Waste energy recovery simplify assessment

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Abstract. The paper deals with research on the energy recovery of municipal solid waste and the related impact of the recovery on the environment. Through research steps, analyses of the current production of waste, its energy recovery and the impact on the environment were gradually performed in the Prešov self-governing region in Slovakia. A simplified comparison was made between the impacts of the current landfill method and the proposed incineration method. In terms of forecasts for the development of municipal solid waste produced in the coming period, scenarios of solid municipal waste treatment possible alternatives for the future period are outlined by the help of the electronic monitoring platform.

1. Introduction

Research activities described in this contribution were done in the frame of the project “Energy Recovery from Municipal Solid Waste by Thermal Conversion Technologies in Cross-border Region” (EnyMSW). Municipal solid waste (MSW) can be defined – in very strong simplification - is a time- and region- varying heterogeneous accumulation of more kinds of solid trash produced by citizens household activities. Municipal solid waste production direct depends on socio-economic indicators can be observed in general. [1] European Waste Framework Directive 2008/98 / EC introduced a five-step waste hierarchy as a priority regulation with the prevention of peak waste and subsequent preparation for re-use, recycling, another recovery, including energy recovery and waste disposal as a last resort. [2], [3] The Directive allows classifying a municipal waste incineration plants as recovery operations, provided that they contribute to high energy efficiency production, to encourage the use of waste for energy production in energy-efficient municipal waste incineration plants and to promote innovation in waste incineration. [4] In this context, it is important to note that ‘recovery’ is an operation whose results waste applying for useful purposes by replacing other materials that would otherwise be used to perform the function or waste prepared for that function in the manufacturing plant.

2. A brief characterization of Slovak waste management

In August 2019, the Slovak government passed a new law on waste, the ambition is to significantly increase the sorting and recycling. Slovakia produces relatively less waste than other EU countries, but recycling is significantly lower. Two-thirds of municipal waste and more than half of all waste is deposited in landfills, which is significantly higher than in the EU. The trend of declining waste landfill and increasing recycling is very weak and will not change without stricter measures. There is also a need
for consistent separation and recovery of biodegradable municipal waste. The economy thus loses significant volumes of materials that could be used secondarily. At present, the Slovak citizen is obliged to sort MSW by law and the municipalities are obliged to create conditions for separation by a suitable system in Slovakia. A tighter waste management policy brings the risk of illegally deposited waste (illegal dumps), the removal of which is often costly. There are thousands of locations with illegally deposited waste in Slovakia, which degrade a given area, threatens the health of population and ecosystems and poses further future risks. Most waste in such landfills is mixed municipal and construction waste. [5]

While the Slovak Republic does not generate more waste per inhabitant than similar economies, it is facing significant challenges in improving the way this waste is managed. Almost 70% of municipal waste is currently still landfilled and almost 80% of landfill municipal waste is mixed municipal waste of non-defined content. [6] Slovakia plan is to increase to 60% of the municipal waste recycling rate, including its preparation for re-use by 2030, and to reduce the land-filling rate to less than 25% by 2035. [5] A general overview of MSW production by Slovak regions is presented in Figure 1.

![MSW production in Slovak regions](image)

**Figure 1.** Production of MSW in Slovak regions [7]

The official statistic showed the first position in MSW amount generation for the Bratislava region - the most developed Slovak region. Prešov Self-Governed Region (SGR) - the region with the highest number of inhabitants in Slovakia - is the lowest MSW amount producer from the relative amount of MSW per capita point of view (Figure 2). [7]

3. Waste management in the examined region

Prešov (SGR) fills the north-eastern part of Slovakia and it stretches from the west to the east. It borders on Poland and Ukraine in the north and east respectively. The region is with over eight hundred thousand population the most populous of all the regions in the country and is known for its hilly landscape. The population density in the region is over 90 inhabitants per km². The region metropolis is the town Prešov, the third biggest town in Slovakia with a population of about one hundred thousand. The Prešov Self-Governed Region consists of 13 districts. There are 665 municipalities, of which 23 are towns, where about half of the region's population live. Strong aspects of the region are well-preserved environment, high forestation of the territory, rich sources of geothermal and mineral springs, a good position at the eastern European Union border, favourable demographic progress, transport connection with the entire Slovak transport system, and qualified workforce. The weak characteristics of the region are high unemployment ratio, the lowest wage rates in Slovakia and need to solve MSW negative impacts. [8]
These analyses raise the question of how to exploit produced MSW to obtain a smaller landfilled quantity of it. One of the possibilities is to use MSW for energy recovery because this MSW treatment is on a relatively low level of utilization in the region.

4. Regional analyses of MSW
For the study of MSW energy recovery capacity in the region was designed methodology:
1. Regional MSW samples collection;
2. The collected MSW Analyse - Weight fraction of collections - identification of typical categories of waste / Exclusion of non-combustible and hazardous components;
3. Experiments sample preparation - by weight fraction identification after exclusion of non-combustible and hazardous components / grounding of the samples for homogenizing of contents;
4. Samples Analyses - Humidity / Calorific analyses - Gross calorific value and Net calorific value calculation;
5. Regional MSW production analyses / landfills analyses - distribution in the region & annual and total capacities;
6. Region energy recovery potential determination;
7. Environmental impact determination.

4.1. Regional MSW samples collection
Municipal solid waste was collected in the time of transhipment operation – freshly MSW just after unloading from low capacity collection vehicles.

Five randomly selected Collections were stored in marked plastic bags in an approximate weight of ten kilograms for every one of them. [9]

4.2. Regional MSW samples analyses
Collected waste was analysed in the laboratory from a composition point of view.

Slovak Waste Catalogue [10] defines in code 20 “Municipal wastes (household wastes and similar wastes from trade, industry and institutions) including their components from the separate collection” 51 detailed components of MSW. The research team prepared a synthesis of the legally stated waste components to simplify structure by grouping similar items to 13 components. In these thirteen components are two of them created by the research team to enrich items defined by the Catalogue:
- 7 Food waste, and
- 9 Hygienic supplies

because of an important proportion in the collected samples—see “Waste structure” column in Table 1.
## Table 1. Analyses of Prešov SGR landfilled MSW

| Waste structure                        | Average content |  |  |  |  |  |  |
|----------------------------------------|-----------------|---|---|---|---|---|---|
|                                        | Full composition|  |  |  |  |  |  |
|                                        | Combustible composition |  |  |  |  |  |  |
| 1 Paper                                | 11.57%          | 13.74% |  |  |  |  |  |
| 2 Plastics                             | 12.25%          | 14.54% |  |  |  |  |  |
| 3 Glass                                | 8.04%           | X     |  |  |  |  |  |
| 4 Metals                               | 2.57%           | X     |  |  |  |  |  |
| 5 Layered packaging materials (Tetrapack, etc.) | 1.47% | 1.75% |  |  |  |  |  |
| 6 Textiles                             | 3.38%           | 4.01% |  |  |  |  |  |
| 6 Food waste                           | 7.33%           | 8.70% |  |  |  |  |  |
| 8 Biodegradable w.                     | 25.61%          | 30.40% |  |  |  |  |  |
| 9 Hygienic supplies (diapers, etc.)    | 8.04%           | 9.55% |  |  |  |  |  |
| 10 Electrical waste                    | 0.70%           | X     |  |  |  |  |  |
| 11 Construction mineral waste          | 3.49%           | X     |  |  |  |  |  |
| 12 Unsorted waste (Dirty plastics, Combined materials, etc.) | 14.58% | 17.31% |  |  |  |  |  |
| 13 Dangerous waste (Batersies, ...)    | 0.97%           | X     |  |  |  |  |  |
|                                        | 100.00%         | 100.00% |  |  |  |  |  |

### 4.3. Experiments sample preparation

MSW collection structure analyses were followed by preparing samples for the next research steps. In this step were prepared five pieces of the one-kilogram sample following weight fraction identification after exclusion of non-combustible and hazardous components (Table 1). Prepared Samples were grounded for homogenizing of contents. Samples humidity evaluation was done in the standard process:

- Weighing of samples before drying - weight $W_0$;
- Drying of the samples in the thermal chamber with maximum temperature up to 90° C;
- Weighing of samples after drying - the result is weight $W_D$;
- Calculation of the collected MSW Samples humidity $H$.

Calculation of the collected MSW samples humidity was done by the formula:

$$H = \left(\frac{W_0 - W_D}{W_D}\right) \times 100\%$$

(1)

Results of the humidity analyse of the samples are presented in Table 2.

## Table 2. Results of the samples humidity analyse

| Sample | Description of analysed features | 1 | 2 | 3 | 4 | 5 | Average |
|--------|---------------------------------|---|---|---|---|---|---------|
|        | $W_0$ weight of samples before drying | 0.9862 | 1.0694 | 0.9831 | 1.0024 | 1.0687 | 1.02196 |
|        | $W_D$ weight of sample after drying | 0.8018 | 0.7875 | 0.7136 | 0.8292 | 0.8878 | **0.80398** |
|        | Humidity (Moisture) | % | % | % | % | % | **21.34%** |
The wide dispersion of moisture values is due to the composition of the waste and the MSW storage conditions before collecting.

4.4. Samples Analyses
Calorific analyses serve for obtaining of MSW important characteristic for calculation of the energy recovery potential of MSW incineration. Evaluation of the potential was processed in steps:

- Calorimetric examination of the samples for determination of results of possible combustion heating characteristics \( Q_s \) (gross calorific value);
- Standardization of the calorimetric results by calculating the influence of real municipal solid waste properties – e.g. vaporization of the water, etc. \( Q_n \) (net calorific value).

Determination of calorific theoretical energy potential value was done in laboratory of Technical University of Košice built in the frame of the funded project. They were prepared samples following the identification of typical MSW categories of the collection of combustible components (Table 1).

The basic formula considering the waste sample chemical composition and moisture is [11]:

\[
Q_n = \left[ (Q_s - 212.2 \cdot HC - 0.8 \cdot (OC + NC)) \cdot \left(\frac{100-H}{100}\right) - 0.2443 \cdot H \right] \%
\]

where:
- \( Q_n \) net calorific value (J/g);
- \( Q_s \) gross calorific value (J/g);
- \( HC \) hydrogen content, in percentage by mass, of the dry fuel;
- \( OC \) oxygen content, in percentage by mass, of the dry fuel;
- \( NC \) nitrogen content, in percentage by mass, of the dry fuel;
- \( H \) humidity (%);
- \( 0.02443 \) correction factor of the enthalpy of vaporization for water (J/g) per 1 wt% of moisture).

Results of the samples calorific evaluation (gross caloric value) and calculated net calorific value are shown in Table 3.

Table 3. Results of the samples calorific evaluation results and calculated net calorific values

| Sample | 1     | 2     | 3     | 4     | 5     | Average       |
|--------|-------|-------|-------|-------|-------|--------------|
|        | \( Q_s \) - gross calorific value (J/g) | 21 457 | 22 147 | 22 164 | 21 561 | 21 698       | 21 805.40    |
|        | \( Q_n \) - net calorific value (J/g)  | 11 323 | 11 721 | 11 731 | 11 383 | 11 462       | 11 524.00    |

4.5. Regional MSW production analyses
In Prešov SGR are 18 MSW deposits (landfills). Some of them are near to achieving maximum capacity. For the region is very important to find long term strategy for increasing of waste recovering of the produced municipal waste.

The trend of the amount of landfilled MSW is relatively stable from 2011 on a level between 150 000 to 180 000 tons per year. Prognose for next period is under uncertainty generated by the increasing trend of the amount of the produced MSW and at the same time a growing trend of recycling. The good results of general MSW management in Prešov SGR are shown in Figure 3 – the amount of recovered MSW is higher year by year.
Numbers for 2019 presented in Figure 3 are [12]: Total waste production 283,338.00 t/year. In this yearly amount are fractions: Material recovery 61,596 t/year; Energy recovery 927 t/year; Recovery of organic matter 50,862.00 t/year; Landscaping 393 t/year; Other recovery 0 t/year; Collected 0 t/year; Incineration without energy collecting 0 t/year; Other disposals 0 t/year; Landfilling 169,560 t/year.

These same yearly results presented in comparison of total MSW amount and landfilled MSW amount in Figure 4 show the increasing ratio of recovered MSW in time and slowly decreasing ratio for landfilled MSW in time. [13]

4.6. Energy recovery potential determination of the region

The official information of the landfilled amount of municipal solid waste 169,560 tons in 2019 was used for calculation of energy potential of the region. This consideration is supported by the long-term development of the amount of waste produced in Prešov SGR in accordance with official statistics presented in Figure 4. [12]

The trend of the generated amount of landfilled MSW is relatively stable in the observed period. Slovakia is also in very good progress to fulfil European Union legislative in decreasing the amount of landfilled MSW.
Next calculations are based on relatively stable production of MSW amount in Prešov SGR for upcoming years. The calculations are divided into two groups – energy-related findings and waste reduction related findings. Both of the calculations are shown in Table 4.

Thermal analysis of the MSW samples was aimed to determine the reduction the MSW by incineration. The analysis was performed in the EnyMSW Laboratory "Small scale system for thermal treatment of municipal solid waste" in Baia Mare, Romania [14]. The result is placed in the table in row 22. The most important energy-related finding is net energy recovery potential of Prešov Self-Governed region in 365 747.14 MWh per year. The most important landfilling related finding is the reduction of landfilled MSW from current 169 560.00 tons per year to 31 681.20 ton per year (26 739.61 tons of non-combustible MSW fractions + 4 941.59 tons of incineration rests) produce the decreasing ratio of landfilled MSW volume to 18.68%.

4.7. Environmental impact determination

Thermal analysis to evaluate the production of the emissions by the thermal treatment of MSW was performed in the EnyMSW Laboratory in Baia Mare, Romania, too. [14] The MSW incineration – as every general burning process - is producing air pollution, ash and slag.

Five samples modelling the MSW composition from collected MSW in Prešov SGR (each in weight 5 kg) were thermally treated in the laboratory built by EnyMSW project funding. The produced average amount of ash, slag and air emission readings of the thermal process are shown in Table 5.

**Table 4.** Figures of analyses results and calculation of energy and waste reduction characteristics

| Figures of 2019 for MSW management in Prešov SGR (t/year) |
|-----------------------------------------------|
| 01 Material recovery | 61 596 |
| 02 Energy recovery | 927 |
| 03 Recovery of organic matter | 50 863 |
| 04 Landscaping | 295 |
| 05 Other recovery | 0 |
| 06 Collected | 0 |
| 07 Incineration without energy collecting | 0 |
| 08 Other disposal | 0 |
| 09 Landfilling | 169 560 |
| 10 Total amount of generated MSW | 293 399 |

| Figures of EnyMSW analyses in Prešov SGR Energy related findings |
|-----------------------------------------------|
| 11 Average humidity of MSW samples (%) | 21.34 |
| 12 Volume of combustible fractures in landfilled MSW (%) | 84.23 |
| 13 Amount of combustible fractures in landfilled MSW \( [\text{r}0.99^\times 0.12/100] \) (t/year) | 142 820.39 |
| 14 \( Q_s \) - net caloric value (MJ/kg) | 11.52 |
| 15 Energy recovery MSW potential \( [\text{r}1.13^\times 1.14^*0.8] \) (MJ/year) | 1 315 699 721.05 |
| 16 Energy recovery MSW potential (MW/h/year) | 395 747.14 |

| Landfilling related findings |
|-----------------------------------------------|
| 21 Volume of landfilled not-combustible MSW \( [\text{r}0.99^*1.13] \) (t/year) | 26 739.61 |
| 22 Average MSW amount reduction by incineration (%) | 96.54 |
| 23 Average net ash reduction by incineration \( [\text{r}1.1^*1.10^*0.22/100] \) (t/year) | 4 941.59 |
| 24 Total volume for landfilling \( [\text{r}21^*0.23] \) (t/year) | 31 681.20 |
| 25 Reduction of landfilling \( [\text{r}0.9]/[\text{r}24^*100] \) (%) | 81.32 |
Table 5. Environmental impact of the MSW incineration experiments

| Incineration by-products average values | Chemical composition (g/kg) |
|----------------------------------------|-----------------------------|
|                                        | Ash | Slag |
| Rest in burning chamber                |     |      |
| Ash (%)                                | 3.34% |      |
| Slag (%)                               | 0.13% |      |
| Air pollution                          |     |      |
| Dust (mg/m³)                           | 0.0128 |      |
| O₃ (%)                                 | 4.87 |      |
| CO (mg/m³)                             | 5.722 |      |
| NO₂ (mg/m³)                            | 200.22 |      |
| NO (mg/m³)                             | 193.073 |      |
| NOₓ (mg/m³)                            | 1415.242 |      |
| SO₂ (mg/m³)                            | 2.572 |      |
| Ca                                     | 82.504 | 43.875 |
| Mg                                     | 1.206 | 0.188 |
| Na                                     | 4.255 | 1.915 |
| K                                      | 52.226 | 8.301 |
| Li                                     | 0.0001 | 0.001 |
| Fe                                     | 1.652 | 2.152 |
| Cu                                     | 0.122 | 0.012 |
| Pb                                     | 0.020 | 0.016 |
| Zn                                     | 2.555 | 2.861 |
| Mn                                     | 1.829 | 2.908 |
| Ni                                     | 0.003 | 0.003 |
| Cr                                     | 0.013 | 0.002 |
| Co                                     | 0.012 | 0.004 |
| Cd                                     | 0.001 | 0.000 |

The environmental impact of the thermal treatment of MSW is a very controversial topic. They can be observed pros in general: Lowering needed space for landfilling; Decreasing of groundwater contamination level; Energy generation; Carbon footprint lowering. Incineration cons are mainly: High investment to incineration plants; Toxic pollutants emissions; Opportunity costs.

The efficiently controlled waste-to-energy process reaches the reduction of greenhouse gas emission over mechanisms: i) by generating electrical power or steam, waste-to-energy avoids carbon dioxide (CO₂) emissions for fossil fuel-based, ii) the waste-to-energy incineration process effectively avoids methane emissions from landfills and iii) the more energy-efficient recovery of metals than production from raw materials. [15]

By the accounting of the above mechanisms is possible to evaluate the thermal treatment of MSW in a more objective form. Comparison of these mechanisms for the model of MSW divided into two basic groups – 30% of recycled and 70% for landfilling or energy recovery is presented in Figure 5. [16]

Figure 5. Quantifying the complete accounting of any MSW management options [16]

The methodology used for this evaluation is the USA Decision Support Tool for Materials and Waste Management. The methodology offers relatively good approximation to the real values of the greenhouse gas emission potential of Waste-to-Energy.

Also, the energy produced at waste power plants contributes to climate protection and security of energy supply by replacing the fossil fuels that would be used to produce this energy in conventional power plants. Efficient energy generators heat the domestic waste and thereby reduce methane emissions.
(a strong greenhouse gas that has 25 times greater climate impact than carbon dioxide) from landfill and CO₂ emissions that would be produced if the amount of energy produced in conventional power plants.

5. Electronic monitoring platform
All research activities were monitored from an information flow point of view. The monitoring resulted in information flow structure design.

The flow structure was optimized for control of data concerning the management of thermal treatment of MSW; for the study of the used methods; and for building application for monitoring all needed consequences. The main required features of the platform were [17], [18]:

For users:
- Easy intuitive use and a good level of reliability;
- Separated access to the application for groups of users;
- To store all information collected in the project;
- To process the collected information in the needed form;
- To present data information in the required form;
- To export stored and processed data in many possible formats and structures;

For administration:
- Flexible data storing and programming environment;
- Data redundancy eliminating and trans actionality;
- Powerful possibilities in connections among different data formats;
- Possibility of simple maintaining of data consistency;
- Simple management of user accounts;
- Ease backup and disaster recovery;
- Very good possibilities to do changes according to a new requirement from application users.

Logical scheme working out following the above requirements can be presented in structure:

- Partners
  - Basic data
    - Countries
    - Regions
    - Partners
    - Stakeholders
    - Reports / Studies
    - Legal documents
  - Research data
    - Waste generation in regions
    - Waste samples evaluation
      - Fractions composition
      - Chemical properties
      - Physical properties
      - Thermal treatment properties
      - Calorific properties
      - Emissions of thermal treatment
      - Ash chemical properties
      - Ash physical properties
      - Slag chemical properties
      - Slag physical properties
    - EnyMSW outputs
      - Studies
      - Project reports
Stakeholders

- EnyMSW reports

The application “Electronic Monitoring Platform” (EMP) was built as web-based on SQL technology as an integrated collection of logically related MSW treatment records. This philosophy allows consolidating of separate information into a common pool of data records. The last by not least property of the most important features of this philosophy is: stored data is independent of the application programs using it. This relational approach allows managing physical data storage without affecting access to that data as a logical structure. Operations on database enable EMP to manipulate the data and structures of the research collected information. Logical operations allow for a user to specify the required content; physical operations determine the manner of data access and task processing. [19], [20] Requirements for the platform working mode is off-line registering of data obtained by three geographically distant laboratories in Romania, Ukraine and Slovakia. The main purpose of the platform is to record and process:

1. Basic data
   1.1. Project partners
   1.2. Regions of evaluation
   1.3. Stakeholders involved
   1.4. Waste generation characteristics by regions (generated amount of the MSW per year, the combustible volume of it, energy potential, MSW mass reduction ratio, etc.)

2. Experimental data
   2.1. MSW samples fractions composition (overall moisture, fractions composition - biodegradable, metals, glass, etc.)
   2.2. MSW samples chemical and physical properties (presence and content of circa twenty chemical elements, pH, electroconductivity, etc.)
   2.3. MSW samples calorific properties (Gross calorific value, the content of chemical elements - C, H, N, S and O)
   2.4. MSW samples thermal treatment characteristics (gas consumption, Temperature, duration, the volume of ash and slag)
   2.5. MSW samples thermal treatment emissions (Concentration, dust, O₂, CO₂, NOx, NO, NO₂, SO₂)
   2.6. Thermally treated MSW samples ash physical and chemical properties (presence and content of circa twenty chemical elements, pH, electroconductivity, etc.)
   2.7. Thermally treated MSW samples slag physical and chemical properties (presence and content of circa twenty chemical elements, pH, electroconductivity, etc.)

3. EnyMSW reports
   3.1. Experiments reports
   3.2. EnyMSW studies
   3.3. MWS related legislation documents

All the data are recorded manually in the application because of very wide area of collected data obtained from equipment with hardware and software inconsistency from geographically remote regions. [21] The application was tested by real data processing and debugged for operability. The programmer team mainly focuses on monitoring of robustness, resilience, deployment, and latency of the application. Robustness was tested by test persons – testers - oriented to use erroneous inputs for the application by more possible hardware and software platforms in the first step (resistance to bad inputs). Next step was testing to the possibility to reach stored data for unauthorized persons (hacker resistance). Platform resilience was tested to recovery ability after network disruption, electricity fails and server crash (by artificial shot down) and followed by an examination of data replication. Deployment testing and documentation of the platform was performed after every required modification of the data structure or migration to a different server. The deployment procedure was done manually because of a relatively simple application. Latency testing was done by testers to obtain information
about the response of the application by using a combination of the most commonly used devices, operating systems and browsers. Testers focused on the most the vertical (independency concerning “machine”) and horizontal (to maintain the flexibility of connected entities) scalability were taken into account as an important condition for the future development of the application, too. The Electronic Monitoring Platform is fully operated in the frame of the EnyMSW project activities.

6. Conclusions

The analysis of the energy potential of MSW of the Prešov Self-Governed Region and the building of the electronic monitoring platform are the subjects of this study. Municipal Solid Waste samples were collected in Prešov SGR, analysed and incinerated within the EnyMSW Laboratory in Baia Mare to find emissions of the thermal process and to determine the reduction the MSW by incineration was performed. Heat treatment the samples was performed in the Inciner I8-10S Incinerator, at high temperatures above 850°C, the recording of emissions during the experiment was done with Flue gas analyser testo 350, weighing of samples and solid residues with Kern ECE 10 K -3N scale. [14] The samples calorific characteristics evaluation was performed in EnyMSW laboratory in Prešov by IKA A10 mill and IKA Calorimeter C1. The most important of energy-related findings is net energy recovery potential of Prešov Self-Governed region in 365 747.14 MWh per year. The most important findings of landfilling related findings are reduction of landfilled MSW from current 169 560.00 tons per year to 31 681.20 tons per year (26 739.61 tons of non-combustible MSW fractions plus 4 941.59 tons of incineration rests) produce ratio to landfilling reduction 18.68%. Characteristics of statistics of the amount of previously generated MSW and composition of it was used as a basement for forecasting of the future trends of global MSW management in Prešov SGR, shown in Figure 6.

![Forecasting of MSW management trends](image-url)

**Figure 6.** Forecasting of MSW management trends (t/year)

The prediction for the pessimistic trend of the MSW production is based on a hypothetical environmental Kuznets curve for the evaluated region. [22] The Prešov SGR is now under strong development and it is powerfully focusing on improving human resources and the business atmosphere while protecting the environment. The prediction of the optimistic trend of the MSW production is based on the European Union strategy of enviro-protection by legislative and educational tools.
Predictions of optimistic and pessimistic trends of MSW recovering is based on EU and Slovak goals for decreasing of the nature pollutions stated in legislative and previously forecasted trends for MW production. The legislative goal is to recovery 80% of packaging materials and 70% of MSW in 2035.

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The project donation serves for EnyMSW laboratory for calorimetric evaluation at the Technical University of Košice, Faculty of Manufacturing Technologies in Prešov. All presented calorimetric results were obtain in the laboratory.

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