	158,731
NK - sběr samostatně	2,266
NK - sběr ve směsi	0,000
směsný odpad	693,910

Source: Municipality Office in Nový Bor

Appendix 5: Description of EKO-KOM system



Source: [EKO-KOM (3), 2014]