RE-SEEties: Towards resource efficient urban communities in SEE

Feasibility study on potentials for utilization of renewable energy sources – City of Nitra

Deliverable report under WP4

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WP Leader:	CNR-IMAA
Contributing partners:	REGEA, CRES

Contents

1. Introduction

Feasibility study on potentials for utilization of renewable energy sources – City of Nitra is an evaluation and analysis of the potential of the proposed project which is based on extensive investigation and research to support the process of decision making. This feasibility studies aim to objectively and rationally uncover the strengths and weaknesses of existing systems but also to identify opportunities and threats present in the environment, the resources required to carry through, and ultimately the prospects for success.

The study starts with a general overview of available renewable energy sources in the Slovakia. The results of the overview will serve as justification and starting point for the elaboration of concrete technical solution of the feasibility study for energy use of municipal waste in the city of Nitra.

2. Methodology

Following a detailed analysis of the current state of the use of renewable energy sources in the City of Nitra a proposal for energy use of the municipal waste was identified as a proper field of the renewable energy sources. Moreover nowadays this field requires also to be solved, and to solve it critical assessment of the suitable and reasonably priced technology is necessary.

The topic was discussed in the frame of the stakeholder platform meeting, as well as within face-to-face discussions led with the particular key stakeholders and decision makers and management of the municipality of the City of Nitra. Within the discussions there were used points of brainstorming and expert reviews, and individually literature and computer-assisted retrieval. The checklist for RES technological solutions was used as a standard supporting tool in regards to five key aspects: technical, legal, economical, organizational and environmental results of the chosen system.

3. Analysis of present situation (state-of-art of technological options)

General overview

The national target of Slovakia on field of exploiting renewable energy sources (RES) is to reach the 14 % share in general energy mix by 2020. It means the 14 % share of RES in so called TPES - total primary energy sources – consumption.

The legal base for nation RES target stems from the Directive 2009/28/EC on the promotion of use of energy from RES. It was endorsed by EU institutions in April 2009. This directive sets:

- mandatory national targets for the overall share of RES among TPES as well as the target in transport sector,
- rules related to statistical transfers between EU member states,
- bio fuels and bio liquids standards.

The national targets were set as + 5,5 % increased share of RES among TPES in comparison with the state in 2005. In addition, the secondary criteria

became the GDP per capita. Therefore, mandatory national target for Slovakia is following:

- 14 % share of RES among TPES (total final energy consumption),
- 10 % share of RES in transport sector.

The most important legislation of Slovakia

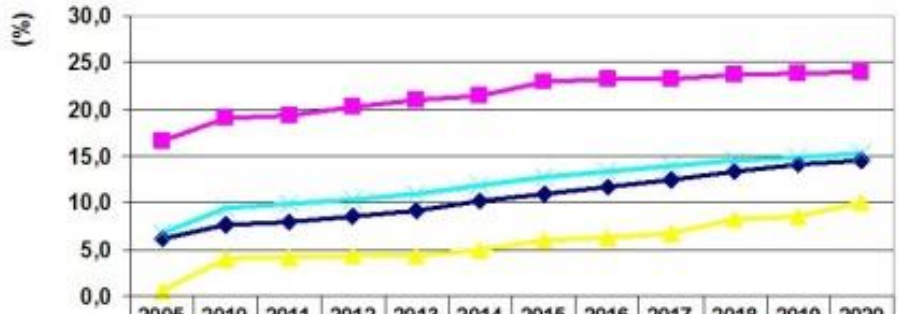
The general strategy of support, promotion and exploitation of RES stems from various governmental documents, which represent subordinated legislation to basis created by Energy Act (adopted in 2012), Regulation Act (adopted in 2012) and mainly Act 309/2009 on support of RES: and Act 657/2004 on thermal energy sector:

- Energy Policy of the Slovak Republic (adopted in 2006),
- Strategy of higher utilization of RES (adopted in 2007),
- Energy Efficiency Concept of Slovak Republic (adopted in 2007),
- Energy Efficiency Action Plan for period 2008 – 2010 (adopted in 2007),
- Energy Security Strategy of the Slovak Republic (adopted in 2008),
- National Action Plan for energy from RES (adopted in 2010),
- Energy Efficiency Action Plan for period 2011 – 2013 (adopted in 2011).

To introduce the National Action Plan for energy from RES by 2010 was the obligation of each EU member state. Due to the early election and the change of government, Slovakia sent this Plan to European Commission just at the end of summer that year, a few months after the initial deadline. However, concrete national targets for 2020, set in Plan are:

- 15,3 % share of energy from RES in TPES,
- 24,0 % share of RES in electricity production,
- 14,6 % share of RES in heat produced in Slovakia,
- 10,0 % share of energy from RES in transport.

The estimated progress and higher use of RES is described in this graph:

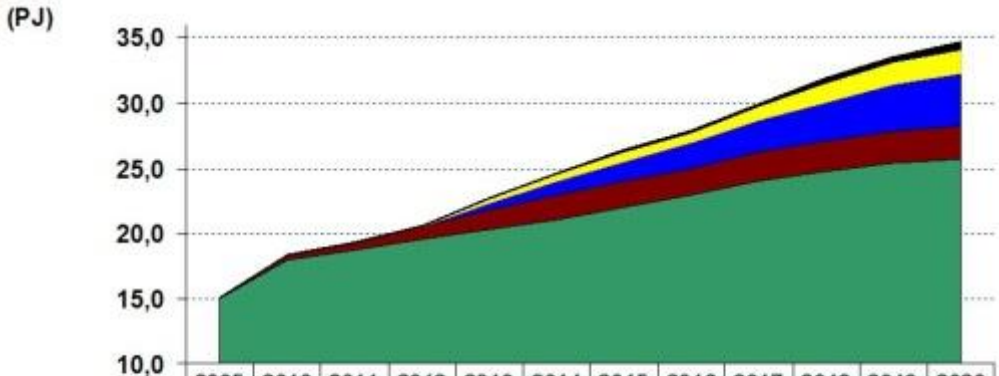


	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Produced heat and cold	6,1	7,6	8,0	8,5	9,2	10,2	10,9	11,7	12,5	13,3	14,1	14,6
Produced electricity	16,7	19,1	19,3	20,2	21,0	21,5	23,0	23,3	23,3	23,7	23,9	24,0
Transport	0,6	4,1	4,2	4,3	4,4	5,0	6,0	6,3	6,8	8,3	8,5	10,0
Overall share of RES	6,7	9,5	9,9	10,4	11,0	11,8	12,8	13,3	13,9	14,6	14,9	15,3

Source: Slovak Innovation and Energy Agency (SIEA)

Fig. 1 Use of RES in Slovak republic

When it comes to heat, the prognosis is following:

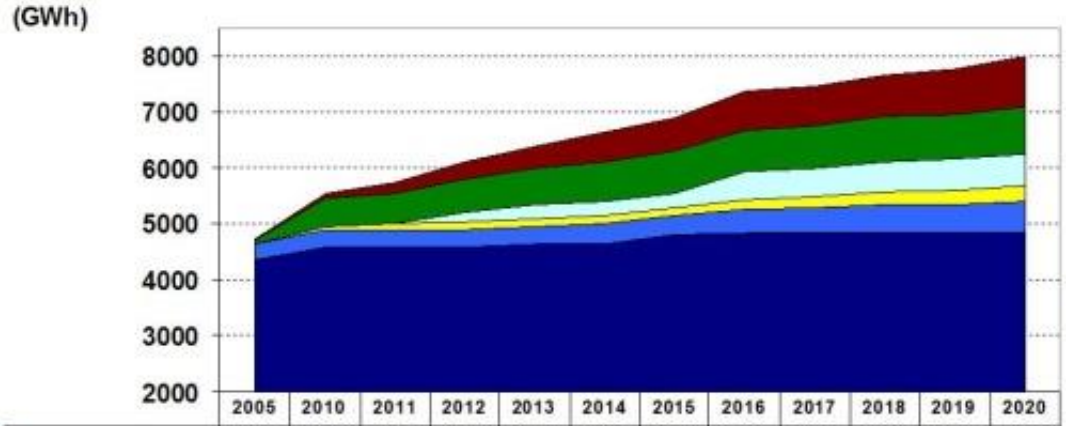


	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
heat pumps	0,1	0,1	0,1	0,1	0,1	0,1	0,2	0,2	0,3	0,4	0,5	0,7
solar	0	0	0	0	0,3	0,5	0,8	0,8	1,0	1,5	1,7	1,8
geothermal*	0	0	0	0	0,5	1,0	1,5	2,0	2,5	3,0	3,6	4,0
biogas	0	0,3	0,5	1,0	1,5	2,0	2,0	2,0	2,2	2,3	2,4	2,5
biomass	15,0	18,0	18,8	19,5	20,3	21,0	22,0	23,0	24,0	24,8	25,4	25,8

Source: Slovak Innovation and Energy Agency (SIEA)

Fig. 2 Prognosis of heat production from RES in Slovak republic

On field of electricity production, National Action Plan estimates this scenario:



	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
biogas	10	100	200	300	400	550	600	700	700	750	800	900
biomass	50	500	550	600	650	700	750	750	750	800	800	850
wind	1	1	1	150	250	250	250	500	500	550	550	550
photovoltaic	1	50	100	150	150	150	150	175	190	210	250	300
hydropower ≤10 MW	300	300	300	300	300	350	350	400	450	500	500	545
hydropower >10 MW	4355	4600	4600	4600	4650	4650	4800	4855	4855	4855	4855	4855

Source: Slovak Innovation and Energy Agency (SIEA)

Fig. 3 Scenario of electricity production from RES in Slovak republic

Table 1 Comparison - plan versus reality

RES		2005	2009	2010	Target 2010
Produced heat and cold	(PJ)	15,7	22,2*	22,9**	19,0
Produced electricity	(PJ)	16,9	18,5	19,0	19,7
Transport	(PJ)	0,4	3,2	3,7	3,8
Total	(PJ)	33,0	43,9	45,7	42,5

* 21,4 PJ from biomass

** 22,3 PJ from biomass

Produced electricity from RES

		2005	2009	2010	Target 2010
Biogas	(GWh)	10	22	32	100
Biomass	(GWh)	50	515	636	500
Wind	(GWh)	1	6	6	1
Photovoltaic	(GWh)	1	0	11	50
Hydropower ≤10 MW	(GWh)	300	256	265	300
Hydropower >10 MW	(GWh)	4 355	4 344	4 347	4 600
Total	(GWh)	4 717	5 143	5 297	5 551

Source: Slovak Innovation and Energy Agency (SIEA)

National overall target

The expected amount of energy from renewable sources corresponding to the 2020 target of 14% was calculated from the expected total adjusted energy consumption according to the additional energy efficiency scenario (Table 2). The figures in Table 2 are expert estimates by the Ministry of Economy. Expected amount of energy from renewable sources for Slovakia is 1 572 ktoe (66 PJ).

Table 2 National overall targets for the share of energy from renewable sources in gross final consumption of energy in 2005 and 2020

Share of energy from renewable sources in gross final consumption of energy in 2005 (S2005) (%)	6.7
Target of energy from renewable sources in gross final consumption of energy in 2020 (S2020) (%)	14.0
Expected total adjusted energy consumption in 2020 (ktoe)	**11 226**
Expected amount of energy from renewable sources corresponding to the 2020 target (calculated as B x C) (ktoe)	**1 572**

Source: Ministry of Economy and Construction of the Slovak Republic

According to the information we mentioned all the major objectives of the project RE-SEEties also correspond with the direction of Slovakia declared in official government documents.

4. Analysis of regional renewable energy potentials

One of the main priorities of Slovakia's Energy Policy, approved in 2006, is to increase the share of renewable energy sources in power and heat generation in order to create appropriate additional resources needed to cover domestic demand.

The gas crisis in early 2009 was an unprecedented situation which saw supplies of Russian gas intended for Slovakia, transmitted via Ukraine, come to a complete standstill for several days. During this period of crisis, the heat sector's high dependence on natural gas highlighted the vulnerability of heat supply security. Slovakia's reserves of individual energy sources indicate that only renewable energy sources (especially biomass) can play a role in reducing overall dependence on natural gas imports.

Use of RES as domestic energy sources has been shown to increase security to some extent and partially diversify energy supply while reducing economic

dependence on unstable oil and natural gas prices. RES use is based on advanced, environmentally-friendly technologies and helps to reduce greenhouse gases and pollutants.

Renewable energy sources play a role in the strengthening and diversification of the structure of industry and agriculture. With an active support policy, the initial stage of importing foreign technology and know-how can be accelerated and opportunities can be created for investment in the manufacture and assembly of components, entire systems, and the establishment of research facilities affiliated to universities. Renewable energy sources encourage the innovation and development of information technology, open up new paths, and are one of the pillars in the building of a knowledge economy. Rational management of domestic renewable energy resources is consistent with the principles of sustainable development, making it one of the pillars supporting the sound economic development of society.

Despite the benefits, RES use also carries certain risks. The most significant risk lies in the nature of these energy sources. The generation of solar and wind power suffers from fluctuations which can have an adverse effect on the safety and reliability of grid operations.

Producers of electricity from RES create derogations from planned production for which they are not held accountable. These derogations and the risk they pose to grid safety are placed in the hands of system operators.

Another risk is significant electricity price hikes. The promotion of the production of electricity from RES in the Slovak Republic is based on a feed-in price, paid to producers for the electricity they generate. The feed-in price is set with a view to ensuring a reasonable return on the investment. In many countries where a feed-in price system has been introduced, the rapid fall in the price of photovoltaic (PV) modules has focused investor attention on the use of solar energy. The significant reduction in PV module prices has resulted in windfall profits for investors. The feed-in price paid for electricity from solar energy, which is several times higher than the market price of electricity, is reflected in electricity prices to a large degree.

Electricity production from RES is dominated by electricity generated in large hydropower plants, accounting for more than 90% of all plants using RES. In this respect, the production of electricity from RES in recent years has been highly dependent on hydropower.

Act No 309/2009 on the promotion of renewable energy and high efficiency cogeneration and amending certain laws (“Act No 309/2009 on the promotion of RES”) was approved in 2009 with a view to promoting the production of electricity from RES. That law has improved the functioning of the electricity market in renewable energy and created a stable business environment. It

has delivered a long-term guarantee of feed-in prices for 15 years and has guided the path followed in the production of electricity from renewable energy sources by encouraging the construction of small and decentralized facilities.

The increase in prices of non-renewable fossil fuels, reflected, in mid-2008, in the highest ever oil prices, shifted biomass as an energy alternative to the centre of economic and political attention. In recent years, the heat sector has witnessed a significant increase in the use of biomass, indicating that in the coming years it will continue to be the most widespread RES. Furthermore, Slovakia has large production capacity to produce pellets and briquettes, most of which must currently be placed on foreign markets. This provides the assurance that, despite the rapidly growing number of biomass boilers being installed, the scarcity of this fuel will not be an issue.

The principle of minimizing costs by means of an integrated approach to the use of renewable energy sources and reductions in greenhouse gas emissions was taken into account when projecting how to apply renewable energy sources. As a result, an appropriate combination of RES and low-carbon technologies will reduce fossil fuel consumption and, by extension, greenhouse gas emissions. The priority will be technologies whose use leads to energy prices close to market prices with the aim of delivering a reasonable final energy cost.

The priority is biomass, use of which can, in many cases, can compete with fossil fuels in terms of price. Increasing biomass use, combined with energy savings and geothermal and solar energy, will reduce the quantity of natural gas consumed for heating purposes.

Legislative conditions have been created to promote the use of biomethane as a refined type of biogas. Once technical conditions have been met, biomethane can be granted preferential access to the distribution network and can be distributed. Producers of electricity from biomethane who generate electricity in the form of CHP receive support. Biomethane producers need to be guaranteed the purchase of their biomethane, provided that they meet all of the requirements of a gas market participant, by means of legislative amendments.

Climate change also has an impact also on the intensity of rainfall, resulting in floods. One flood prevention measure is the construction of hydropower plants that are aligned with flood protection plans; in this regard, the use of the idle hydropower potential is a priority.

In the field of biofuels, significant growth in second-generation biofuels is projected by around 2020, which will make an appreciable contribution to the target of 10% use in transport. Not even the gradual marketing of electric

vehicles after 2015 is expected to make the same impact in achieving this target as second-generation biofuels.

The path followed by Slovakia in the use of renewable energy is set out in the Energy Security Strategy of the Slovak Republic, which was approved in 2008 and which states that the greatest prospects offered by RES up to 2020 lie in heating and cooling.

4.1. Solar energy

Solar potential in Slovakia is in total up to 54 000 TWh, while usable potential (real) is 9,4 TWh (estimated for solar collectors) and 1537 GWh (estimated for solar modules)

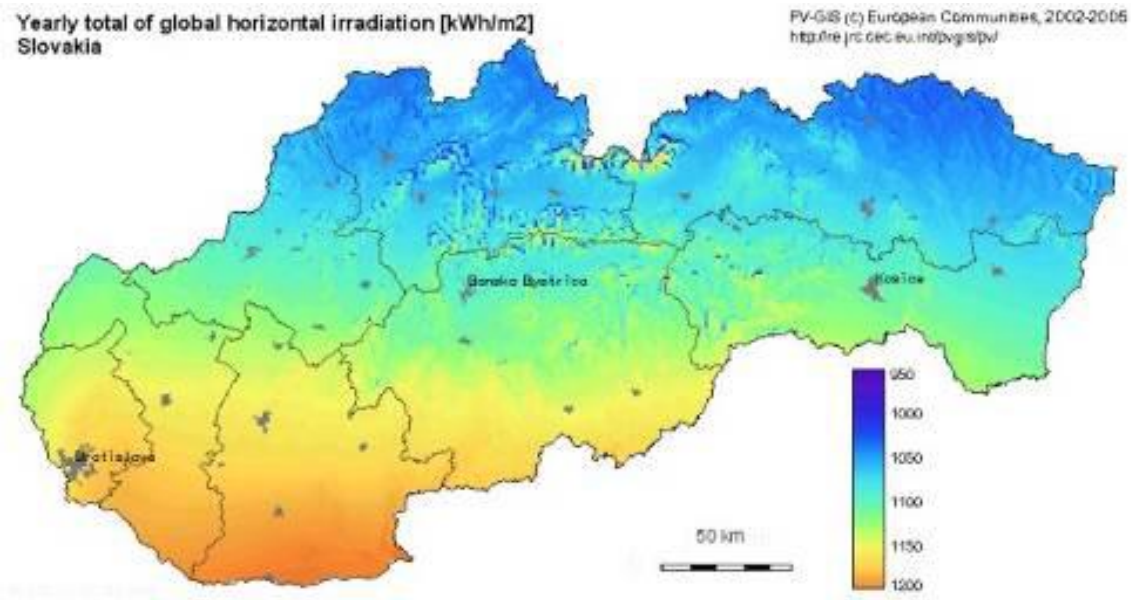


Fig. 4 Yearly global irradiance energy (incident on horizontal plane [kWh/m^2])

Electricity in Slovakia is produced by PV photovoltaic solar modules. Installed power is around 15 kWp , what gives around 0,01-0,015 GWh/year. Photovoltaic power plants in Slovakia (state to 30.6.2011), it is 809 photovoltaic power plants (total 473,6 MW), of this:

- 325 (244,1 MW) - 40,1% Central Slovakia,
- 285 (115,1 MW) - 35,2% Eastern Slovakia
- 199 (114,4 MW) - 24,7% Western Slovakia

Heat production in Slovakia is represented by installed solar collectors in the total installed area of over 55 000 m^2, what gives 100 TJ. Growing tendency for around 5 000 m^2/year (7 400 m^2 installed in 2006). Average heat production is around 500 kWh/m2/year.

4.2. Hydro energy

Hydro energy is the most used renewable energy source in Slovak Republlic. Big hydropower plants currently generate 4448 GWh of electricity annually and small power plants 248 GWh.

The technical energy potential of Slovak rivers is 6700 GWh, from which 70.6 % is actually utilised. From the 26.074 GWh of electricity produced in Slovakia during 2009, hydropower plants generated sizeable 17.9 %. Hydropower plants accounted for 34.9 % of the total installed capacity 7101 MW.

Fig. 5 Hydropower plant Horná Streda (2 X 8.25 MW)

Slovakia has 25 big hydropower plants. The hydroelectric dam Gabčíkovo with a total installed capacity 720 MW is the biggest one. Others are Čierny Váh, Liptovská Mara, Ružín and Dobšiná and they also carry out the function of regulators. Technically available hydropower potential in Slovakia is 7361 GWh/year of energy

Currently is in operation in Slovakia 250 small hydropower stations (power up to 10 MW), which represents utilization of approximately 25% of the total potential.

4.3. Biomass energy

Among RES in Slovakia, biomass has the largest energy theoretical potential which is 120 PJ, what represents up to 15% of energy consumption of SR.

Biomass represents an important potential for the development of regional and local economy. As results from the prognosis of electricity production, the most intensive development is expected in the use of solid biomass, biogas or biomethane.

Biomass is the source that has the largest technical potential (46% of all RES), closely followed by geothermal energy (26%) and solar energy (21%). The technically exploitable potential for wind and small hydropower have respectively a share of less than 3% and less than 5% of the RES technical potential.

Slovakia's total annual capacity in the production of forest biomass suitable for energy production will reach around 1,080 thousand tons by 2010 (16.9 PJ) 14. It is realistic to increase the amount of forest biomass available after 2010 through more intensive wood cutting and growing of energy crops in an area of 45,400 ha. Energy crops are promising source of fuel biomass, which can be grown in areas unsuitable for conventional agricultural and forestry production, on land temporarily set aside from agricultural production, contaminated land suitable only for non-food production, as well as on damaged land in industrial agglomerations.

Wood-processing industry produces 1 410 thousand tons of waste annually (18.1 PJ) 15, of which 2/3 originates from mechanical wood processing and 1/3 from black liquor. The greatest waste producers are large wood-processing companies, which also most frequently use this waste for energy purposes. Another possible source is the production of agricultural biomass – cereal, corn and sunflower straw, winter rape, orchard and vineyard wood waste.

The production of biofuels will increase significantly by 2010 due to the implementation of the objectives set out by Directive 2003/30/EC. The estimated production of biodiesel amounting to 100 thousand tons is equivalent to 11.0 PJ of heat.

The production of biogas from cattle manure can reach 277 million m^3 annually, which corresponds with 6.9 PJ of heat. Wastewater treatment plants are important source of biogas. There are currently about 100 co-generation units in operation using their own biogas and it is expected that co-generation units will be built at all wastewater treatment plants in larger towns.

Theoretically, biomass with energy equivalent to as much as 46.5 PJ can be produced in agriculture without negatively affecting agricultural production.

4.4. Wind energy

Natural conditions of Slovak Republic determine total usable potential of only 600 GWh/year, because it is strongly reduced by national parks. Possible installed power is 300 MW, what is 5% from total electric energy plants installed. Most suitable areas are Kysuce, Orava, Spiš and Malé Karpaty.

Current installed power is 5 MW:

- Wind power plant Cerová (operation since October 2003): 4x660 kW
- Ostrý vrch Myjava (operation since July 2004): 500 kW (pilot run)
- Wind park Skalité, locality Polana (begin operations in September 2005 and currently is suspended operations, older turbines removed): 4 x 500 kW turbine

There are almost no places in Slovakia where yearly average wind speed is over 5 m/s. This was long-term measured in specific places. Average wind speed:

- Krížna (5,7 m/s),
- Červenica – Dubník (5,7,m/s),
- Chopok (9,8, m/s)

Possible wind energy installations in Slovak Republic depends on wind conditions. Table below shows average wind speed and energy production possibilities.

Table 3 Average wind speed and potential in electricity production in Slovakia.

Type of location	**Average wind speed (m/sec)**	**Energy production (kWh/m^2 yearly)**
Poor	5,5	330 - 420
Acceptable	6,5	550 - 690
Good	7,5	850 – 1 050
Very good	8,5	1200 - 1 540

4.5. Geothermal energy

Slovak Republic has around 26 perspective areas concerning geothermal energy with potential of 60 GWh of annual electricity production. Slovakia has 116 verified holes with temperature frames of 18-129 °C and thermal power of 314,3 MWt.

Geothermal water is used in 36 areas with power of 131MWt (what is 42.7%, 2.3% from total). In 12 localities it is used for greenhouse heating and in 2 localities for fish farming. 32 localities use geothermal water for recreation purposes. For house heating there are installations in 10 localities – in year 1996 Galanta with 1240 flats and hospital.

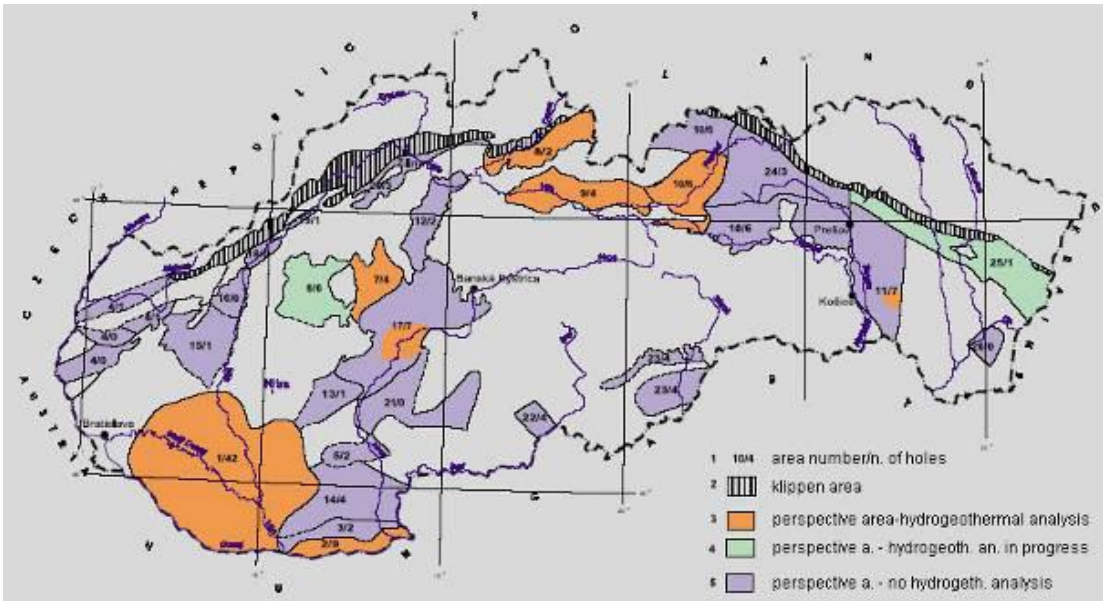


Fig. 6 Geothermal energy perspective areas

5. Feasibility study of new technology options and future energy system

In the City of Nitra there are gradualy carried out projects aimed at energy savings (natural gas) in the district heating supply (reconstruction of the distribution systems and boilers) as well as thermal insulation of buildings including replacement of the windows.

Upon accession to the Covenant of Mayors and Magistrates in December 2008, City of Nitra committed to prepare and send within one year after access the Sustainable Energy Action Plan (SEAP). Energy Agency in Nitra

(EAN) was delegated by City of Nitra to prepare the SEAP. The main goal has been to reduce 21% of CO2 emissions in Nitra city within the year 2020.

The City of Nitra carried out a project aimed at a modernisation of the wastewater treatment plant (Project ISPA 2000/SK/16/P/PF/002) in 2004 - 2006. Capacity of the WWTP is 212000 equivalent inhabitants. An integral part of the WWTP is also biogas production with cogeneration units.

Within the Hungary – Slovakia Cross-border Co-operation Programme 2007-2013 - HUSK / 0901/2.1.2/0207 City of Nitra in the cooperation with EAN prepared a project entitled “Study of the use of waste as a renewable source of energy with a focus on biogas stations in the region of Nitra and Budapest Főváros” aimed mainly at business meetings to exchange experience in energy policy, analysis processing waste types to obtain renewable energy sources, publicity of renewable energy sources. The project was approved in 2010 and completed in December 2011. One of the main project outputs is a study about the efficient use of energy from waste and support of renewable sources.

5.1. Technical aspects

Feasibility study of the City is focused on seeking opportunities to find more effective way of waste management system from their collection, storage, separation up to their potential energy and material use.

Nitra is now tackling waste using conventional options partially separate collection followed by exporting waste to landfill 50 km away. The main objective of the case study is a detailed overview of the waste handling and structure and quantities of waste generated in the city of Nitra and proposals to improve waste management, including the possible of energy use.

The current state of the infrastructure in City of Nitra

Based on data elaborate by preparation of the Sustainable Energy Action Plan the biggest part on the consumption of fossil fuels and on the production of CO_2 emissions in City of Nitra represents transport and buildings including residential buildings, tertiary buildings, equipment/facilities and the municipal buildings, equipment/facilities. SEAP of City of Nitra sets the highest potential for energy savings and utilisation of renewable energy in these two sectors. Reduction of the fuel consumption and CO_2 emissions could be achieved through limitation of private and commercial transport at the expense of public transport, conversion of diesel buses to CNG buses, through traffic limitations

in the city centre and promotion of public transport, cycling and walking. The energy efficiency of buildings could be achieved through the thermal insulation of residential buildings and through comprehensive solution of technical condition of municipal buildings as well as the tertiary buildings (insulation of walls, roofs and floors of the building, exchange of windows and doors for energy saving ones, measurement and control of the heating system). The measurements include professional advisory services for households about utilisation of alternative energy sources within construction and reconstruction and also for raising awareness of employees of public institutions in the field of energy efficiency. Reconstruction of boilers and the renovation of hot water pipelines of central heating source is one of the priority investment projects of City of Nitra. Local production of electricity can be achieved through the installation of photovoltaic panels on the roofs of school buildings. Through the implementation of green public procurement in the City Council the purchase of environmentally friendly products with lower energy intensity and purchase of electricity from renewable sources will be ensured.

Residential houses

The current state of panel houses in Nitra city is quite unsatisfactory. The main reason is the high energy consumption, which does not meet today's requirements of the standard STN 73 0540. According to these standards the construction must meet the minimum criteria for thermal performance.

Another problem is the unsatisfactory technical conditions of buildings, especially non-compliance techniques during construction and age structures. Almost 60% of the objects are older than 35 years.

We identified the worst buildings, according to consumption per m^2 and proposed to the inhabitants of these houses a comprehensive reconstruction to achieve a better quality of housing and lower operating costs.

Family houses

Based on the survey of the houses we found out that the vast majority of houses in the district of Nitra is insulated. Newly-built houses are in low energy standard (quality insulating materials for insulation, window construction, use of the modern technology for heating - condensing boilers, heat recovery).

The mostly commonly used fuel for heating and hot water preparation in family homes is natural gas, followed by wood (biomass) and at the least used is the mostly environmentally friendly source for the preparation of hot water -

solar energy. Through raising awareness (training, leaflets on solar collectors, etc.) we would like to promote the installation of solar collectors. Within the Nitra District Energy Plan there were defined the potential savings for the preparation of hot water by using solar panels for single-family homes.

City of Nitra and Energy agency carries out many activities to reinforce awareness about the practical use of alternative heating devices for houses:

- heating of family home by boilers, furnaces for biomass - to save operating costs for heating by about 30-60%,

- increased use of solar panels on houses - in order to reduce the operating costs of hot water production by about 30%.

Municipal buildings

The Energy agency analyzed the current state of objects that are owned by City of Nitra. EAN created interactive database according to total consumption and prices for consumed energy. It identified the worst buildings, for which there was carried out a study to identify possible savings potential especially related to the use of thermal energy in buildings. In the study the heat losses were calculated in more detail. Further there were proposed measures to reduce these heat losses and to improve energy performance and quantify possibilities of various preliminary returns. For other buildings, EAN developed a study where current conditions of buildings and redesigned system of their renovation in order to achieve the greatest financial savings were analysed. The study was presented to individual administrators of buildings where the procedure and recovery model was accurately explained. EAN submitted to City of Nitra discounted offer to develop energy performance certificates in cooperation with the agency. EAN most important priority is suitable financing model (e.g. ESCO partner, grants, loans, city budget) for the renovation of municipal buildings and then to ensure regular monitoring and evaluation of the achieved savings in the energy management.

EAN created active database of residential houses and public buildings. In the database, EAN lined up buildings according to area and total energy consumption. The database is constantly upgraded so we can compare energy consumption.

5.2. Legal framework

Waste Management Plan of SR for the years 2011 - 2015

Every year, the European Union (EU) and its 27 member states produce about 3 billion tons of waste, a number that is increasing over time. Waste refers to materials for which the generator has no further use for its own purpose of production, transformation or consumption.

In Slovakia it is produced yearly about 11 million tons of waste, out of which is up to 1.7 million tons of municipal waste.

For each citizen the average is up to 321 kg of municipal waste. Majority of the municipal waste (82%) is landfilled, for energy 6.8% of it is used, and materially recovered is 8,4%. This means that more than 80% of the total amount of waste is possible to use.

Waste Management Plan (WMP) of SR for the years 2011 – 2015, which entered into the force from the 22nd of February 2012, contains 5 chapters covering the following areas:

1. Basic data
2. The current status of Waste Management in SR
3. Obligatory objectives
4. Targets
5. Budget of Waste Management

The main objective of Waste Management by 2015 is to minimize the negative effects of the creation and management of waste on human health and the environment, as well as reducing the use of resources, and favour the practical application of the waste hierarchy, which is defined in Article 4 of the Waste Framework Directive:

a) prevention

b) preparation for re-use

c) recycling

d) other recovery, e.g. energy recovery

e) disposal

The strategic objective of Waste Management is diverting waste from landfill, respectively reducing the amount of waste sent to landfill. That is why it is necessary to:

- introduce measures to prevent waste, reduce hazardous characteristics of wastes and to promote the reuse of products
- establish an integrated waste management system in the area that would be associated with the rational use of energy from waste in this area
- introduce the use of materials derived from recycled materials to produce products and improve market conditions for such materials,
- increase the recovery of waste material and energy recovery of waste

For the selected waste streams the specific objectives are established in accordance with the requirements of European legislation. The selected waste streams:

- Municipal waste
- End-of-life vehicles
- Biological waste
- End-of-life tires
- Electrical and electronic equipment
- Construction and demolition waste
- Packaging waste
- PCB waste and PCB contaminated equipment
- Used batteries and waste oil

Target part of WMP

Facilities for the recovery of waste

- increase capacity for the recovery of construction and demolition waste
- increase the level of energy recovery from waste and fuel production from waste
- mechanism to support the use of compost produced from waste
- use organic waste as material for biogas production

Waste disposal facilities

- In SR 118 landfills are operated, out of which 89 are designated for non-hazardous, 12 for hazardous waste and 17 for inert waste.
- In Slovakia optimal should be placement of municipal waste incinerators (with energy efficiency of at least 0.65) for the areas approximately with 300,000 to 500,000 inhabitants, with a capacity of 100,000 tonnes of waste per year each.

Waste collection systems

- Municipal waste – reduce costs of waste collection process and optimize collection routes or build transfer stations for the purpose of reducing the cost of collecting and transportation of municipal waste.
- There is not yet in operation any system of collection of biodegradable municipal waste (excluding waste from green).
- Central integrated waste management information system - on-line system is proposed.

Current legislation on waste management in SR

The Act No. 223/2001 Coll. on waste is the most significant legislation project of the Ministry of Environment of SR. The new Act was necessary to harmonise Slovak legislation with EU legislation in the field of waste management. For the first time, some market oriented economic instruments were implemented in the environmental legislation.
In relation to adopted law on waste, several legislative statutory instruments were issued:

a) Concerning Waste Management

- Decree of the Ministry of the Environment No. 283/2001 Coll. For implementing certain provisions of the Waste Act.
- Decree of the Ministry of the Environment No. 284/2001 Coll. establishing the Waste Catalogue.
- Decree of the Ministry of the Environment No. 126/2004 Coll. The authorization, issuance of expertise in matters of waste.
- Notification of the Ministry of the Environment No. 75/2002 Coll. establishing uniform methods for the analytical control of waste.
- Act No. 17/2004 Coll. Fees for waste disposal.

b) Climate protection

Ministry of agriculture, environment and regional development (MAEaRD)

- Act No. 137/2010 Coll. on air protection.
- Decree of the Ministry of the Environment. 314/2010 Coll. establishing the content of reducing emissions from stationary sources of air pollution data and the content and method of informing the public.
- Ordinance No. MAEaRD. 363/2010 Coll. The monitoring of emissions, technical requirements and general conditions of operation of stationary sources of air pollution and air quality.
- Act No. 76/1998 Coll. for the Protection of Ozone Layer and the amendment of Act No. 455/1991 Coll.

- Decree of the Ministry of the Environment. 283/1998 Coll. implementing the Act on Protection of Ozone Layer, as amended by Decree No. 437/2000 Coll.
- Act No. 572/2004 Coll. on emission trading.
- Decree of the Ministry of the Environment. 711/2004 Coll. implementing certain provisions of the Emissions.
- Act No. 286/2009 Coll. on fluorinated greenhouse gases.

c) Environment in general

- Act No. 17/1992 Coll. on the environment.

The objectives of new EU legislation are reflected in two upcoming legal actions in the SR area of waste management:

i) Waste Management Programme for the years 2011 - 2015

- Strategy Paper on Waste Management of the Slovak Republic for the years 2011 to 2015 (the fourth one).
- Current status: approved by government.

ii) A new law on waste

- Transposition of the European Parliament and Council 2008/98/EC of 19 November 2008 on waste.
- The current status: the law despite the initial assumption (acceptance by the end of 2011) under discussion and due to parliament election in March 2012 postponed.

The proposal of new law on waste

The new law on waste (end of the 2011 year version) contains the following crucial proposals and measures:

- Waste law and Packaging law merging and law on charges for waste disposal in landfill as well.
- Recycling Fund cancellation to 31.12.2012.
- Some new definitions (by-product, the end state of waste etc.).
- Establishing of waste management responsible person for dedicated subjects in industry etc.
- Waste prevention program.
- After 31 December 2015 ban on landfilling of waste, where the organic carbon content higher than 5%.
- Increase financial reserves of landfills dedicated for remediation mixed municipal waste is unsorted municipal waste or residual municipal waste after sorting the components of municipal waste intended for recovery of any of the operations R1 to R11.

- Municipal waste management - Contract should be signed for a fixed period, the longest – 4 years.
- In addition to the fee for disposal of waste to landfill there are proposal for fee for waste incineration and waste co-incineration without energy recovery.
- Fees revenues should go to municipalities in the administrative area where the equipment is located and the Environmental Fund.
- Integrated Information System for waste management.

Table 4 Landfill taxes (euro/ton) proposed by the new waste law

Waste types/year	2013	2014	2015
Inert waste	1	1	1
Non-hazardous waste	25	28	31
Mixed municipal waste - MSW	31	34	37
Waste 20 02 01 and 20 02 03	35	40	45
Hazardous waste	170	180	190

Proposed fees will be subject of the future discussions during legislation process.

In view of this proposal is importance of new WtE (Waste to Energy) facilities design as a waste recovery facility. In the construction and operation of facilities for energy recovery of waste it would allow to pay no fees in accordance with the prepared Act and improve the economic competitiveness of the projects against other waste disposal systems (landfill, incineration without efficient energy recovery).

At the same time draft a new law on waste expected after 31 December 2015 ban on landfilling of waste, where the organic carbon content higher than 5 weight %.

WMP SR measures envisaged for the years 2011 - 2015 reflected in the above-mentioned provisions of the draft of new law on waste would significantly increase economic pressure to increase material as well as energy recovery from waste, including municipal waste.

According experience of other EU countries, mainly because of the economic efficiency, facilities WtE exist mainly for large regions with a capacity of 100 000 t of waste and more. It would be very good to consider in Slovakia

the same approach in order to have economic and environmental sustainable solutions especially in the management of municipal waste.

Nowadays can be a new draft of the Law on Waste, or The amendment to the Law changed. Ministry of Environment is currently considering the amendment to avoid penalizing because of the failure to implement the directives from the EU Commission. The legislative process is not yet complete.

Funding opportunities

There are some main national and private funds supporting waste management activities in Slovakia:

EU Structural Funds

Most important type of grants available at national level in Slovakia are EU structural funds. Support to projects in this field comes from Operational Programme – Environment, under authority of the Ministry of Environment of the SR.

Specific objectives of operational programme are.

Completing waste management infrastructure in SR pursuant to EU legislation and Slovak legal regulations, reduction and elimination of adverse effects caused by environmental burden and landfills on people´s health and ecosystems.

Main measures on the priority axes – Waste Management are as follows:

Measure 4.1 – Support of activities in separated waste collection.

Measure 4.2 – Support of waste recovery activities.

Measure 4.3 – Environmentally friendly treatment of hazardous waste.

Measure 4.4 – Closure and rehabilitation of landfills.

Environmental Fund

Environmental fund has been established under authority of MoE of the SR, composed of financial sources coming from environmental penalties and supplements collected in the economy. At the moment the fund is supporting only non-profit projects meeting social needs.

- Funded by penalties to polluters, donations etc.
- Not connected to State Budget of the SR;
- Support form: subsidy or loan;
- Eligible applicants: natural persons, legal entity, municipalities, associations, foundations and other non-profit organisations, private sector (companies).

Local taxes for municipal waste and small construction waste

Other private investment sources

- Recycling Fund.
- Sources of collective and eligible organizations.
- Sources of waste producers and holders.
- Fees for waste disposal in landfills.

The current state of the city of Nitra waste management system

In the city of Nitra the MSW – Municipal Solid Waste is collected by standard systems by different companies. There is no central regional unified system for waste management. Each subject has its own solution. Everywhere it is landfilling of MSW. For Nitra town this service is provided mainly by Nitra Communal Services (Ltd. - Company Limited with the participation of city Nitra). They provide mixed MSW collection, separate sorted collection and further handling of those streams of waste.

Other way of collection individual fraction of household waste is collection yard – two places in town Nitra. This service is again provided by Nitra Communal Services Company. MSW after collection by collection trucks is landfilled. Separate collection fractions as glass, paper and plastics is collected by trucks and treated in nearby town Levice. The PET bottles, PE films, and other waste plastics are sorted manually and pressed to bales by continual hydraulic baler. The same way is treated paper and corrugated cardboard as well. Final recycling is done in Slovak or other plastic recycling companies or papermills.

Green waste from town is collected on collection yards mainly from citizens gardens and yards and main part comes from town parks and gardens. Whole

volume of this stream of waste is composted on composting facility of Nitra city.

Whole other streams of waste – mainly hazardous batteries, electrical goods etc. are collected and disposed or recycled standard way by private collection or recycling subjects.

The collecting is one times per month from the houses – it includes the waste from household. A lot of people separate the waste – paper, plastic, and glass. In the city of Nitra are used 4 containers for separate waste collection.

The municipality was separated following components of municipal waste:

- paper and cardboard packaging, including paper, glass, glass packaging, metals and metal containers, plastics and plastic packaging, biodegradable waste

Bulky waste and construction waste:

- Bulky waste is collected by the municipality throughout the year based on individual orders of the waste on their own moods to large container / concrete, plaster, rubble /

Disposal of minor construction waste from routine maintenance work shall be determined in the opinion of municipality in the civil proceedings, respectively by notification in construction work.

The municipality carries out, as needed, at least twice a year collection and disposal of consumer electronics and white goods, whose date and place of collection is announced ahead of time.

Nitra Communal Services, Ltd. provides collection and processing of waste generated by citizens and companies in Nitra. Overview of the total production in tons and the structure of waste between 2009 and 2012 is shown in the following table:

Table 5 Waste production in Nitra

Year	2009	2010	2011	2012
t (tonnes)	38 060	36 399	36 463	35 016

From this separate collection - submitted for valorisation

	2009	2010	2011	2012
paper	2 197,32	2 197,35	1 996,16	1 739,22
glass	580,86	496,24	585,36	536,92
metals	57,36	37,34	29,75	19,66
multi-layer combined materials	16,3	19	23,3	25,05
batteries	5,52	4,57	4,54	2,31
plastics	384,43	615,32	442,6	440,48
green waste	1250	950	900	920
electronics	83,83	112,6	106,01	81,52
Together	**4 575,62**	**4 432,42**	**4 087,72**	**3 765,16**

Proposal of the use of waste to energy in Nitra city

We have to say that the waste management in the city of Nitra is at the standard level as in rest of Slovakia. The whole volume of the MSW is landfilled. Sorting and recycling represented by separate collection is on standard level app. 10% of whole volume of MSW. Hazardous waste is regularly collected and disposed in accordance with law. Waste Electrical and Electronic Equipment (WEEE) is also collected and recycled.

For mixed MSW we see one nice opportunity how to divert a part of this waste stream from landfill to energy recovery. There are two principal end users for part of MSW. One is cement industry and the second (not tested yet for this type of waste) is possibility to gasification (Waste-to-Energy Plant, WtE plant).

There are few technologies how to do it and one of simplest is shredding of whole volume of mixed MSW in order to open plastic bags, break very large pieces and then screening – sorting of pre shredded material by rotary or vibrating screen to get rid of heavy fraction with low calorific value. The light fraction can be taken by cement industry and there to burn.

Technology for energy use of waste

Two new technologies have pushed their way into the forefront of the treatment of waste products in the past 5-10 years – Pyrolysis and Gasification. These technologies have been developed in direct response to the need on a global basis to produce energy from renewable sources – bio-mass, communal waste, tyres etc.

Pyrolysis and Gasification are used to turn wastes into Syn-Gas by heating the waste under controlled conditions.

Whilst Incineration fully converts the input waste into energy and ash, Pyrolysis and Gasification deliberately limit the conversion so combustion does not occur. Pyrolysis and Gasification convert the waste into valuable intermediates that can be further processed for materials recycling or energy recovery.

The principle advantages of these new technologies over Incineration are:

- Far lower emissions well within the limits specified by the Waste Incineration Directive.

- The syn-gas produced can be fed directly to gas engines or gas turbines achieving greater electricity conversion efficiencies than incineration /steam turbines.

- Gasifiers require a homogenous feed of waste using a Refuse Derived Fuel (RDF) plant where recyclables (such as plastic) can be (although we don't recommend it) recovered for separate processing

To date most schemes have involved the use of bio-mass to either produce electricity and heat energy or to produce bio-fuels. The impression has been given, mostly by the manufacturers of the technology that these systems are naturally very expensive - running into many tens of millions of Euros - and requires very large quantities of raw materials to operate efficiently.

While it is true that the larger the system the more cost effective it becomes, gasification equipment is much more scalable than incineration systems and there are systems now available which specifically address the requirements of small to medium size towns and cities.

The equipment being offered in this case is just an example. Several plants have been installed to handle 50 - 100,000 tons of waste.

The technology consists of a primary part which will take the raw waste and remove any inert materials (glass, metal, etc.) and any materials for recycling (plastics and glass) if required. The remaining bio-degradable waste is then shredded and dried to reduce its mass before being fed- into the Gasifier. This is referred to as the Refuse Derived Fuel (RDF).

Behind the Gasifier the syn-gas is cooled and cleaned using active carbon and lime filters before being fed into the gas engine, or in the diagram steam turbine, used to generate electricity and hot water at about 90ºC. The electricity produced is fed directly into the main electrical network and the hot water is used locally.

Emissions from these plants are dramatically lower than those allowed for by the EU's Waste Emissions Directive. The chart below shows actual emission levels in ppm compared with the EU limit (at the 60% level).

Using information about the quantity and composition of waste in Nitra have been analysed the "black bin" waste according to the Slovak national statistics into the volumes of organic material, plastic, paper etc. Based then on generic calorific values this has been transformed into the energy it is expect the system to release and then using typical performance characteristics of a gas engine we have predicted the output from such a system in both electricity and heat. With this volume we therefore calculated that the proposed system could have the installed electric power 2.5 MW and heat power of 3.9 MW.

5.3. Economic analysis

With respect to the unfinished process of the definitions of the calls for project proposals for the planned period 2014 – 2020 it is very difficult to carry out a detailed economic analysis of the proposed project. For the purpose of the global assessment we used cost estimation from a similar project prepared in Slovakia:

Costs of the gasifications power plant	6.5 million €
Annual production electricity	14 040 MWh a year
Annual production of heat	22 400 MWh a year
Simple economic return	10 years

Subjects in charge: City of Nitra, Nitra Communal Services, Ltd., EAN

Implementation deadline: 2016 - 2020

Benefits: the annual energy production from renewable sources makes 36.4040 MWh

5.4. Organizational aspects

The proposed solution of the gasifications power plant could be a further organizational unit of the existing company (Komunálne služby – Nitra Communal Services, Ltd), which ensures the municipal waste collection and separation in Nitra city. The plant, which does not need any great area, could be located within the Nitra suburb at the existing collection site for municipal waste. The produced electricity could be sold into the public grid and a part could be used to cover the technology particular parts consumption. Heat from the cogeneration unit could be delivered to the district heating system in Nitra city.

5.5. Environmental impact

One of the gasifications power plant products will be syngas composed mainly of the highly combustive gases: hydrogen and carbon monoxide. This gas will be burned down in the gas engine (cogeneration unit) producing electricity and heat. The input substrate will be separated municipality waste, what means that there will be lower greenhouse gas production into the air, only so much as it is contained in the input substrate. At the proposed system output there will be saving CO_2 translating to 7 320 tons per year.

6. Project development and next steps

A sequence of the particular steps of the realization of the project aimed at the construction of the gasifications power plant for the energy use of the municipal waste could be the following one:

- Approval process of the intention of the gasification power plant construction in the City Council, including the identification of its most suitable location (2015)

- Elaboration of the gasification power plant implementation project, including investment cost detailed calculation (end of the year 2015)
- Assessment and selection of an appropriate grant scheme: Ministry of Economy or Ministry of Environment (end of the year 2015)
- Approval process of the grant application (middle of the year 2016)
- In case of an successful approval process beginning pf the project realization (2016)

7. Conclusions and recommendations

Based on the analysis of the opportunities of the city of Nitra it is possible to conclude that it is possible to improve the use of waste. How very convenient and promising technology for energy use appears the waste gasification followed by the combined production of electricity and heat. On the basis of calculations based on the amount and composition of municipal waste in Nitra, it would be possible to build a facility for gasification with the installed electric power of 2.5 MW and heat power of 3.9 MW.

The proposed gasification system would significantly contribute to reducing the amount of waste that would have to be landfilled and it would also increase the share of energy production from renewable sources in Nitra.