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Impact of biogas production in Bulgaria, Croatia, Greece, Latvia, Romania and Slovenia

Deliverable 2.7

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Content

1 Introduction

The production and utilisation of biogas from anaerobic digestion (AD) provides many environmental, economic and socio-economic benefits for both the society as a whole, as well as for involved stakeholders such as farmers, biogas plant operators, investors, etc. Utilisation of the internal value chain of biogas production enhances local economic capabilities, safeguards jobs in rural areas and increases regional purchasing power. It improves living standards and contributes to economic and social development. Biogas generally has the potential to contribute significantly to the electricity supply providing a valuable alternative energy source compared to the fossil fuels. In this way biogas can create new markets for agricultural regions giving new perspectives. Using renewable resources in a sustainable way for biogas production facilitates the closure of the carbon and nutrient cycle. In parallel, biogas can contribute (apart from the above mentioned sectors) to the reduction of the European Union's energy dependency and energy safety.

On the other side, biogas production may also have some negative impacts on people and environment. However, most of these negative impacts are human made and can be avoided by proper biogas plant concepts and planning processes.

This report provides an overview about the impacts of biogas production in general, and more specifically on the impacts in Bulgaria, Croatia, Greece, Latvia, Romania and Slovenia which are the target countries of the BiG>East project. BiG>East is supported by the European Commission in the framework of the Intelligent Energy for Europe (IEE) Program. The objective of BiG>East is to transfer knowledge from biogas experts of Western Europe to farmers, biogas plant operators and decision makers in Bulgaria, Croatia, Greece, Latvia, Romania, and Slovenia.

2 Overall positive and negative impacts of biogas production and use

2.1 Environmental Impacts

Due to its several advantages, biogas exploitation can contribute to the energy, agricultural and environmental policy of the European Union. Biogas production apart from its energy content can be an effective waste management method, providing a natural high quality fertilizer for crop cultivation and environmental protection (reduces emissions of particulate matter and nitrous oxides and contributes to GHG mitigation).

However, the environmental impact of biogas production and exploitation needs careful consideration in order to be used in a sustainable way. For instance, although generally the biogas exploitation contribute toward a more sustainable waste management, in some cases the feedstock production and use (e.g. production of energy crops, expansion of monoculture) may be less environmental friendly unless certain care is taken.

In order to promote the benefits of biogas production, local, national, European, and international environmental and agricultural legislation has to be considered: e.g. Habitats Directive, Birds Directive, Natura 2000, Cross Compliance, International Convention on Biological Biodiversity, and United Nations Framework Convention on Climate Change.

2.1.1 Air and emissions

Utilisation of fossil fuels such as lignite, hard coal, crude oil and natural gas converts carbon, stored for millions of years in the Earth's crust, and releases it as carbon dioxide (CO_2) into the atmosphere. An increase of the current CO_2 concentration in the atmosphere causes global warming as carbon dioxide is a greenhouse gas (GHG). The combustion of biogas also releases CO_2. However, the main difference, when compared to fossil fuels, is that the carbon in biogas was recently up taken from the atmosphere, by photosynthetic activity of the plants. The carbon cycle of biogas is thus closed within a very short time (between one and several years).

Biogas production by AD reduces also emissions of methane (CH_4) and nitrous oxide (N_2O) from storage and utilisation of animal manure as fertiliser. The GHG potential of methane is 23 fold and of nitrous oxide 296 fold higher than of carbon dioxide. The amount of worldwide methane emissions from agricultural production comprises about 33 % of the global anthropogenic methane release. Animal husbandry alone comprises 16 %, followed by rice fields with 12 % and animal manure with 5 %. While methane released through digestion of ruminants (about 80 million tons CH_4 per year) can rarely be reduced, methane emissions from animal waste can be captured and energetically used through anaerobic treatment. The amount of methane emission mainly depends on fodder, animal type and animal waste systems. For example: the methane emission potential from dairy cattle in industrialized countries is about 0.24 m^3 CH_4/kg volatile solids (influence of fodder), in developing countries it is only about 0.13 m^3 CH_4/kg volatile solids. But taking into account the aerobic condition of solid dung systems (only 5 % of the methane emission potential is released) it is mainly the liquid waste management systems, which contribute through anaerobic conditions with a high methane release to the climate change (up to 90 % of the methane emission potential is released). From the worldwide 30 million tons of methane emissions per year generated from the different animal waste management systems like solid storage, anaerobic lagoon, liquid/slurry storage, and pasture, half of the emissions could be reduced through controlled AD and biogas production. Eastern Europe, Asia and Far East emit 6.2 million tons methane emissions per year. While in Eastern Europe the emissions are caused by unsuitable animal waste management systems, in the Far East they are caused by the high numbers of livestock.

Utilisation of biogas displaces fossil fuels and treats animal wasted (manure) and thus reduces emissions of CO_2, CH_4 and N_2O, contributing to mitigate the global warming.

On the other side, careful attention is needed for the biogas plant design, operation and maintenance in order to ensure that complete and high quality combustion of the biogas is achieved. This is important since biogas consists mainly of methane (45-70 %). Methane leakages from the digesters, digestate storage facilities, as well as from the pipelines have to be avoided. Furthermore, emissions from the feedstock storage have to be avoided, especially if domestic and industrial wastes are treated. If dedicated energy crops are used for biogas production, it should be considered that excess use of fossil nitrogen fertilizer may cause nitrous oxide emissions which also contribute to climate change. This can be avoided by fertilizing energy crops with digestate from AD.

Other air emissions which are related to the biogas production are:

- Hydrogen sulphide (H_2S) is probably the substance in biogas with the most potential hazard. Several methods can be used in order to reduce the H_2S concentration in the biogas (e.g. biogas cleaning, intake of fresh air).
- Nitrogen (N_2) and oxygen (O_2) may be present in small amounts, but these gasses are not perceived as environmental hazard
- Carbon monoxide (CO) may also be present in trace amounts but CO-emissions are produced only when all of the carbon in the waste is not oxidised to carbon dioxide.
- Ammonia (NH_3) may also be present in trace amounts but the amount of ammonia is negligible compared to the potential for reduction of nitrogen to the environment resulting from the improved utilization of the bio fertilizer compared to untreated slurry.

2.1.2 Energy balances

Till the near past, fears and doubts were expressed that a large scale biomass energy project would need much extra energy inputs for operation and feedstock production. Nowadays, the experience has shown that when the mass and energy balances have been properly estimated and optimized and if the inputs and outputs have been carefully considered this is rarely the case. In environmental terms the energy balance of a biogas plant is a reflection of its environmental impact. The lower the energy input for feedstock production and biogas plant operation, the lower is the impact on the environment. On the contrary, the greater the energy output, the greater is the environmental protection due to the displacement of fossil fuels and their implied pollution.

2.1.3 Water

Like for any energy exploitation, also biomass production needs water. Thereby, water consumption mainly depends on the feedstock material, as well as on climatic conditions. If energy crops are used for biogas production, artificial irrigation should be avoided. Anyhow, when compared to other biofuels, biogas needs the lowest amount of process water. This aspect is very important since many regions of the world are prone to water shortages.

Another impact of biogas production which should be avoided is the release of leakage fluids into the environment. This may cause water pollution, either above ground or below ground.

2.1.4 Soil

Most impacts on soils depend on the type of feedstock. The use of waste material for biogas production and the application of digestate on the fields have beneficial impacts. Digestate has improved fertiliser efficiency due to homogeneity and higher nutrient availability. Furthermore, the C/N ratio is improved since some carbon compounds remain in the digestate, improving the carbon content of soils.

However, if energy crops are used for biogas production, impacts on soils have to be carefully assessed, especially with regard to soil erosion and soil compaction. This largely depends on the agricultural practices and on the type of energy crop.

2.1.5 Landscape and land use

In the case of biogas production from energy crops special concern about the impact on Europe's agricultural landscape has been expressed (e.g. visual impact, biological biodiversity, high inputs of pesticides and fertilizers, monocultures). Monocultures for energy crops (e.g. corn) can be avoided in biogas production if intercropping (e.g. corn, sunflower and other crops) is applied. The intensity of the used land for feedstock production may be as important as the extent of agricultural land for energy crop production. Land that is exploited for biomass energy production can provide valuable ecosystem services, depending upon the intensity of ecosystem management. The use of perennial energy crops is beneficial in terms of soil conservation and biodiversity.

Furthermore, the sitting and construction of a biogas plant by itself has impacts on the landscape; thus the impact of the size of the plant on the surrounding landscape has to be assessed.

2.1.6 Waste management

One of the main advantages of biogas production is the ability to transform waste material into a valuable resource, by using it as feedstock for AD. Many European countries are facing enormous problems associated with an overproduction of organic wastes from industry, agriculture and households. Biogas production is an excellent way to comply with increasingly restrictive national and European regulations in this area and to utilise organic wastes for energy production followed by recycling as fertilisers. Biogas technologies contribute to reduce the volume of wastes and the costs for waste disposal.

2.1.7 Fertilizer use

A biogas plant is not only a supplier of energy. Digested biomass feedstock, named digestate, is a valuable soil fertiliser, rich in nitrogen, phosphorus, potassium and micronutrients, which can be applied on soils with the usual equipment for application of liquid manure and slurries. Compared to raw animal manure, digestate has improved fertiliser efficiency due to homogeneity and higher nutrient availability, better C/N ratio and almost absence of odours.

The nutrient cycle of the biogas production process – from feedstock production to the application of digestate as fertiliser – is closed. Carbon compounds (C) are reduced by the digestion process, where methane (CH_4) is used for energy production and carbon dioxide (CO_2) is released to the atmosphere and up-taken by vegetation during photosynthesis. Some carbon compounds remain in the digestate, improving the carbon content of soils when digestate is applied as fertiliser. Biogas production can be perfectly integrated into conventional and organic farming, where digestate replaces mineral fertilisers, produced with consumption of large amounts of fossil energy.

2.2 Social Impacts

Biogas production has many social benefits when compared with the use of fossil energy sources. Most of these impacts are related to job creation and rural development. However, there must be some issues considered, such as the social acceptance of biogas plants and prevention of health hazards.

2.2.1 Employment

The development of a national biogas sector stimulates the establishment of new enterprises with significant economic potential, which will increase the income in rural areas and create new jobs. Compared to the use of imported fossil fuels, production of biogas from AD requires much larger work power for production, collection and transport of AD feedstock, manufacture of technical equipment, construction, operation and maintenance of biogas plants. Permanent jobs may be created in the region.

2.2.2 Rural development

Generally, agriculture is recognised as a priority sector for support under the EU Funds. These funds are targeting to reduce the gap between the Member States of the EU and between different regions, promoting the economical and social cohesion.

Biogas production, especially in small to medium size decentralised biogas systems, may have considerable advantages in agricultural rural regions such as:

- Offer to their owners and to the farmers new income opportunities and increase the economic growth of the area.
- Substitute costly fossil fuels for heat and electricity generation, contributing this way to energy diversification, security, competitiveness and sustainable supply.
- Offer direct or indirect, local or regional job opportunities and support the development of high value skills.

- Improve the social cohesion of the local population.

2.2.3 Social acceptance

Most public concerns against the set-up of biogas plants are resulting from neighbouring inhabitants. Their concerns are related to increased odours directly released from the biogas plant, as well as increased noise due to the traffic from feedstock supply and digestate transport. These aspects are serious and have to be considered in the planning process. Participation of neighbouring inhabitants of the plant is a crucial process for the acceptance and success of the plant.

On the other hand, biogas plants have the overall potential to reduce odours from agriculture. Storage and application of liquid manure, animal dung and many organic wastes are sources of persistent, unpleasant odours and attract flies. AD reduces these odours by up to 80 %. Digestate is almost odourless and the remaining ammonia odours disappear shortly after application as fertiliser on the fields. Anyhow, in close vicinity of a biogas plant there will be usually some odour remaining.

2.2.4 Health issues

Biogas plants serve as waste and sewage treatment facilities and in this way directly contribute to a better hygienic situation. Utilisation of digestate as fertiliser improves veterinary safety, when compared to untreated manure and slurries. AD implies controlled sanitation of digestate, in order to be suitable for the use as fertiliser. Sanitation of digestate can be provided through retention at thermophilic digestion temperature, pasteurisation or pressure sterilisation, depending of the type of feedstock involved. In all cases, the aim is to inactivate pathogens, weed seeds and other biological hazards and to break the chain of disease transmission.

2.3 Economic Impacts

Biogas production has impacts on local, regional and national levels. In general, it strengthens national and regional economies, since it is locally produced and not imported. On the other hand, in most countries biogas production requires subsidies of incentives to compete with fossil fuels (which are also subsidised in many cases). Thereby, negative external costs for fossil fuels are often neglected.

2.3.1 Impacts for farmers

Production of feedstock in combination with operation of biogas plants makes biogas technologies economically attractive for farmers and contributes to increase their income. Apart from the additional income, farmers obtain a new and important social function as energy providers and waste treatment operators.

2.3.2 Substitute for fossil energy

The current global energy supply is highly dependent on fossil energy sources (crude oil, lignite, hard coal, natural gas). These sources are fossilised remains of dead plants and animals, which have been exposed to heat and pressure in the Earth's crust over hundreds of millions of years. For this reason, fossil fuels are non-renewable resources which reserves are being depleted much faster than new ones are being formed.

The peak oil production is defined as "the point in time at which the maximum rate of global production of crude oil is reached, after which the rate of production enters its terminal decline". According to different researchers, the peak oil has already occurred or it is expected to occur within the next period of time. Unlike fossil fuels, biogas from AD is permanently renewable, as it is produced from renewable biomass. Biogas from AD will not only improve the energy balance of a country but also make an important contribution to the preservation of the natural resources and to environmental improvement.

Biogas is a flexible energy carrier, suitable for many different applications. In developing countries, one of the simplest applications of biogas is for cooking and lighting. In many European countries biogas is used for combined heat and power generation (CHP). Biogas is also up-graded and fed into natural gas grids, used as vehicle fuel or in fuel cells technology.

The utilization of biogas contributes to an enlarged range of energy fuels offered on the market. In this way the local basis of the energy supply can be extended and secured, and it also simplifies the setting of additional commercial activities where energy supply has so far proved to be a problem.

2.3.3 Substitute for energy imports

Fossil fuels are limited resources, concentrated in few geographical areas of our planet. This creates, for the countries outside this area, a permanent and insecure status of dependency on import of energy supply. Most European countries are strongly dependent on fossil energy imports from regions rich in fossil fuel sources such as Russia or the Middle East. Developing and implementing renewable energy systems such as biogas from AD, based on national and regional resources, will increase sustainability and security of national energy supply and reduce the energy import dependency.

3 Impacts in Bulgaria

With a national territory of 110,994 km^2, Bulgaria is a middle-sized country in South-Eastern Europe. It is situated on the western coast of the Black Sea and borders on Romania in the north, Serbia and Macedonia in the west, and Greece and Turkey in the south. The landscape is dominated by the Balkan Mountains in the centre, which slope gently towards the Danube plains in the north, and drop more abruptly to the south. Further to the south are the Rhodopi Mountains and in the west rises the highest mountain of the Balkan Peninsula, Mount Rila, the highest point of which is 2,925 m high. Farmland and forests are the prevalent forms of land use, accounting altogether for almost 80 % of the national territory.

3.1 Environmental impacts

3.1.1 Air emissions

In the years 2004–2006, emissions of methane and ammonia from agriculture in Bulgaria increased primarily because of the increasing number of breeding cattle. According to Executive Environment

Agency (MOEW) in 2005 and 2006 the share of emissions of methane, emitted by the agricultural sector occupies 18 %.

Currently manure in Bulgaria is stored in open storage capacities. The variation of the CH_4 emission trend from agriculture is shown on Figure 1.

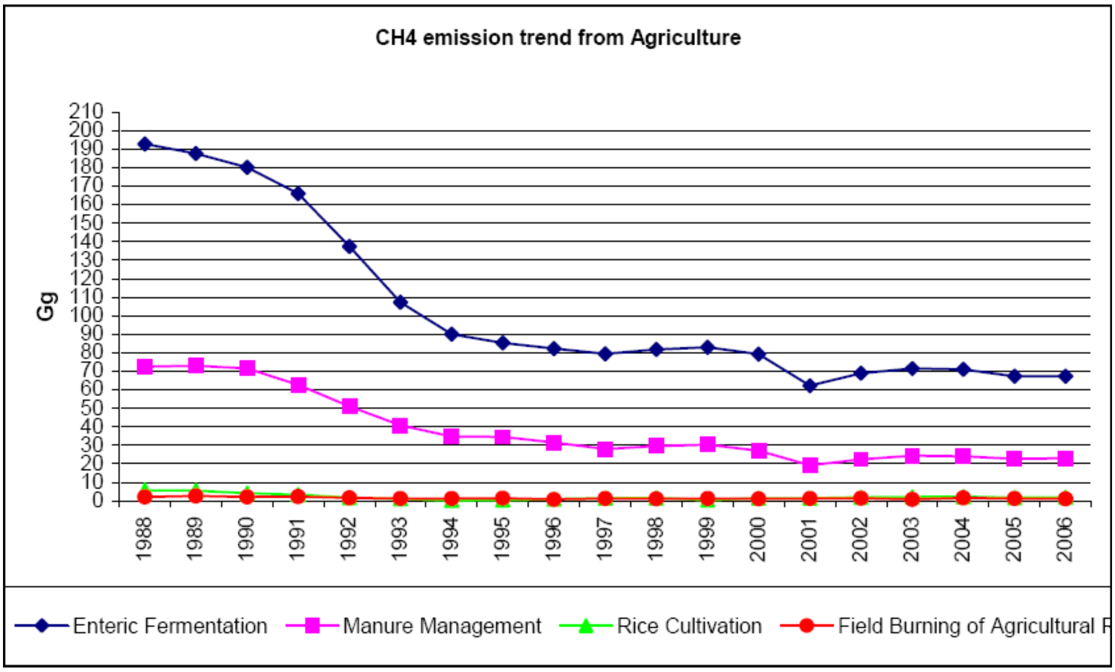

Figure 1: Variation of CH_4 emission trend from Agriculture in Bulgaria, 1988-2006, Gg; Source: National inventory report, 2008, MOEW

Table 1 presents the emission trend in Bulgaria from 2004 to 2006, per source category and gas in Gg CO_2-eq.

Table 1: Emission trend in Bulgaria per source category and gas, Gg CO_{2eq}; Source: National inventory report, 2008, MOEW

Source category	2004	2005	2006
Agriculture	5081.04	4804.03	4720.07
CH_4 Enteric Fermentation	1490	1414	1414
CH_4 Manure Management	505	478	485
CH_4 Rice Cultivation	48	40	43
CH_4 Field Burning of Agricultural Residues	33.80	27.10	26.13
N_2O Manure Management	390	369	366
N_2O Agricultural soils	2604	2468	2379
N_2O Field Burning of Agricultural Residues	2961	2335	2283
Waste	8651	7882	7570
CO_2	NA	NA	NA
CH_4	8502	7735	7425
N_2O	150	147	145
Total emissions	70548.4	71455	71343.6
International bunker	775	826	823

Substitution of fossil fuels by renewable energy as a whole has a positive effect on air quality in Bulgaria. Biogas has the potential to reduce methane emissions, having an unfavourably impact on the environment.

3.1.2 Water

Unfortunately, Bulgaria is one of the poorest countries in water resources in Europe. The annual average amount of water per resident is around 2,300 – 2,400 m^3 and the usable part of it ranges from 800 to 1,000 m^3 per resident. In future, the water deficit will grow and will become a very serious social, economic and environmental problem for the country, therefore wastewater becomes extremely important.

Currently, in Bulgaria 52 municipal wastewater treatment plants (MWWTP) are built, of which 13 plants purify water only mechanical and 39 have biological sludge treatment facilities. In MWWTP the sewage water of 47 towns and 35.3 % of the country's population is treated.

The total amount of non-hazardous sludge generated from MWWTP in 2006 was 147,683 t including 29,987 t dry matter. The amount of sludge generated from other WWTP is insignificant and is not included in the report by the Executive Environment Agency.

From the total amount of 147,683 t sludge in 2006, 65,183 t (44 %) were deposited, 60,542 t (41 %) were recovered and 21,956 t (15 %) are temporarily stored. From 41 % recovered sludge, 34 % were used on agricultural land and 7 % were used on disturbed areas (Executive Environment Agency, MOEW).

Data from analyzes about the content of heavy metals and nutrients[1] in a municipal WWTP with a capacity of more than 300 kg. BOD5[2] per day, are presented in Tables 2 and 3:

Table 2: Concentration of heavy metals in sewage sludge (2006), mg/kg TS; Source: Executive Environment Agency, 2008, MOEW

	Cd	Hg	As	Ni	Pb	Cr	Cu	Zn
TLV[3]	30	16	25	350	800	500	1600	3000
Average content	8.23	2.61	11.62	89.96	237.13	510.461	207.5	826.01

1 Chemical elements with minimal daily requirement greater than 100 mg. Calcium, phosphorus, magnesium, potassium, sodium and chloride are nutrients.

2 Biological Oxygen Demand: the amount of dissolved oxygen consumed in five days by biological processes breaking down organic matter.

3 **TLV**- Threshold Limit Value

Table 3: Concentration of nutrients in sewage sludge, mg/kg TS; Source: Executive Environment Agency, 2008, MOEW

Total N	3530.7
Phosphor (P_2O_5)	14282.54
Potassium (K_2O)	4054.03

Biogas production could contribute to process wastewater. This reduces the amount of wastewater released to the environment and provides renewable energy. Furthermore, biogas could reduce nitrogen leaching from animal manure and guarantee sustainable fertilization of fields. This would have very positive impacts on ground water quality and on biodiversity as whole.

A negative impact of biogas production could be influenced by the generally low precipitation amount and intense seasonal rains, which are typical for Bulgaria. Precipitation amount during the warm season (April-September) is less than 300 mm, which is extremely insufficient and could hamper agricultural production in the country. The most threatened areas are located in South-East Bulgaria, Eastern Dobrudja and the valley of the Struma River. Between April and October, there are about 70 intense rains (annual average), which sometimes destroy part of the agricultural crops (Executive Environment Agency, MOEW).

3.1.3 Soil

Agriculture is the main source of the soil degradation processes in the country. Misuse of the soil, use of plant protection products and fertilizers, burning of crop residues and other agricultural practices not only reduce to decrease of fertility, but damage to the soil as a natural resource.

Soil erosion is caused by applying inappropriate cultivation techniques and agricultural practices. Areas in Bulgaria with moderate to high erosion risk, significantly increased compared with previous years. The total erosion area in Bulgaria was estimated at 2,010,223 ha for 2006.

In recent years, due to intensive fertilization with nitrogen fertilizers (mainly ammonium nitrate) some areas are acidificated in Bulgaria, which harm plants. Therefore, it should be taken into account, which soils need to be fertilized.

On the other hand, there are some areas with very poor soil quality due to the heavy industry, which has been active in their surroundings. In those areas digestate could be used for recultivation.

The use of manure for biogas production could reduce the environmental pollution in Bulgaria and increase the soil nutrients availability of agricultural land. The use of organic fertilizer reduces soil degradation processes in Bulgaria (MAF).

3.1.4 Landscape and land use

Landscape

The forestry sector in Bulgaria is closely related to the agricultural sector. Forestland in Bulgaria covers 3.91 million ha, which represents 34 % of the national territory.

In the past 6-8 years, dramatic decline (more than 5 %) in the areas covered by forests is observed in Bulgaria. This is due to the illegal cuttings and lack of control in these rural regions, where firewood is the main energy source.

Deforestation causes habitat and biodiversity losses, as well as declining fuel-wood and quality of life. This leads to future cost increases of agricultural production, which could have negative impacts for the production of biogas.

Land use

The *Area with agricultural uses* (AAU) in Bulgaria was 5,666,336 ha and occupied 51.1 % of the national territory in 2007.

In 2007, the *utilized agricultural area* (UAA) is 5,116,220 ha, or 46.3 % of the territory. The largest share of UAA in Bulgaria is in the North-East region with 1,228,000 ha (23.7 % of UAA), followed by the regions South Central (20.6 %) and North-Central (19.7 %). In total a minor decrease of 1.4 % of the share of agricultural area used is observed.

Furthermore, in 2007, *Arable land* included 3,057,740 ha and represented 59.8 % of the utilized agricultural area. The region with the most arable land in the country is North –East with 1,002,000 ha (32.8 %) of the arable land in the country, followed by North Central with 686,000 ha (22.4 %) and South Central with 531,000 ha (17.4 %). A slight decrease in arable land compared to previous years in observed (MAF).

From the analysis can be concluded that Bulgaria has sufficient agricultural and forest area, which is a prerequisite for the development of livestock and crop industry, if land is treated adequate. Climatic conditions of the country are favourable for the development of agriculture.

3.2 Social & economic impacts

In recent years, there is a tendency of macroeconomic stability and creating conditions for sustainable economic development trough stimulating employment and reducing unemployment. Furthermore, there is a tendency of increasing disposable income of the population and business, as well as of increasing investments, including investment for environmental protection and renewable energies.

In 2006 an economic growth of 6.3 % of Gross Domestic Product (GDP) was achieved. Negative growth was observed in crop production due to poor harvest of cereals and vegetable, and in livestock-breading. Regardless of the negative growth in the agriculture in 2006, the high investment activity in the sector is a prerequisite for real positive development of agriculture in the medium term (Executive Environment Agency, MOEW).

The production of renewable energy, including biogas production, creates opportunities for employment and rural development in Bulgaria.

3.2.1 Impacts on rural development

After the transition period in Bulgaria, some negative consequences in the agricultural sector were noticed:

- lack of qualitative agricultural equipment and machinery;
- expensive fertilizers, lime and pesticides;
- lack of experience and management;
- financial limitations and a difficulty in getting loans.

Despite of these negative consequences, there are good preconditions for organic farming and biogas production in Bulgaria due to the still low labour costs, favourable geographical and climatic conditions, low use of pesticides and fertilizers during last decade, extensive farming, necessary know-how, and due to the already harmonized legislation.

Some of the negative social and economic factors, which might affect biogas production in Bulgaria, are:

- Depopulation of the rural and mountain areas (the share of the population in the agricultural sector is decreasing mainly because of the increase of the unemployment). Depopulation not only leads to unsustainable management of agricultural land, but also to lasting deterioration of the land quality and productive potential.
- Abandonment of agricultural land (The commercialization of agriculture through technological development and increased off-farm activities resulting from industrialization and urbanization in accessible lowland areas has motivated many farmers to migrate, either temporarily or permanently);
- Big infrastructural problems in the rural areas;
- Lack of knowledge and training among the “new farmers” (especially in the semi-subsistence farms);
- Need of investments for reconstruction of buildings and barns (shelters); building of places for storage the manure; own forage production and limitation of antibiotics and no growth promoters;
- Fragmented ownership of land: due to the fact that 50 % of the arable land is rented, 45 % - leased and only 5 % of farmers have their own land, users of agricultural land are not motivated to invest in land, which complicates the process of sustainable land management and hinders agricultural production.
- Relatively low investment activity due to insufficient financial resources in the agricultural enterprises and high-risk nature of agricultural production.

3.2.2 Substitution of fossil energy for renewable energy

Bulgaria has a diverse energy mix with an average dependency on imported fuels. Domestic production includes nuclear energy and solid fuels, which are the main fuels for electricity generation. Renewable energy contribution (biomass and hydro) has been increasing in recent years, although it is still below the EU average.

Since 1988, the Bulgarian energy profile has changed considerably. Between 1988 and 2000, the total primary energy supply (TPES) decreased by more than 40 %. The consumption of oil products fell by 61% and electricity consumption fell by 32.4 %. In 2004, the most important energy sources were solid fuels (36 %), crude oil (22 %) and nuclear energy (22 %), followed by natural gas (13 %). The share of renewables is 5 % of TPES.

The Bulgarian energy import dependency is slightly below the EU-27 average. Oil accounts for 45 % of imported energy, whereas gas accounts for 25 %. The Russian Federation is the main oil supplier for Bulgaria and the only supplier for natural gas. The remaining 30 % of total imports are solid fuels. Imported energy has declined by 49 % in the period 1990-2004, mainly due to reduced energy consumption (MEE).

The production of biogas as renewable energy source in Bulgaria would be an efficient measure to reduce dependency of fossil energy imports.

4 Impacts in Croatia

Croatia is a small central European and Mediterranean country that borders with Hungary on the North, Serbia on the East, Slovenia on the West, Montenegro on the far SW and embraces Bosnia and Herzegovina from the South, West and North. The Southern border of Croatia (direction SW-SE) is the Adriatic Sea with Italy across. Geographically, Croatia stretches from the outskirts of East Alpine area at the NW via Pannonian plain and banks of river Dunav on the East, via mountain massive of Dinara (1,831 m) towards the shores of Adriatic Sea that continue towards West and South. The Dinara massive is the natural border between Croatia and Bosnia and Herzegovina along the Adriatic coast. Most, if not all, Hungarian, Slovenian, Serbian, southern Bosnian borders are determined by rivers. The total mainland area is 56,594 km^2 while the sea area is 31,067 km^2. Croatia has 3,259 km^2 in 1,185 islands, islets and riffs, out of which only 47 are inhabited. The total population of Croatia is 4.4 million while little less than a million are living in the capital, Zagreb. Split (188,694 inhabitants), Rijeka (144,043 inhabitants), Osijek (114,616 inhabitants) and Zadar (72,718 inhabitants) are Croatian largest urban centres.

Climate is moderate continental at the northern parts with four seasons – moderate cold winters and hot summers. Central part of Croatia and mountain range along the Adriatic coast have mountainous climate with cold snowy winters and fresh summers while coastal part of Croatia and islands have a typical mild Mediterranean climate.

Croatia is abundant in freshwaters with both rivers, lakes, underground waters and fresh water reserves which places special responsibility to protect them from pollution. Coastal area is fragile karst which provides large biodiversity but also intense fragility of ecosystems. Three types of climate on such a small area provided wide biodiversity of nature: 7,613.5 km^2 or 8.7 % of total area belong to some level of protected areas of nature (Figure 2).

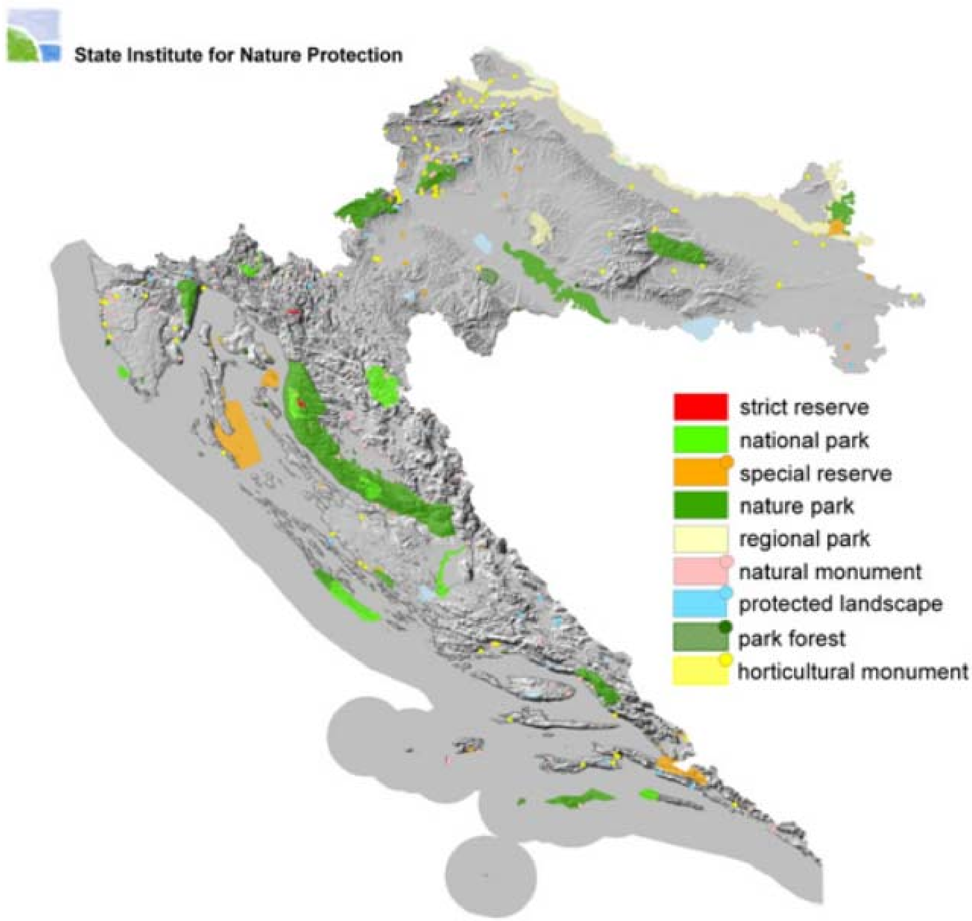

Figure 2: Nature protected areas in Croatia; Source: Governmental Office for Nature Protection

4.1 Environmental impacts

Contribution to the **environmental protection** of biogas in Croatia is in its positive impact on soil, water and air quality as well as on GHG emissions savings. In some of national counterparts of acquis biogas is clearly mentioned as one of solutions to either mitigate or provide solutions of the topic. Such examples are transposition of EU Nitrate Directive, Regulation EC No 1774/2002 (with corresponding amendments) on laying down health rules concerning animal by-products not intended for human consumption; Kyoto and MPME protocols as being the most mentioned.

4.1.1 Agriculture and land use

Livestock production is concentrated in few areas: NW counties (Varaždinska and Međimurska) are known for their poultry production; middle North counties (i.e. Koprivničko – križevačka and Bjelovarsko – bilogorska) are known for cattle breeding while eastern parts of Croatia (Slavonia) are more orientated at pig breeding. Whereas Slavonia is a predominantly agricultural region with suitable agricultural land for manure spreading, other parts of Croatia are not so plentiful with land and agricultural areas and will have to consider other ways of handling manure than spreading on land. Arable land is estimated at 15 % of total area whereas 2.5 million ha of forests cover about 44 % of total Croatian area.

4.1.2 Air and emissions

Due to its global influence on climate change, a development of the greenhouse gas inventory became a fundamental obligation under the United Nations Framework Convention on Climate Change (UNFCCC). In 1996, the Croatian Parliament ratified the UNFCCC (Official Gazette – International Agreements 2/96) by which Croatia, as a signatory party, has assumed the scope of its commitments within the framework of the Annex 1 to the Convention. Croatia ratified the Kyoto Protocol in the April 2007. According to the Kyoto Protocol, Croatia has the obligation to reduce the emissions of greenhouse gases from anthropogenic sources by 5 % in the period from 2008 to 2012 in relation to the base year 1990.

Under the UNFCCC and the Convention on Long-Range Transboundary Air Pollution (CLRTAP) the Republic of Croatia is obliged to calculate air pollutant emissions on the national level. The compulsory registration of emissions is based on the Law on Air Protection (OG 178/2004).

Croatia ratified the CLRTAP Convention (OG - International Agreements 1/92 in May 2008, by ratification of the ***Protocol to Abate Acidification, Eutrophication and Ground-level Ozone***, so called multi-pollutant/multi-effect protocol (MPME). The main objective of the Protocol is to monitor and reduce the total annual emissions of sulphur dioxide, nitrogen oxides, non-methane volatile organic compounds and ammonia from anthropogenic activities. Croatia is obliged to reduce SO_2 emission for 61 %, NMVOC emission for 14 %, NH_3 emission for 19 % by 2010 in comparison with 1990, while NO_x emission should be in 2010 lower than emission level in 1990. National emission targets defined by MPME protocol are also national environmental strategy targets.

If one assumes that biogas plants will be installed at all business entities with livestock production in Croatia, total estimated potential ranges between 0.7 and 2.1 PJ/year. According to the IPCC recommendation, CO_2 emissions from biogas burning in cogeneration plant are not recorded in the total emission balances since it has been absorbed during the lifetime of biomass. Avoided emissions by generating electricity and heat from biogas in comparison to the usual energy sources for the same energy transformation (direct use) in Croatia are shown in the Figure 3.

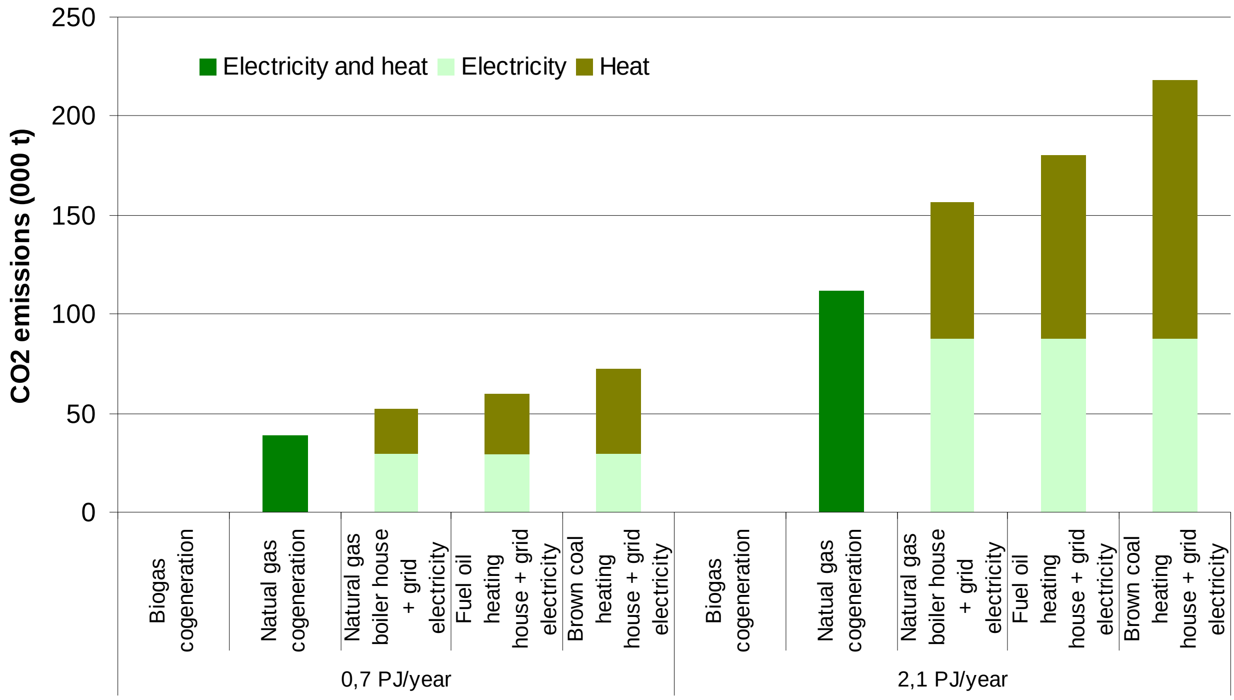

Figure 3: Comparison of avoided CO_2 emissions from biogas cogeneration installations in Croatia; Source: EIHP, 2009

Total CO_2 emissions are little above 24 million tons in Croatia for 2007 (Figure 4), out of which little more than 85 % is energy related (57 % stationary energy sources and 28 % mobile energy sources). In 2006, total GHG emissions for Croatia were approximately 30.8 million tons of CO_{2eq}.

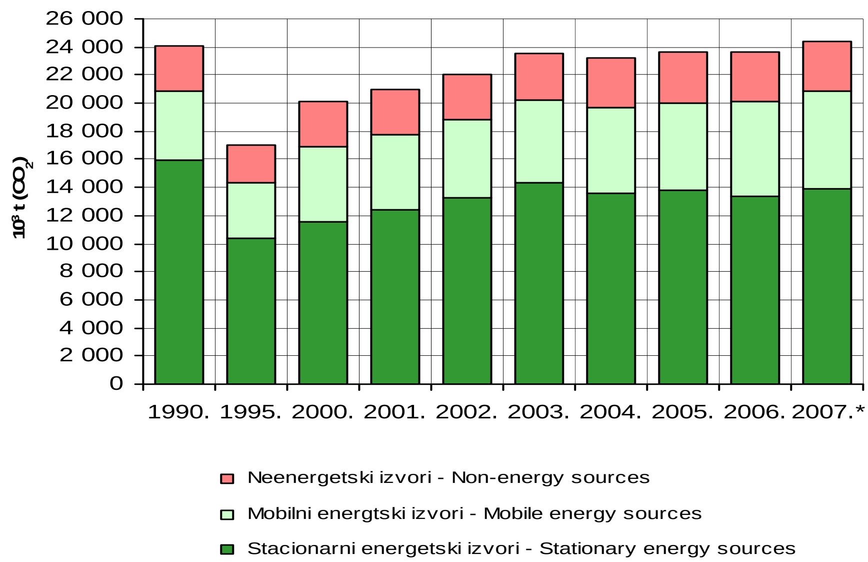

Figure 4: CO_2 emissions trend in Croatia; Source: Energy in Croatia 2007 (*estimated)

CO_2 savings range from 0.04 t of CO_2 (natural gas) to 0.07 of CO_2 (combination of brown coal and grid electricity) for lower biogas potential and from 0.11 and 0.22 t of CO_2, respectively, for higher biogas potential. In general, if only agricultural biomass is considered (without energy crops and agro-food processing), avoided CO_2 emissions range from 0.16 to 0.89 % in total CO_2 emissions while among CO_2 emissions from stationary energy sources amounts 0.28 to 1.57 %, depending on the lower or higher biogas potential value and energy source to be substituted.

In addition to that, the avoided CH_4 emissions from utilising animal manure for energy purposes (enteric fermentation and manure management) are about 1,055 t /yearly.

In order to calculate complete effect on GHG emission savings from utilisation of animal manure for biogas production (CO_2, CH_4 and N_2O) one should make detailed investigation on exact composition of biogas substrate (i.e. cattle category has to be divided into dairy cows, males and youngs (IPCC, 2006)) which is at this stage of preliminary research on biogas potential not feasible. Nevertheless, average values delivered in the EU document Second Strategic Energy Review: An EU Energy Security and Solidarity Action Plan – *Energy Sources, Production Costs and Performance of Technologies for Power Generation, Heating and Transport* {CON˙2008)781 final}, could provide sufficient ground to calculate approximate values. If assuming 31 % technology net efficiency, it is possible to generate 60 to 180 GWh of electricity from biogas potential on business entities in Croatia. Lifecycle emissions depend on the feedstock used (manure, energy crops, landfill gas) for biogas production and vary from 6 to 245 kg CO_{2eq}/MWh, meaning that electricity from Croatian biogas potential will deliver from 360 to 44,100 tons of CO_{2eq} /year. In comparison to the same electricity output from coal, oil and natural gas, this is a decrease of 10,000 tons of CO_{2eq}/year order of magnitude, depending on the energy source (Table 4).

Table 4: Lifecylce emissions (t CO_{2eq}/year) from not utilizing biogas potential for generating electricity of 60 to 180 GWh/year

Energy source	Power generating technology	kgCO_{2eq}/MWh	tCO_{2eq}	
			Lower value of biogas potential 60 GWh	Higher value of biogas potential 180 GWh
Natural gas	Open Cycle Gas Turbine	640	38 400	115 200
	Combined Cycle Gas Turbine	420	25 200	75 600
Oil	Internal Combustion Diesel Engine	690	41 400	124 200
	Combined Cycle Oil-fired Turbine	585	35 100	105 300
Coal	Pulverised Coal Combustion	820	49 200	147 600
	Circulating Fluidised Bed	960	57 600	172 800

	Combustion			
	Integrated Gasification Combined Cycle	855	51 300	153 900
Nuclear	Nuclear fission	15	900	2 700
	Biogas	**6-245**	**360**	**44 100**

Nevertheless, even this fragment of biogas potential (animal manure on agricultural business entities only) suggests that biogas from organic waste from agro-food industry could contribute to the efforts of meeting the Kyoto Protocol and MPME Protocol obligations.

4.1.3 Agricultural waste management

Transposition of EU Nitrate Directive to the national legislation as *Pravilnik o dobroj poljoprivrednoj praksi u korištenju gnojiva* (OG 56/08) shifted focus of livestock breeding farmers and companies to manure and its disposal. The Directive has four years adoption period where 210 kg N/ha is allowed after which follows the regular 170 kg N/ha. It also determines periods when the land application of certain types of fertilisers is prohibited:

- 1/12 – 1/03: fertilisation with manure and slurry are forbidden at all agricultural areas
- 1/05 – 1/09: fertilisation with manure and slurry without insertion in soil are forbidden at all agricultural areas
- 1/05 – 1/09: fertilisation with solid manure is forbidden at all agricultural areas
- 1/11 – 1/02: fertilisation with mineral fertilisers with nitrogen at all agricultural areas. In very special cases, it is allowed to apply urea-ammonium-nitrate (UAN) at harvest residues.

In the period from harvest to the beginning of periods with banned fertilisation, amount of nitrogen applied with mineral fertilisers cannot exceed 40 kg/ha at light (sandy) soils and 80 kg/ha at heavy (clay) soils.

Adoption of the Directive also delivers prohibition for application of solid manure and slurry at certain soils and in certain occasions.

Application of manure is forbidden:

- at II zone of sanitary protection of water wells;
- at water-saturated, snow-covered, frozen or/and flooding soils;
- in production of berries and herbs 30 days before ripening and harvest;
- mixed with waste sludge or compost from waste sludge;
- from husbandries that are identified with disease agents resistant to conditions at the manure collector.

Slurry application is forbidden:

- at II zone of sanitary protection of water wells,
- at 25, 20 and 5 meters distance from wells, lakes, other water courses, respectively;
- at steep slope terrains with run-offs.

Croatian version of Nitrate Directive ends with recommendation that, if a husbandry lacks sufficient agriculture area for manure and slurry application, produced manure and slurry have to be taken care of as so that:

- Apply manure and slurry for fertilisation of agriculture area that is owned by somebody else. This application has to be based on a contract.
- Processing manure into biogas, compost or substrate;
- Taking care of manure in other ways (it is not specified what “other ways” are.).

It is hard to predict dynamics of enforcement but one could assume that the period of “non-management” or “improvisation in animal excrements disposal” is passing by. In addition to that, Croatian livestock production is somewhat concentrated: NW counties (Varaždinska and Međimurska) are known for their poultry production; middle North counties (Koprivničko – križevačka and Bjelovarsko – bilogorska) are known for cattle breeding while eastern parts of Croatia (Slavonia) are more orientated at pig breeding. Whereas Slavonia is predominantly agricultural region with possibility to find agricultural land for manure spreading, other parts of Croatia are not so abundant with land and agricultural areas.

Regulation EC No 1774/2002 (with corresponding amendments) on laying down health rules concerning animal by-products not intended for human consumption is transposed as *Pravilnik o načinu postupanja s nusproizvodima životinjskog podrijetla koji nisu za prehranu ljudi* (OG 56/06). It describes special conditions that an object for production of biogas and compost has to fulfil in Annex VI.

4.1.4 Municipal waste management

Utilisation of organic fraction of municipal waste as biogas feedstock could be considered as one of the **waste management tools for prolongation of landfill’s life time** since less volume of waste has been disposed. It also **prevents leaching of pollutants to underground waters**. Biogas is mentioned as one of recycling techniques in the Waste management strategy but to utilise organic fraction of municipal waste one has to introduce the whole system of separate collection and disposal of municipal waste.

4.1.5 Fertilizer production and nutrient cycle

A by-product of biogas production is digestate that could be used as fertiliser, if only agricultural inputs are utilised for biogas production. Digestate represents about 40 to 50 % of initial dry matter of the feedstock which lowers transportation costs at same or higher quality fertilising matter.

Total consumption of mineral fertilisers in 2006 amounted 365,000 tons which represents steady decrease from 2001 when utilisation of mineral fertilisers peaked with 435,000 t. Legal entities in agriculture (commercial agro-businesses) utilised 31 % of the total quantity or 115,000 t out of which 49,000 t of nitrogen 4,000 t of phosphorous and 10 t of potassium. The same group of consumers utilised active substances in total of 50,000 tons, out of which N 21,000 t, P_2O_5 12 000 t and K_2O 17,000 t in 2006.

4.2 Socio-economic impacts

Since livestock breeding occurs in rural regions, biogas production could be introduced as **new economic activity to the community**. The inputs-outputs flow could be very close to the sustainable concept of having locally produced feedstock and locally utilised output. Although it is most possible that electricity generated in biogas cogeneration plant will be sold to the grid in order to gain from feed-in tariff, heat and digestate remain outputs to be utilised locally.

4.3 Impacts on national policies

Croatia has set target to have minimum **5.8 % share or 360 MW of RES-E** in the total electricity consumption **by 2010**. It is fair to expect that the Green Paper on "20 20 by 2020" will be also considered in the national RES targets. The latest official estimates on biogas potential are made within National Energy Programmes – BIOEN – Energy from biomass and waste, in 1998. That document provides **biogas potential** of 2 PJ/year which roughly corresponds to the results of preliminary biogas potential research from agriculture residues in 2008: **from 3.2 -11.3 to 0.7 – 2.1 PJ/year**. Biogas production and utilisation will be left at modest contribution (0.3-0.9% of total gross electricity consumption) if feedstock is not extended to energy crops and other sources such as food processing industry, kitchen waste, expired foodstuff, slaughterhouse waste and similar. So far, no research has been done in investigating biogas potentials in Croatia other than agriculture feedstock.

Nevertheless, despite its modest contribution at the national level, biogas could represent the first best options for those regions rich in agriculture feedstock. Those regions will not only have locally produced energy and, to some extend, energy independency at local level but also will greatly benefit with biogas production externalities in environmental protection and rural community development.

The Ordinance of **Biofuels** Quality (OG 141/05) recognises biogas as one type of motor vehicle fuel with prescribed properties if placed on market. National target for biofuels share in total consumption of motor vehicles fuels amounts **5.75 % or 5.095 PJ by 2010.** For 2009 it is foreseen that only about half of that target could be met based on the existing and expected production capacities. All biofuels producing capacities are focused on biodiesel.

5 Impacts in Greece

5.1 Environmental impacts

5.1.1 Air and emissions

Air pollution in Greece is happening mainly in the big cities because of the high concentration of the housing sector, the industrial and commercial activities and transportation. Athens is the best known case of urban air pollution in the country. Although the pollution episodes in rural areas are rare, Anaerobic Digestion is an important factor in GHG reduction and particularly CO_2, since biogas exploitation offers the opportunity of the substitution of fossil fuels. Especially in the case of optimal biogas exploitation the overall emissions effects from an AD plant is positive, namely:

- The growth and biomass exploitation on a sustainable way results in a more lasting solution than the use of fossil fuels and especially lignite in Greece (dominate fuel).
- In the case of landfill gas the trapping and biogas exploitation provides and extra benefit by converting the CH_4 in CO_2 and thus avoiding accidental explosions due to horizontal mitigation of methane.
- CH_4 conversion to CO_2 has a positive input to GHG effect since a molecule of methane is nearly 30 times as effective as a molecule of CO_2 in trapping the earth’s radiated heat.
- Storage and application of animal manure increase the methane emissions. Biogas exploitation mitigates the total methane emissions from agriculture.

It is worth mentioning that although biogas is a potential low-carbon energy source, this depends on the way how biogas is produced. In the case that biogas comes from residues, waste or from energy crops grown on abandoned agricultural land this offers sustained GHG advantages. On the contrary converting arable land to produce energy crops as biofuels creates a “carbon debt” by releasing more CO_2 than the total reduction that these feedstock provide by replacing fossil fuels (in a LCA basis). Thus, the environmental impacts and implication of biogas exploitation needs careful consideration and are site specific and oriented in a project base.

Based on the last available GHG national report prepared by the Ministry for Environment, Physical Planning and Public Works (National Inventory report 2008):

- GHG emissions from Agriculture decreased by 13.86 % between 1990 and 2006, with an average annual rate of decrease of 0.86 %. Manure management is responsible for methane and nitrous oxide emissions. Methane is produced during the anaerobic decomposition of manure, while nitrous oxide is produced during the storage and treatment of manure before its use as fertilizer. CH_4 and N_2O from manure management in 2006 accounted for 4.19 % and 2.49 % of total GHG emissions from Agriculture respectively, and for 0.37 % and 0.22 % of total national emissions respectively (without LULUCF).
- GHG emissions from Waste in 2006 decreased by 20.38 % compared to 1990 levels, while the average annual rate of decrease of emissions for the period 1990 – 2006 is estimated at 1.27 %.Greenhouse gases emissions from solid waste disposal on land present an increasing

trend, while, on the contrary, emissions from wastewater handling are gradually decreasing (Figure 1).

- Domestic and industrial wastewater handling under anaerobic conditions produces CH_4. In Greece, domestic wastewater handling in aerobic treatment facilities shows a substantial increase since 1999, while in the industrial sector only a few units exist where wastewater is handled under anaerobic conditions. CH_4 emissions from wastewater handling in 2006 accounted for 0.4 % of total GHG emissions and for 15.6 % of GHG emissions from Waste.
- The total CH_4 recovery from the solid waste disposal sites (SWDS) of Athens, Patra, Thessalonica and Larissa was estimated to 53,800 kt (the CH_4 emissions from managed and unmanaged solid waste disposal in 2006 were reached to 123,860 kt).

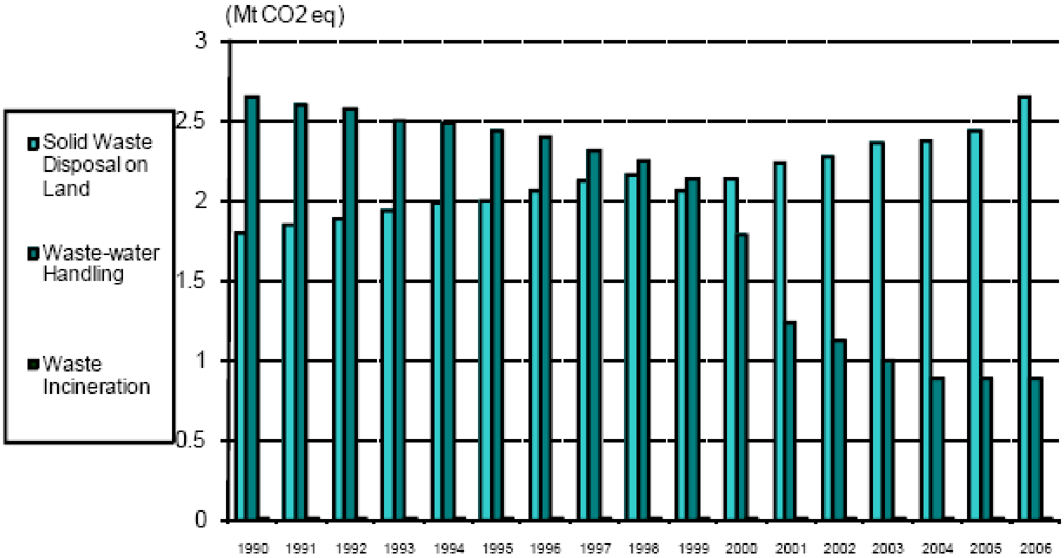

Figure 5: Greenhouse gases emissions (in kt CO2 eq) from Waste per source category for the period 1990 – 2006 (Source: National Inventory report 2008).

The revised Greek National Programme for Climate Change, estimates realistic CO_2 savings of 4.5 Mt CO_2-eq from the increased use of Renewable. Among others it is estimated that Anaerobic Digestion of pig manure (35 % of the total breeding animals in 2010 and 50 % of the total breeding animals in 2015 respectively) can reduce greenhouse gas emissions by 60,000 t CO_2-eq in 2010 and 83,000 t CO_2-eq in 2015.

In Table 5 an air emission calculation based on a plant with an annual output of 1,000,000 kWh is demonstrated based on different fuel types. At the same time the process can diminish uncontrolled methane generation by capturing methane[4].

According to estimations made by CRES[5], and based on a conservative scenario, it is estimated that the AD of manure and organic wastes from the slaughter houses and milk factories could feed CHP plants of total installed capacity of 350 MW and a mean annual electricity production equal to 1,121,389 MWhe/y. This means an indirect yearly CO_2 reduction by 729 kt.

Table 5: Energy plant air emissions

Data	**Fuel type**					
	Unit	**Lignite**		**Oil**		**Biogas**
Power (to the grid)	kWe/y	1,000,000		1,000,000		1,000,000
PPC plant air emissions (Lignite) *	**Air emissions**					
	CO_2	**CO**	**HC**	**SO_2**	**NO_x**	**Particulate**
Air emissions (g/kWh)	850	0.18	0.05	15.5	1.2	0.8
Total emissions (tn/year)	850	0.18	0.05	15.5	1.2	0.8
PPC plant air emissions (Oil) **	**Air emissions**					
	CO_2	**CO**	**HC**	**CO_2**	**NO_x**	**Particulate**
Air emissions (g/kWh)	1,062.5	0.18	0.05	19.4	1.5	1.00
Total emissions (tn/year)	1,062.5	0.18	0.05	19.4	1.5	1.00
Biomass plant air emissions (Biogas)	**Air emissions *****					
	CO_2	**CO**	**HC**	**CO_2**	**NO_x**	**Particulate**
Air emissions (g/kWh)	200					
Total emissions (tn/year)	200					
Air emissions comparison	**Air emissions (tn/year)**					
	CO_2	**CO**	**HC**	**CO_2**	**NO_x**	**Particulate**
Biogas – Lignite (tn/year)	***-650***					
Biogas – Oi (tn/year)	***-862,5***					

* Lignite power plants (mainland), Ministry of Development 2005
** Autonomous PPC plants (islands), Ministry of Development 2005
*** Barbara Klingler, Environmental Aspects of Biogas Technology

Odour is a site specific problem arising mainly from the feedstock management and storage into the biogas plant and the digestion process. Some of the recommendations for odour control measures

4 Cassada M. E., Safley L.M.Jr., 1990: „Global Methane Emissions from Livestock and Poultry Manure". EPA CX-816200-010.
5 Zafiris Christos (2007). Biogas in Greece. Current situation and prospectives. European Biogas Workshop proceedings "The Future of Biogas in Europe – III", University of Southern Denmark Esbjerg, Denmark 14-16 June 2007.

are the limited storage time, the careful handling procedures, the use of odour control equipment where such devises are necessary and covered units.

5.1.2 Soil and water

Generally in Greece, the Anaerobic Digestion technology is used mainly as a waste treatment method but not accompanied with biogas and energy production (at least not in a wide extent at the moment). The general approach is that the waste are disposed after some treatment (aerobic or anaerobic) than the adaptation of a well know and integrated technology (AD) for parallel biogas production and the substrate use as fertilizer, too. Furthermore, the wastes disposal (e.g. manure) creates so far only a few problems compared to what happen to the other EU Member States (e.g. West Europe). Thus, the implementation of biogas schemes for reduction of water and soil pollution is not so imperative in Greece until now. In parallel in most of the cases the «polluter pays» principle is not efficiently applied although the Greek environmental legislation is very strict.

Concerning waste there are special provisions on the use of biological sludge from wastewater treatment plants in the agriculture (M.D. 80568/4225/91, which conforms to 86/278/EC). M.D. 80568/4225/91 includes limits for heavy metal concentrations in sludge and total heavy metal quantity put on the ground, sampling and analysis methods, cases where use is prohibited, etc.

According to M.D. 80568/4225/91 the concentrations of heavy metals in sewage sludge (mg/kg ts) for application on farm land in Greece is:

Country/region	Cd	Pb	Hg	Ni	Zn	Cu	Cr
EC	20-40	750-1200	16-25	300-400	2500-4000	1000-1750	1000-1500
Greece	20-40	750-1200	16-25	300-400	2500-4000	1000-1750	-

As it shown Greece follows the directive limits. In these MD there are also limits for the quantities of heavy metals that can be applied on farm land per year (mg/ha/year) in base of 10 years average.

Country/region	Cd	Pb	Hg	Ni	Zn	Cu	Cr
Greece	0,15	15	0,1	3	30	12	-

According to the requirements of the EU Nitrate Directive 91/676/EEC (JMD 195652/1906/1999, OJG 1575B), seven sensate areas toward nitrogen pollution from agricultural run-offs have been established (Thessaly plain, Kopaida plain, Argolida plain, Pinios basin, Thessaloniki plain, Strimonas basin, Preveza-Arta plain). In these areas the implementations of special Action Programmes has been planned and are obligatory to all the farmers of these areas.

In parallel, that animal manure, municipal sewage and agro-industrial waste can contain substances (bacteria, viruses, parasites, heavy metals, harmful organic substances) that can potentially be a threat to public health or the environment[6].

5.1.3 Landscape and land use

The Greek Special Framework for the Spatial Planning and Sustainable Development for the Renewable Energy Sources-RES[7] identify criteria and guidelines for the site allocation of RES projects, per RES category and type of geographic area. For biogas plants the most suitable sites are considered those located near to the «feedstock» production and availability. The Plan sets some general criteria in order to exclude some areas or land uses but does not recommend specific sites (eg. like in wind parks).

Proposals to use the surplus agricultural land for energy crops have open a big discussion, among others, about the negative effects on the agricultural landscape of Greece (e.g. Reduction of biological diversity, high input of fertilizers and pesticides, visual impact, monoculture of certain crops and effects to the surrounding landscape). Till today it is seemed a more lasting solution the biogas exploitation from manure, residues and waste, sludge and agro-industrial residues and unsuitable plants for other purposes.

5.2 Socio-economic issues

Some of the social and economic aspects related to biogas exploitation in Greece are the following:

- Lignite, the main domestic fossil fuel resource of Greece, it seems that will continue to play a major role in the country's fuel mix in the future. Although the last decade, the social pressure and the economic conditions (e.g. public awareness for environment protection and clean energy, gradually deregulation and liberalization of energy market, etc), the legislative framework (e.g. energy and environmental policy, EU and country commitments, new law for energy matters, etc) and the financial environment have changed the picture, so that new biogas plants were constructed and operated, there are still barriers (mainly no technological) which affect to biogas exploitation and deployment in Greece (eg. public perception, experience and awareness mainly on farm scale and industrial biogas applications, lack of price for the heat production, licensing procedure, lack of "gate fees" for waste disposal, externalities like euthrophication, groundwater pollution, replacement of fossil fuels which are not assessed and monetized, etc). Nevertheless, as the gas penetrates more and more to the Greek energy market the biogas production can contribute towards to energy diversification, security and efficiency.

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[6] European Parliament 2008. Report on sustainable agriculture and biogas: a need for review of EU legislation (2007/2107(INI)).
[7] Source: Hellenic Ministry for the Environment Physical Planning and Public Works

- According to LAW No. 3428/27.12.2005 “Liberalization of Natural Gas Market” (Officail Gazette 313/A/2005) article 39: “The use of Natural Gas Systems pursuant to the provisions of this law is also allowed for the transmission of biogas, gas produced from Biomass and other kinds of gases, provided that it is so possible from a technical point of view and the technical specifications are met, after taking into consideration the quality requirements and the chemical features thereof”.
- The new law for RES (law 3468/2006) is dedicated to the promotion of RES and set a tariff of 73 €/MWh (75.82 €/MWh for the year 2007) for biogas plants. Although higher electricity price must be examined based on the form of Biomass (there is no differentiation according to biomass form) this incentive guarantees a regular income for the plant owners.
- The implementation of a biogas plant can increase direct or indirect the jobs during the all project phases and lifetime (especially in the case of the construction and operation of a CAD plant). Even in the case of a small farm scale plant the part time employment of the farmer can give benefits and parallel new income opportunities.
- With over 56 % of the population in the 27 Member States of the European Union (EU) living in rural areas, which cover 91 % of the territory, rural development is a vitally important policy area. An energy scheme like a biogas plant contributes not only to the exploitation of local energy sources but also toward improving the quality of life in rural areas and encouraging diversification of the rural economy. This dimension is vital especially in Greece where the agricultural areas despite the development efforts continue to suffer from high unemployment rates and the young people continue to search jobs to the urban or semi-urban places or work in temporary jobs.
- A biogas plant must be adapted to the particular regions and must be accepted from neighbours and the general public. Thus apart form its economical and technological viability a biogas plant must have also “environmental and social compatibility” based on thorough examination of the project and public awareness and participation.

6 Impacts in Latvia

Latvia is a comparatively small country located in north-eastern Europe. The area of Latvia is 64,559 km^2, including 24,431 km^2 of agricultural land and 29,382 km^2 of forest area. Latvia is situated near the Baltic Sea with a 498 km long sea border, it has borders with Estonia (to the north) with Russia (to the east), with Belarus (to the southeast) and with Lithuania (to the south).[8]

[8] Central Statistical Bureau of Latvia: www.csb.gov.lv

6.1 Environmental impacts

There are 12,581 km^2 of protected areas in Latvia.[5] Regarding nature protection areas, the responsible organization for implementation of unified nature protection policy in Latvia is Nature Protection Board. According to the information found from this organization altogether in Latvia there are 633 specially protected natural areas, including: 1 biosphere reserve, 3 national parks, 4 strict nature reserves, 9 areas of protected landscapes, 43 nature parks, 278 nature reserves, 206 geological and geomorphological formations with protectable qualities, 89 dendrological planted areas, that makes 12 % of the area of Latvia in total. The most of these protected areas are established as Natura 2000 protection areas. Indication of nature protection areas in Latvia is given in Figure 6.1.[9]

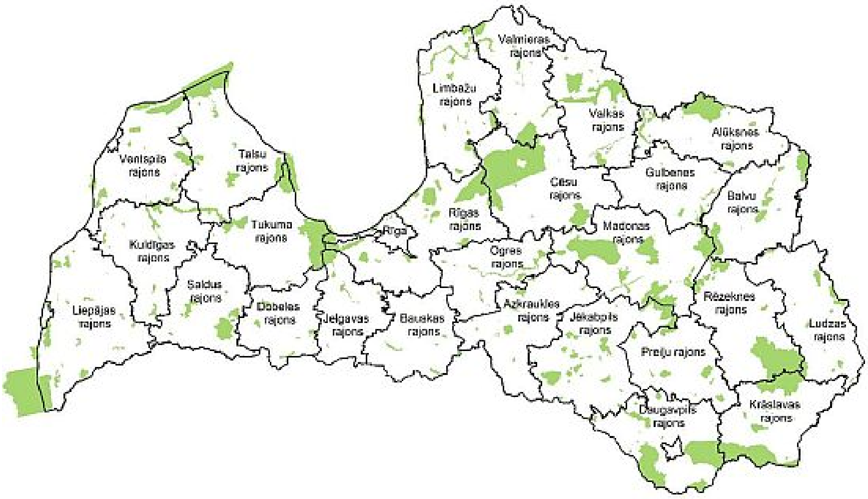

Figure 6: Nature protection areas (in green) in Latvia [6]

Before any potential expenditure it must be considered if there could be any impact on protection areas from intended activity.

6.1.1 Air and emissions

According to the Latvia's National GHG Inventory Report 1990-2006[10], the most significant sources of anthropogenic greenhouse gas (GHG) emissions in Latvia are energy (including transport) and agriculture sectors. In 2006 energy sector has more than 73.5 % share of the total GHG emissions, following the agriculture sector with approximately 17 % of Latvia's total GHG emissions. An overview of GHG emissions by sectors is given in Figure 7.

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[9] Nature Protection Board of Latvia: www.dap.gov.lv

[10] Latvia's National Inventory Report 1990-2006: Submitted under United Nations Convention on Climate Change and the Kyoto Protocol, 2008

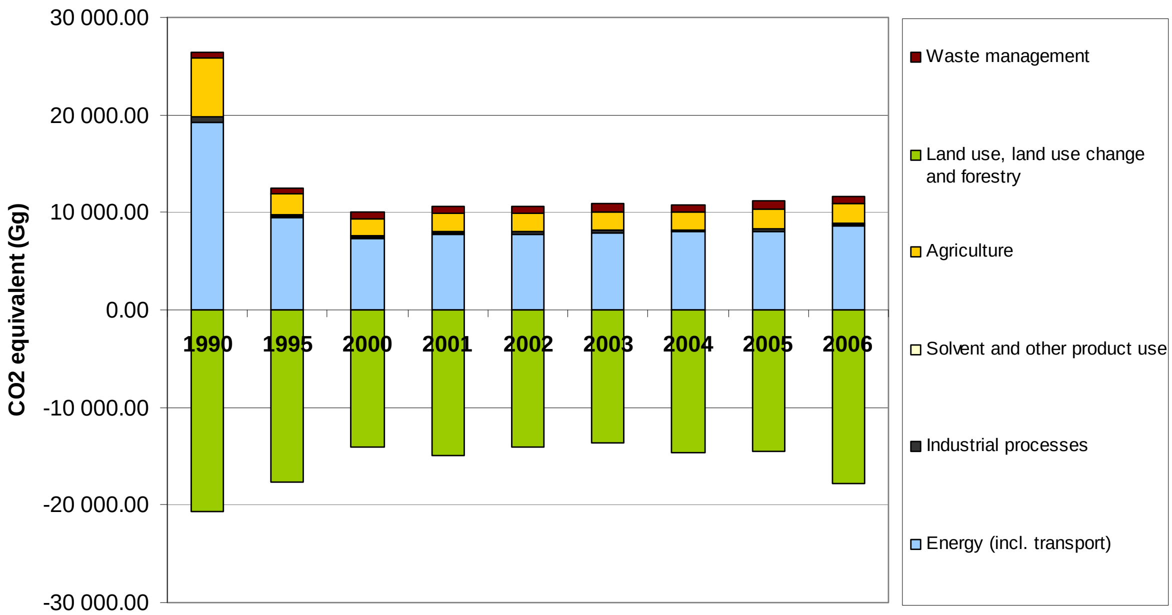

Figure 7: GHG emissions in Latvia 1990-2006, Gg CO_2 equivalent

As shown in Figure 7, between 1990 and 2000 GHG emissions decreased significantly. The reason for that was crisis in Latvian national economy in the beginning of 1990-ties. In 2006, Latvia's total GHG emissions showed a decrease of 56 % from the base (1990). However, compared to the total GHG emissions in 2005, emissions have risen by about 4.5 % in 2006. So far the land use, land use change and forestry (LULUCF) is a net sink in Latvia and the main sink is forestland.

Biogas in Latvia has a large potential for substitution of fossil fuels and to reduce the GHG emission form energy sector, e.g., using biogas for energy (heat, electricity, CHP) generation and as transport fuel.

GHG emissions from the agriculture in Latvia include emissions of CH_4 from enteric fermentation, manure management and emissions of N_2O from manure management and agricultural soils. Yet, the annual GHG emissions form agriculture have reduced approximately by 66 % since 1990 (due to decreases in the number of livestock and in nitrogen fertilisation), the total GHG emissions from agricultural activities in Latvia is slightly increasing every year. Biogas could give a significant contribution for reduction of CH_4 and N_2O emissions from animal husbandry and animal manure storage and application. In particular this is a case for Latvia where in 2006, methane emissions from enteric fermentation of domestic livestock comprised 87 % of total agricultural emission.

6.1.2 Water and soil

Agriculture like other human activities has substantial impact on environment, especially water quality. Run-off from agricultural land seems to have good water quality, but, in principle, it is leakage from soil matrix with considerable concentration of nutrients (N; P; K and microelements).

Results of run-off monitoring implemented in Latvia in 2005[11] indicated that in several sites (Bērze, Vecauce) nitrate concentrations where higher than the limiting values of EU Nitrate Directive. Highest losses were measured in Zemgale region, part of which has been designated as vulnerable zone (see Figure 8).

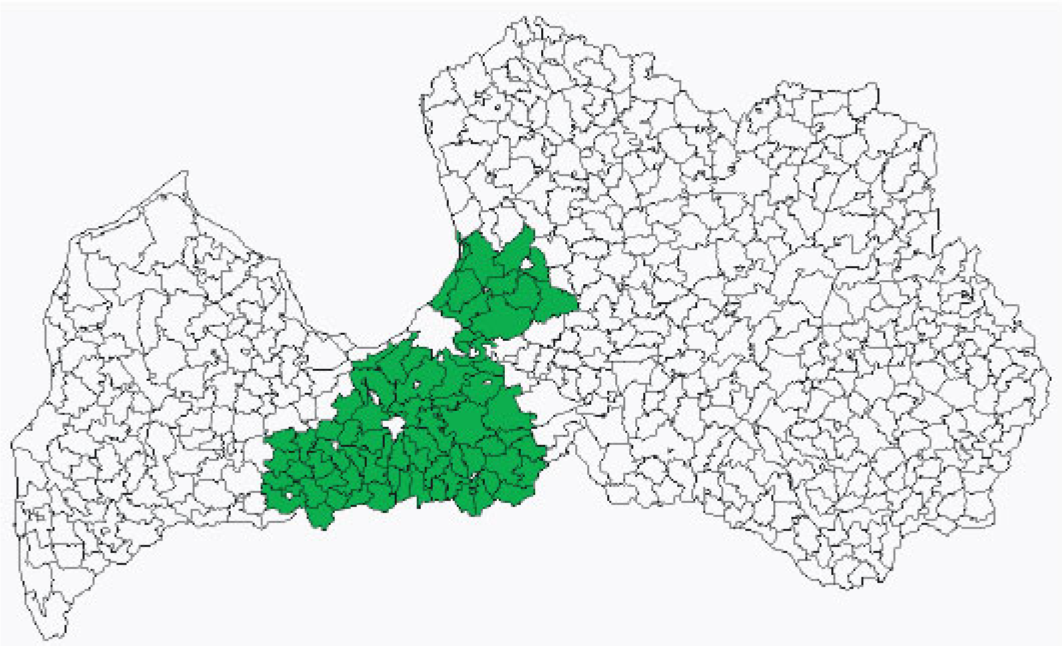

Figure 8: Location of vulnerable zones (in green) in the territory of Latvia[12]

According to the run-off monitoring results, the highest leaching and run-off losses were observed in areas characterized by high animal density and intensive application of the manure. To avoid the release of leakage fluids in to the watercourses, ground waters and soil, particularly concerning nitrogen vulnerable zones, practices of proper manure management and application have to be considered.

[11] Lauksaimniecības notečų monitorings (Monitoring of Agricultural Run-offs), University of Agriculture of Latvia, 2006

[12] Regulation of Cabinet of Ministers of Latvia Nr.1002 „Kārtība, kādā ieviešams programmdokuments „Latvijas Lauku attīstības plāns Lauku attīstības programmas īstenošanai 2004.-2006.gadam", 30.11.2004

6.1.3 Land use

One of the most significant environmental impacts resulting from growing of energy crops for biogas production is land use change. After 1990 there was a rapid decline in agriculture in Latvia resulting to a lot of unused agricultural areas. According to the national statistical data[13,] during the last 8 years the area of utilized agricultural land tends to increase, however, almost 40 % of available agricultural land in Latvia is still not used for agricultural production. Biogas production could contribute to more intense use of available agricultural land allowing increasing the standard of living for farmers.

According to the recent investigations[14] prepared by the University of Agriculture of Latvia, the huge amounts of unused land ensures that growing energy crops for biogas production will not stand the competition with agricultural crops and in long term increase of competition would promote more intensive development of agriculture in Latvia and giving agricultural products with higher additional value.

6.1.4 Waste

According to the Latvia's National GHG Inventory Report 1990-2006[15], GHG emissions from waste sector have been increased since 1990. In 2006, emissions were ~12 % higher than in 1990, contributing to about 6.57 % of total GHG emissions (excluding LULUCF).

The main directions in the waste management are the development of the construction of polygons and collecting system for non–hazardous municipal waste. According to Latvian Waste management plan for 2006-2012[16] there will be 11 waste polygons in Latvia. Biogas collection and use for energy production from biodegradable wastes and sludge is set as one of priorities in Latvia.

6.2 Social and economic impacts

Concerning the level of development, there is a big difference among urban and rural territories of Latvia. To evaluate the level of development, every year the State Regional Development Agency[17] calculates development index for each administrative territorial unit of Latvia. The development index is calculated based on different indicators like unemployment rate, income-tax per capita, demographical load, population density, change in number of population, etc. Comparison of development indexes for rural territories shows that from the total 449 rural parishes only 147 (33 %) has positive development index in 2006. Exploitation of locally produced renewable energy

[13] Central Statistical Bureau of Latvia: www.csb.gov.lv

[14] Biomasas izmantošanas ilgtspējības kritēriju pielietošana un pasākumu izstrāde (Development of actions and implementation of sustainability criteria for biomass use), University of Agriculture of Latvia, 2009

[15] Latvia's National Inventory Report 1990-2006: Submitted under United Nations Convention on Climate Change and the Kyoto Protocol, 2008

[16] Latvian Waste management plan for 2006-2012, Ministry of Environment, 2005

[17] State Regional Development Agency: http://vasab.org/en/about/ , Development Index in 2006

resource like biogas could positively affect all those indicators and increase the level of development of rural territories of Latvia.

6.2.1 Employment, income, and rural development

Biogas sector development creates new jobs and new markets for manufacture of technical equipment, construction and operation of biogas plants. This is very important for Latvia since due to the economical crisis unemployment rate recently has increased in all sectors and in all regions of Latvia.

Biogas gives new income opportunities for farmers that could gain additional income from biogas production by producing energy and reducing their organic waste amounts. Biogas production could be one of the solutions for farmers suffering from low milk prices having in Latvia one of the lowest prices among all European countries[18].

In case of Latvia when a lot of agricultural land is unused each activity that promotes the use of agricultural land including biogas production will give a positive impact on income of farmers and overall rural development.

6.2.2 Substitute for fossil energy and energy imports

Latvia has a relatively high dependency on fossil fuels end imported energy. According to the National Energy Development Plan for 2007-2016[19], only 36 % of energy consumption is covered by locally available energy resources. About 29 % of primary energy resources are covered by natural gas that is imported from one supplier – from Russia, ~30 % are imported oil products from CIS and other countries, coal and imported electricity are counting for the rest of ~5 %.

Biogas production would allow reducing dependency from imported fossil fuels and to strengthen national and regional economy in Latvia. In order to achieve that and to be able to compete with fossil fuels, a strong incentives or subsidies for biogas are required. Yet, the new feed-in tariff system for biogas electricity is introduced in Latvia; still the efficiency of the new system is not proved on real projects.

6.2.3 Social acceptance

Generally public attitude regarding renewable energy and biogas is positive. However, time by time as well some negative experiences regarding odours from industrial and agricultural processes, particularly from pig farms are circulating in regional media. Therefore building a biogas plant could be a very sensitive issue regarding the social acceptance. To improve the social acceptance of particular biogas project public involvement is crucial and it must be considered during the planning process.

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[18] EU Farmgate Milk Prices Report, 24/02/2009: http://www.mdcdatum.org.uk/MilkPrices/eumilkprices.html

[19] National Energy Development Plan 2007-2016, Ministry of Economy of Latvia, 2006

7 Impacts in Romania

Romania is a country located in South-East Central Europe, North of the Balkan Peninsula, on the Lower Danube, within and outside the Carpathian arch, bordering on the Black Sea. Almost all of the Danube Delta is located within its territory. It shares a border with Hungary and Serbia to the west, Ukraine and the Republic of Moldova to the northeast, and Bulgaria to the south. Romania has the 9th largest territory and the 7th largest population (with 22 million people) among the European Union member states. Its capital and largest city is the 6th largest city in the EU with 1.9 million people.

Figure 9: Topographic map of Romania

Owing to its distance from the open sea and position on the southeastern portion of the European continent, Romania has a climate that is transitional between temperate and continental with four distinct seasons. The average annual temperature is 11 °C (52 °F) in the south and 8 °C (46 °F) in the north. The extreme recorded temperatures are 44.5 °C (112.1 °F) in Ion Sion 1951 and −38.5 °C (−37 °F) in Bod 1942.

Spring is pleasant with cool mornings and nights and warm days. Summers are generally very warm to hot, with summer (June to August) average maximum temperatures in Bucharest being around 28 °C (82 °F), with temperatures over 35 °C (95 °F) fairly common in the lower-lying areas of the country. Minima in Bucharest and other lower-lying areas are around 16 °C (61 °F), but at higher altitudes both maxima and minima decline considerably. Autumn is dry and cool, with fields and trees producing colorful foliage. Winters can be cold, with average maxima even in lower-lying areas being no more than 2 °C (36 °F) and below −15 °C (5.0 °F) in the highest mountains, where some areas of permafrost occur on the highest peaks.

Precipitation is average with over 750 mm (30 in) per year only on the highest western mountains — much of it falling as snow which allows for an extensive skiing industry. In the south-centern parts of the country (around Bucharest) the level of precipitation drops to around 600 mm (24 in), while in the Danube Delta, rainfall levels are very low, and average only around 370 mm.

7.1 Environmental impacts

A high percentage of natural ecosystems (47 % of the land area of the country) is covered with natural and semi-natural ecosystems. Since almost half of all forests in Romania (13 % of the country) have been managed for watershed conservation rather than production, Romania has one of the largest areas of undisturbed forest in Europe. The integrity of Romanian forest ecosystems is indicated by the presence of the full range of European forest fauna, including 60 % and 40 % of all European brown bears and wolves, respectively. There are also almost 400 unique species of mammals (of which Carpathian chamois are best known), birds, reptiles and amphibians in Romania.

There are almost 10,000 km^2 (3,900 sq mi) (almost 5 % of the total area) of protected areas in Romania. Of these, Danube Delta Reserve Biosphere is the largest and least damaged wetland complex in Europe, covering a total area of 5,800 km^2 (2,200 sq mi). The significance of the biodiversity of the Danube Delta has been internationally recognized. It was declared a Biosphere Reserve in September 1990, a Ramsar site in May 1991, and over 50 % of its area was placed on the World Heritage List in December 1991. Within its boundaries is one of the most extensive reed bed systems in the world. There are two other biosphere reserves: Retezat National Park and Rodna National Park.

Romania has implemented most of the European regulation related to environment protection and emissions. Also, regulations related to minimum share of bio-energy and renewable energy target are similar to European Union recommendations.

In the light of those regulations, biogas sector development impact could be assessed to be beneficial, and able to contribute to the below mentioned areas.

7.1.1 Air emissions

The Kyoto Protocol was signed by Romania in 1999 and ratified in 2001. After 1989 a net decrease of GHG was observed. Anyhow, growing economy and increased development of industrial sectors raised the net amounts in the last 8 years. Tendency is linked with the economic development and it will increase on a yearly base. New means of keeping the GHG emissions within limits must be developed.

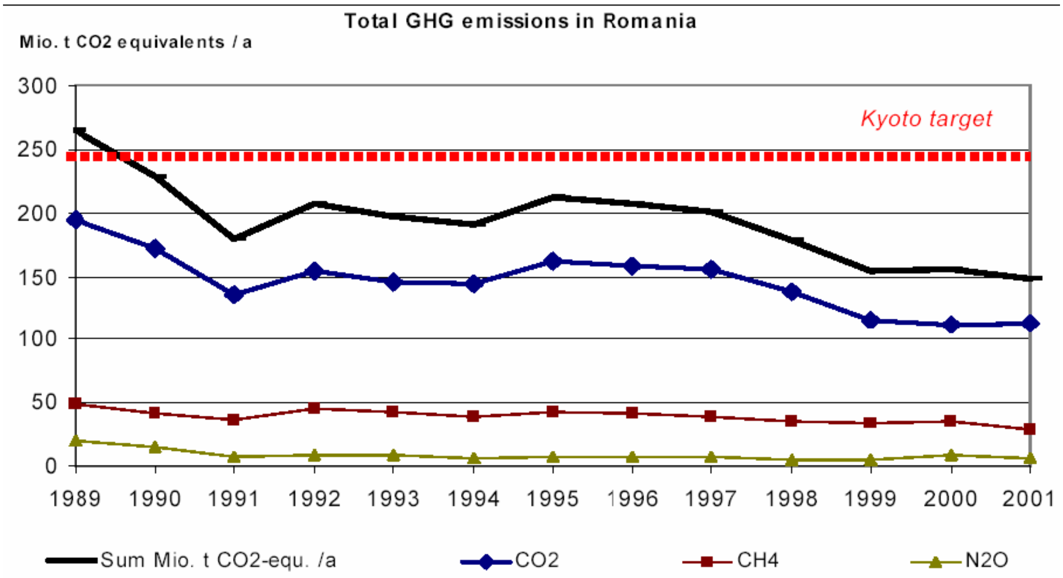

Figure 10: Total green house gas emissions in Romania in the "decreasing" period

7.1.2 Water, soil and waste management

One important problem that could be alleviated by the biogas sector is waste management. A large majority of the urban residues is stored in waste dumps. Solid residues from water sewage sludge treatment are seldom also stored in waste dumps. This open air waste deposits constitute a big source of GHG, especially CH_4.

Biogas plants could deal with part of organic matter disposed in wastewaters treatment plants, contributing to a lower GHG emissions.

7.1.3 Land use

Romania is covered by 40 % of agricultural land and 27 % of forest.

The share of biomass in the total energy production of the country is almost 10 %. Currently, biomass is used only for heating purposes, direct burning for cooking and hot water preparation consuming the largest share. About 95 % of the biomass currently used is firewood and agricultural waste, the rest is wood waste from industrial processes.

7.2 Social and economic impacts

Dependency on fossil energy reserves was highly discussed matter. Romania itself depends only in a proportion of 20-30 % of total natural gas consumes on Russian gas. Romania exploits own reserves and those counts for 70-80 % of total consume. A highly developed hydropower infrastructure is supplementing power need, along with a nuclear power station counting for 10 % of the total electricity consume of the country.

Anyhow, there is a clear legislative frame, aiming to increase the quota of alternative energy to 20 % from the total need till 2030. Biogas could be one of the possible ways to reach this target.

7.2.1 Social acceptance

There is a general good opinion on biogas production in Romania. Surprisingly, there were opinion pros and cons for biodiesel production for example. Most of the arguments are based on the competition for land with the food production. Contrarily, biogas is perceived as a potential green energy, and general perception is that biogas production could and should be developed in Romania. Nevertheless, a series of barriers, described in other deliverables of the BiG>East project, slow down the development of the sector.

8 Impacts in Slovenia

In its motion for a European parliament resolution on Sustainable Agriculture and Biogas: a need for review of EU-legislation (2007/2107(INI)) the European Parliament acknowledges biogas as a vital energy resource that contributes to sustainable economic¸ agricultural and rural development and environmental protection; and encourages the member states to exploit the huge potential in biogas by creating a favorable environment as well as maintaining and developing support schemes to inspire investment in and sustenance of biogas plants.

This position is supported also by Slovenian authorities and experts. Positive impacts and areas where there is need for remediation can be clearly seen if we look at the current environmental situation in Slovenia.

8.1 Environmental Impacts

8.1.1 Air and emissions

Industrialisation has contributed to a considerable rise in greenhouse gas (GHG) emissions, which cause global warming. By signing the United Nations Framework Convention on Climate Change, Slovenia joined the efforts to reduce the influence of human activity on the environment. The next step in this direction was the Kyoto Protocol the signing of which committed Slovenia to reduce its emissions by 8 % in respect of the 1986 base year, within the first target period 2008-2012. The indicator shows the trend of total greenhouse gas emission quantities in Slovenia and main source categories. The quantities are calculated using the IPCC methodology (IPCC – Intergovernmental Panel on Climate Change).

The total emissions of GHG in 2007, sinks not considered, amounted to 20,709.94 kt CO_2 eq., which represents a 1.8 % increase of emissions compared to 1986 base year. In the period 1986-91, a reduction of emissions was recorded due to the economic conditions at that time. In the period 1992-97, a strong increase of emissions was recorded, which was a consequence of increasing economic growth and revival of industrial production. In the second half of that period, the increased emissions were a consequence of “gasoline tourism” (25 % of the total sale of motor fuels in the Republic of Slovenia), since the prices of motor fuels in Slovenia were appreciably lower than in the neighbouring countries.

CO_2 emissions, which results mainly from fuel combustion, in 2007 represented 82 % of overall emissions of greenhouse gases. CO_2 emissions followed the consumption of energy and with regard to their fraction exerted a major influence on total emissions. Compared to 1986, in 2007 they increased by 4.3 %. The second largest contributor was methane, mostly deriving from wastes and agriculture. CH_4 emissions represented 10.4 % of total emissions in 2007 (11.7 % in 1986) and were lower than in 1986 by 9.4 % and third di-nitrogen oxide, deriving from agriculture as well. N_2O emissions represented 6.4 % of total emissions and were lover of N_2O emissions in 1986 by 4.1 %. Also noticeable were traffic-related emissions. Emissions of F-gases which include hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6), are very small, but due to high greenhouse potential, their contribution to global warming is far from insignificant. F-gasses represent 1.2 % of total emissions and some of them (HFC and SF6) have shown significant increase since 1995 (base year for F-gases).

Table 6: GHG emission trends by gas; Source: Slovenia's national inventory report 2009 (*Land Use, Land Use Change and Forestry)

GREENHOUSE GAS EMISSIONS	1986	1990	1995	2000	2005	2006	2007	Change from 1986 to 2007
	CO_2 eq. (Gg)	CO_2 eq. (Gg)	CO_2 eq. (Gg)	CO_2 eq. (Gg)	CO_2 eq. (Gg)	CO_2 eq. (Gg)	CO_2 eq. (Gg)	(%)
CO_2 emissions including net CO_2 from LULUCF*	14,703.31	11,557.49	10,062.30	10,047.35	11,244.70	12,120.72	11,214.81	-23.73
CO_2 emissions excluding net CO_2 from LULUCF	16,292.56	14,743.24	14,967.54	15,222.51	16,675.07	16,853.81	16,989.17	4.28
CH_4	2,384.02	2,303.59	2,167.33	2,228.86	2,183.56	2,148.70	2,159.88	-9.40
N_2O	1,376.36	1,256.12	1,170.75	1,319.39	1,284.10	1,309.29	1,319.45	-4.13
HFCs			28.96	31.13	95.62	112.05	130.91	100.00
PFCs	276.29	257.44	285.68	105.61	123.53	115.55	91.69	-66.81
SF_6	10.24	10.30	11.52	15.74	18.84	18.84	18.84	83.97
Total (including net CO_2 from LULUCF)	**18,750.22**	**15,384.96**	**13,726.55**	**13,748.07**	**14,950.35**	**15,825.15**	**14,935.59**	**-20.34**
Total (excluding net CO_2 from LULUCF)	**20,339.47**	**18,570.70**	**18,631.79**	**18,923.23**	**20,380.72**	**20,558.24**	**20,709.94**	**1.82**

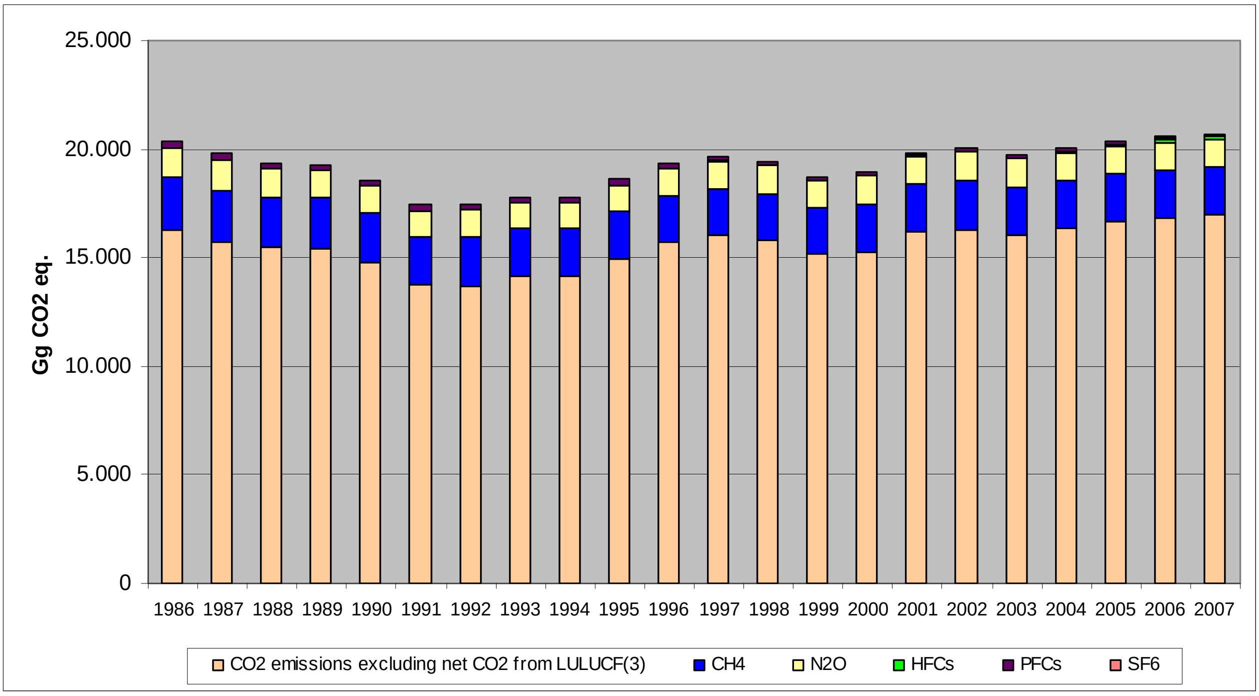

Figure 11: GHG Emissions in Slovenia by gas; Source: Slovenia's national inventory report 2009

In order to fulfil the obligations arising from the Kyoto Protocol it was therefore necessary to introduce additional measures. The majority of them are described in the Operational Programme for the Reduction of Greenhouse Gas Emissions, drawn up and adopted by the Government of the Republic of Slovenia in 2003. For the reduction of greenhouse gas emissions in the area of energy production and consumption, the Energy Act was adopted in 1999, and the National Energy Programme (NEP) has been drawn up as well. Both these documents envisage a sustainability-oriented development of the energy sector by enhancing the effectiveness of energy as well as consumption of renewable energy sources. In 2005, one of the three most essential Kyoto mechanisms has begun functioning as well, i.e. trade in greenhouse gas emissions, which include 97 installation operators from Slovenia. In the EU, emission trading will be introduced in the period 2005-2007, and on a global level, in the period 2008-2012.

According to the UNFCCC Reporting Guidelines, emissions estimates are grouped into six IPCC categories: Energy, Industrial Processes, Solvent use, Agriculture, Land Use, Land-Use Change and Forestry, and Waste.

By far the most important sector is **Energy**, which in 2007 accounted for 80.6 % of the total GHG emissions. Emissions in this sector have increased by 3.9 %, compared to the base year. Within this sector, in the period 1986-2007, GHG emissions from Energy Industry, as the biggest sub-sector, have been reduced by 2.0 %. In the most recent period, 1999-2007, steep growth (+25.9 %) has been recorded which is due to the increased consumption of electrical energy. Undoubtedly, the highest increase of GHG emissions has been in traffic sector, by as much as 165.3 %, due to an increase in road transportation, while emissions from other kinds of traffic have been slightly reduced. There was an appreciable reduction of GHG from industry in period 1986-2000 (-52 %). In the time after 2000, a stabilisation of emission has been observed.

Lower emissions than those in the base year are noticed within the agricultural sector, which is mostly a result of reduction in the number of livestock units. The future projections anticipate that the number of cattle will again rise due to quotas determined for Slovenia. On the other hand, agricultural policy will, by introducing good agricultural practice in fertilising and establishing biogas consumption for electricity and heating production, influence the reduction in agricultural emissions. This is especially true in case of landfill gas capturing and utilisation.

In **Agriculture** as the second most important sector, emissions in 2007 amounted to 2082.1 Gg, which represented 10.1 % of all emissions. Agriculture represents the main source of methane and N_2O emissions, namely 52.9 % of all methane emissions and 71.1 % of all N_2O emissions. Within the agricultural sector, N_2O emissions account for 45.1 % of emissions, CH_4 emissions account for 54.9 % of emissions. GHG Emissions from agriculture show small oscillations for individual years, but the general trend is on the decrease. In 2007, emissions were 10.8 % below the base year.

The most important sub-sector are emissions from agricultural soils, which contribute 36.7 % of all emissions from agriculture, followed by emissions from enteric fermentation with 32.9 %, the rest is contributed by emissions of methane and N_2O from animal manure (30.4 %).

In 2001 the territory of the whole Slovenia was declared as an area sensitive to nitrates pollution. This means the Nitrate directive applies for whole Slovenia.

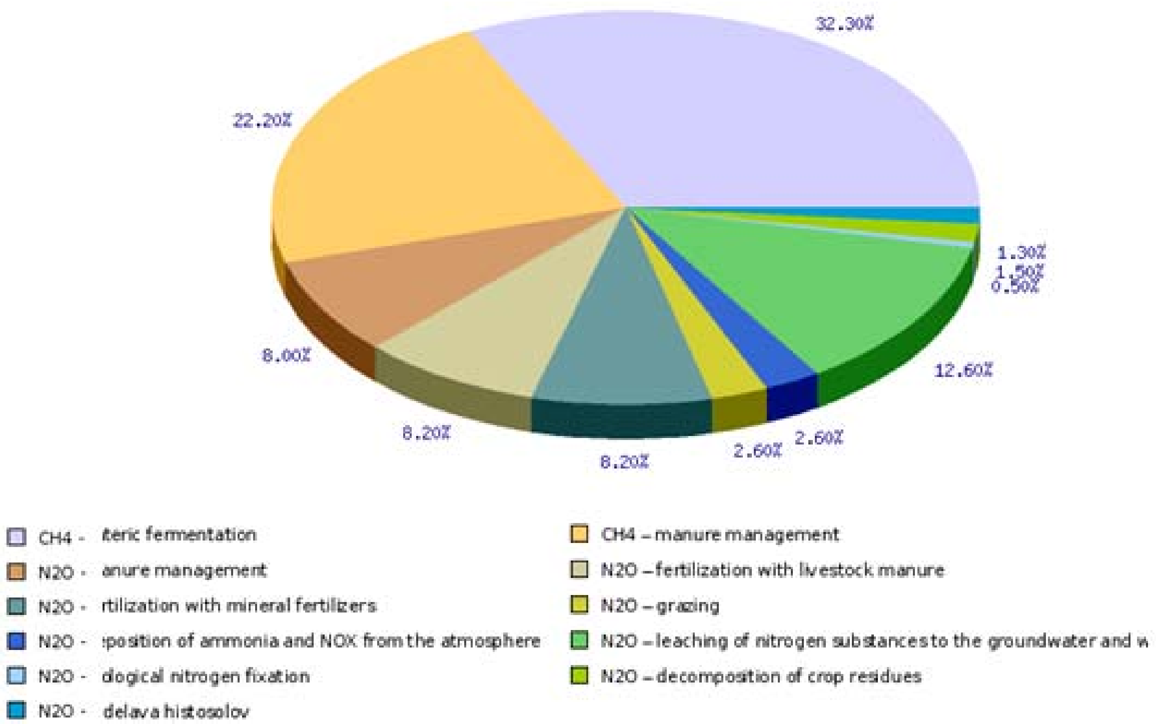

Figure 12: Structure of greenhouse gases in agriculture in 2006; Source: Environmental Agency of the Republic of Slovenia, ARSO

In 2006, agriculture contributed 95.6 % of total ammonia emissions in Slovenia. According to the data for 2002, ammonia emissions per hectare of utilised agricultural area (37.4 kg per year) are considerably above the EU-15 average (21.7 kg per year). Between 1990 and 2005, ammonia emissions in Slovenia were reduced by 12.9 %. In the last few years, ammonia emissions in Slovenia have been just below the limit defined by the adopted international obligations (20,000 tons per year).

Ammonia causes a lot of damage to people's health, environment and agriculture. Its salts are transported to long distances, forming small particles which cause respiratory diseases. It also contributes to the formation of acid rain and causes soil acidification. With ammonia, nitrogen is deposited into natural ecosystems, causing their changes. In large concentrations, ammonia has a direct harmful effect on the health and well-being of people and animals, and a direct poisonous effect on plants. And last but not least, with ammonia, we are losing nitrogen in the air, which is a valuable nutrient.

Agriculture contributes a great majority of all atmospheric ammonia emissions. The most ammonia is released in fertilization with livestock manure, followed by emissions from animal houses and due to grazing, emissions from livestock manure storage and emissions due to fertilization with mineral fertilizers. One of the reasons for major emissions in fertilization is the lack of machinery for banded application or incorporation of slurry into soil. Emissions during soil fertilization using this machinery are considerably lower than during the common method of spraying the slurry. Of all types of farming, cattle production, including emissions from application of cattle manures, contributes the most ammonia (59.9 %), followed by pig production with 19.3 %.

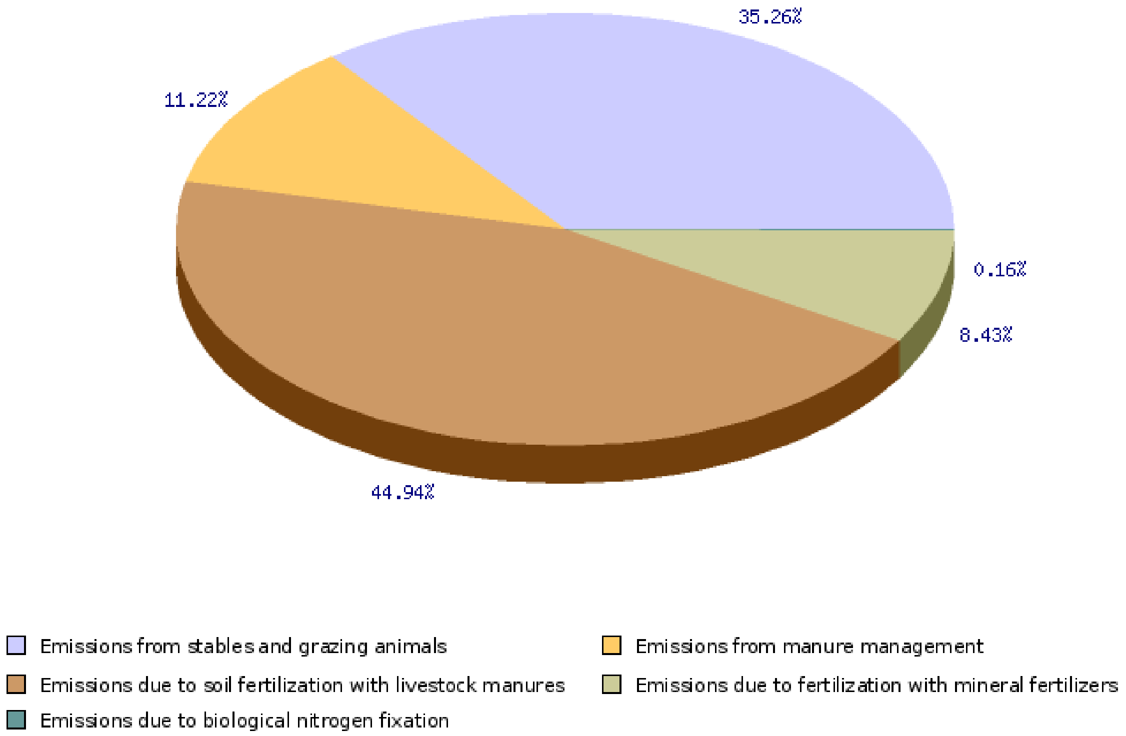

Figure 13: Sources of ammonia emissions in agriculture in Slovenia in 2006; Agricultural Institute of the Republic of Slovenia, 2008

Annual emissions of ammonia per hectare of utilised agricultural area in Slovenia are well above the EU-15 average. This is due to the large share of grassland and consequently well developed livestock production. On the national level, in the countries with well developed arable farming, the emissions of ammonia from livestock production are distributed to the arable areas with a relatively low number of livestock. High emissions are also the consequence of the prevailing barn rearing of livestock, where emissions are much higher than in free-range production systems.

Methane emissions from the **Waste** sector are the second largest source of methane and represent 28.2 % of all emissions of methane in Slovenia. The fraction of methane emissions in this sector amounts to 90.6 %, the remaining part representing N_2O. Solid-waste handling contributes 67.5 % to the total emissions from this sector, municipal wastewater 23.6 %, and industrial wastewater 8.9 %.

Compared to the base year, emissions have risen by 19 %, which is mostly due to emissions from SWDS that show an increase of 51.7 %. The increase of emissions from this source is a consequence of the increase in the amount of disposed municipal waste and the application of FOD method for calculating emissions. Emissions from wastewaters are lower than in the base year by 18.3 %, which is mostly due to the recovery of gas in wastewater treatment plants and the decrease of industrial production.

Forests cover more than 57 % of Slovenia's land surface and constitute an important source of reducing GHG emissions. Calculations of sinks are considerable due to land use change and forestry; in 2003, CO_2 sinks reached 5,561 Gg, exceeding a much lower recognizable level. On the basis of the condition stipulating that these sinks must be a direct result of human activity so that the state may use them for the purposes of fulfilling its obligations, an assessment was selected according to which it will be possible to make use of at least 840 Gg CO_2 during the period 2008-2012.

Table 7: GHG emissions and removals in Slovenia by sector: 1986-2007; Source: Slovenia's national inventory report 2009

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1986	1990	1995	2000	2005	2006	2007	Change from 1986 to 2007
	CO_2 eq. (Gg)	CO_2 eq. (Gg)	CO_2 eq. (Gg)	CO_2 eq. (Gg)	CO_2 eq. (Gg)	CO_2 eq. (Gg)	CO_2 eq. (Gg)	(%)
1. Energy	16,069.02	14,395.13	14,854.08	15,074.34	16,423.88	16,574.18	16,688.36	3.85
2. Industrial Processes	1,288.06	1,292.16	1,109.47	970.14	1,185.69	1,217.45	1,225.49	-4.86
3. Solvent and Other Product Use	81.90	43.40	17.25	42.73	43.32	44.15	42.16	-48.52
4. Agriculture	2,334.30	2,242.73	2,117.36	2,162.34	2,005.80	2,029.22	2,082.08	-10.80
5. Land Use, Land-Use Change and Forestry	-1,589.25	-3,185.75	-4,905.24	-5,175.16	-5,430.37	-4,733.09	-5,774.35	263.34
6. Waste	566.19	597.29	576.29	673.68	722.03	693.24	671.85	18.66
7. Other	NA	NA	NA	NA	NA	NA	NA	NA
Total (including LULUCF)	**18,750.22**	**15,384.96**	**13,769.22**	**13,748.07**	**14,950.35**	**15,825.15**	**14,935.59**	**-20.34**
Total (excluding net CO_2 from LULUCF)	**20,339.47**	**18,570.70**	**18,631.79**	**18,923.23**	**20,380.72**	**20,558.24**	**20,709.94**	**1.82**

There is another emission that could be reduced (but also enhanced if not handled right) through biogas production – odour from cattle breeding. Odour is a site specific problem arising mainly from the feedstock management and storage into the biogas plant and the digestion process. Some of the recommendations for odour control measures are the limited storage time, the careful handling procedures, and the use of odour control equipment where such devises are necessary and covered units.

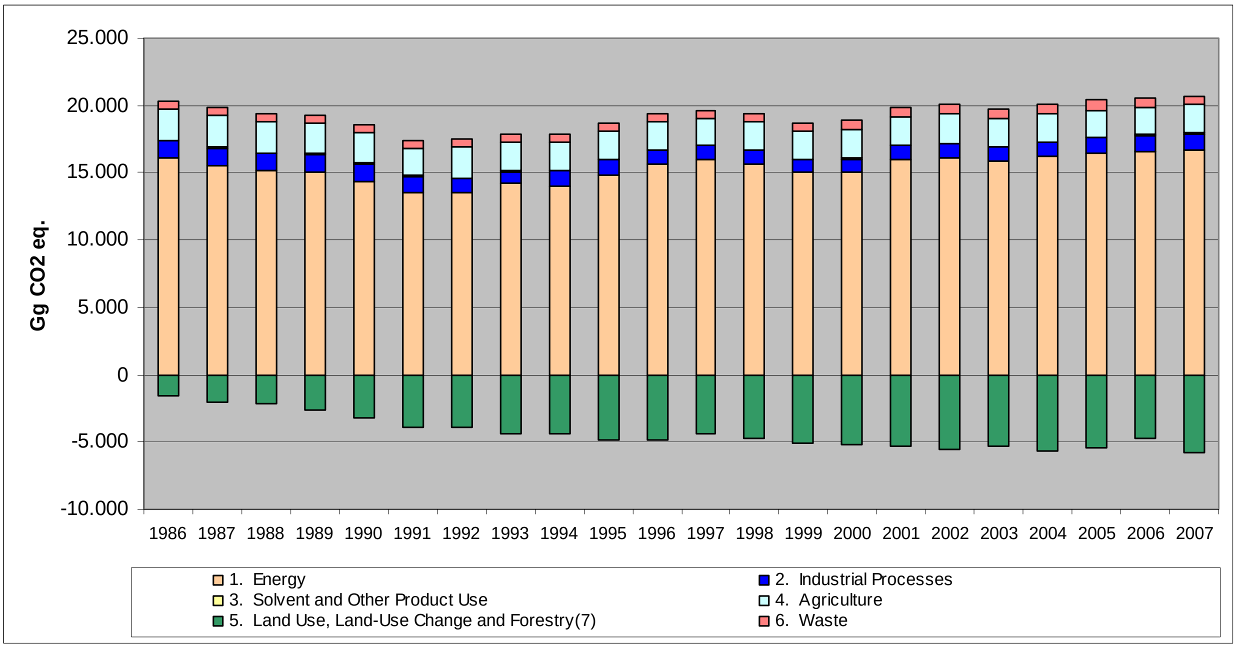

Figure 14: GHG Emissions in Slovenia by sector; Source: Slovenia's national inventory report 2009

8.1.2 Soil and water

In comparison with other countries, water quality in Slovenia is among the highest in Europe. One of the reasons is undoubtedly that most of the rivers rise on the territory of Slovenia. But this does not mean that Slovenia has no problems with surface water and groundwater quality. Some river sections are still loaded with excessive amounts of industrial and municipal waste waters and are therefore substantially polluted or even over-polluted. Problems are also present in groundwater, which represents the main source of drinking water in Slovenia. Groundwater is polluted with nitrates and pesticides, and, on a local level, additionally with chlorinated organic solvents. The highest level of pollution is registered in the north-eastern part of Slovenia and in the vicinity of Celje.

In Slovenia, alluvial aquifers present 60 % of the drinking water sources, and karst-fractured aquifers present 40 %. Due to populated areas and intensive agricultural production, alluvial aquifers are exposed to greater risks of pollution with nitrates. In two out of four alluvial aquifers (Lower Savinjska dolina valley, the Bolska River valley and Prekmursko-Mursko polje), excessive burdening of underground water with nitrates (more than 50 mg/l) was detected in the period between 1993 and 2004, and individual samplings of nitrate contents were also exceeded in the Krško-Brežiško polje aquifer. Three selected karst-fractured aquifers did not indicate excessive burdening with nitrates.

Monitoring showed that most aquifers where limit values are exceeded are located in lowlands with intensive agriculture. The water quality of Slovenia's rivers and streams is improving. The number and efficiency of purifying devices and percentage of treated wastewater is increasing, therefore it is expected that water quality should increase even more in the future. The concentrations of pesticides and nitrates in ground water will decrease, but there still exists the risk of old environmental burdens.

54 % of Slovene water potential is in Sava river basin and 42 % in Drava river basin. 41 % of water that flows through Slovenia comes from Austria.

The quality of surface water was improved mainly due to decrease in pollution (lower emissions from industry, improved and extended waste water treatment). The number of WWTP and thus the share of treated wastewater is increasing. The number of Illegal landfills that may cause serious negative impact on quality of surface or groundwater decreased. The percentage of rivers and streams in Class IV "very polluted" is in the last years stable (5 %).

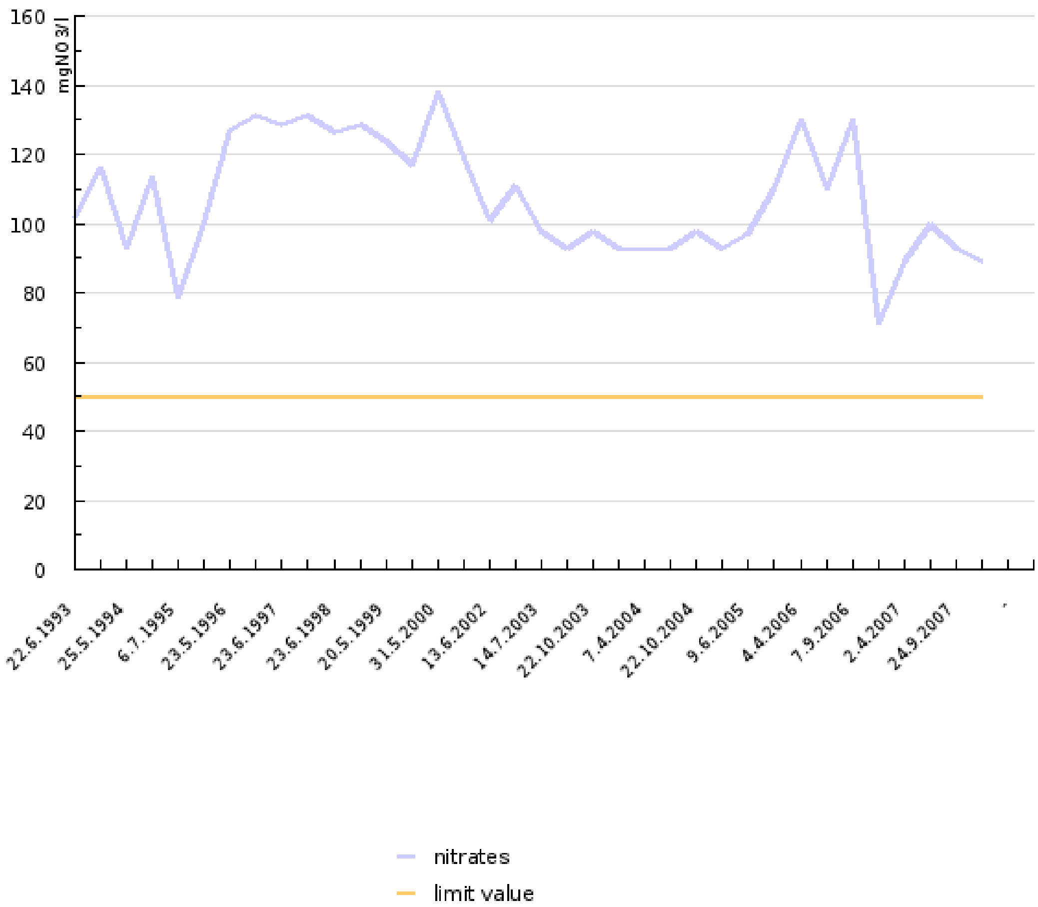

Figure 15: Groundwater nitrates concentration on monitoring station Lipovci, Murska kotlina groundwater body in the period 1993-2007; Source: Environmental Agency of the Republic of Slovenia (ARSO), 2008

The main source of the input of nitrates into groundwater is point pollution (unregulated livestock manure storage and sewage system) and non-point pollution due to the use of livestock manure and mineral fertilizers. To reduce the burdening of water with nitrates, a stocking density limitation on agricultural land has been in force in Slovenia since 1996, and environmentally friendly ways for the fertilization of agricultural land have been prescribed. Agro-environmental measures, implemented in accordance with the Rural Development Programme, are oriented toward the reduction of water pollution with nitrates. Recipients of payments in this field of work are bound by even stricter measures regarding stocking density on agricultural land than those prescribed by the legislation. The results of stricter regulations and special measures, however, are not yet evident from the state of aquifers. In accordance with the Rural Development Programme, Slovenia started to take measures for the adaptation of agriculture to European standards in 2004 by building new livestock manure storages which will significantly help improve the state of waters. The results of this measure are only expected to show in the years to come.

Organic matter in **soil** is an important indicator of the quality of soil. In general, soil in Slovenia is well supplied with organic matter; this is evident from soil map data, which indicate that 86.2 % of agricultural land contains more than 2 % of organic matter, and 30.9 % of land contains more than 4 %.

This relatively good condition of soil is due to the fact that grassland is the prevailing element in the composition of agricultural land and that arable land and permanent crops are relatively abundantly fertilized with livestock manure. In the areas with intensive land cultivation, the soil has a lower organic matter content than the soil on land that is not ploughed or deep ploughed. The reason for this is the more intensive rate of mineralization of organic matter on such land.

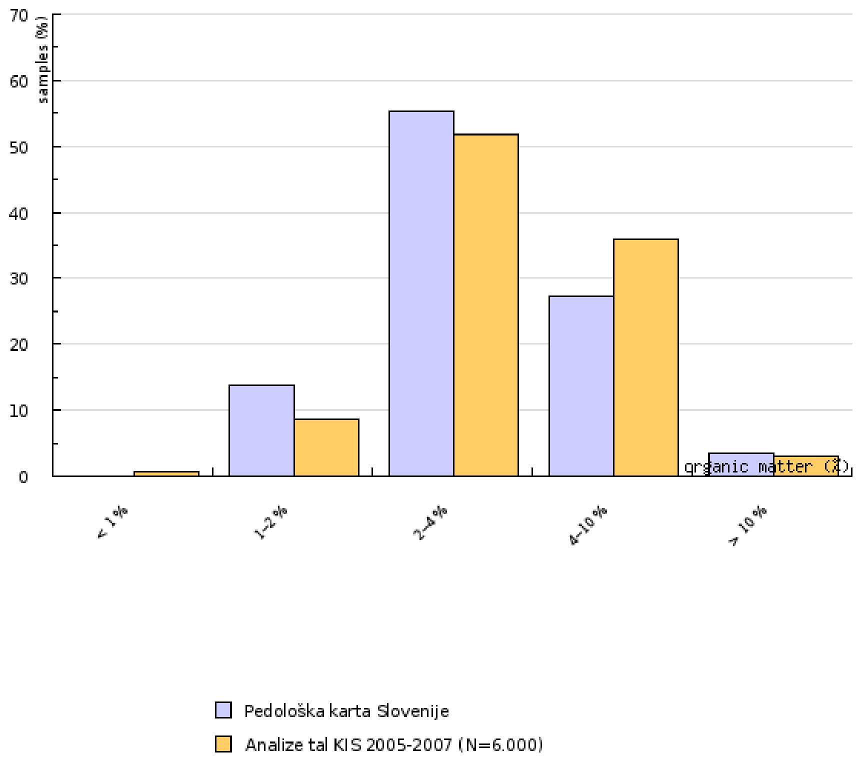

Figure 16: Distribution of organic matter in soil for the data acquired from the Soil Map (SM) 1:25.000, and for the laboratory analyses data in 2005-2007 (AIS); Source: ARSO

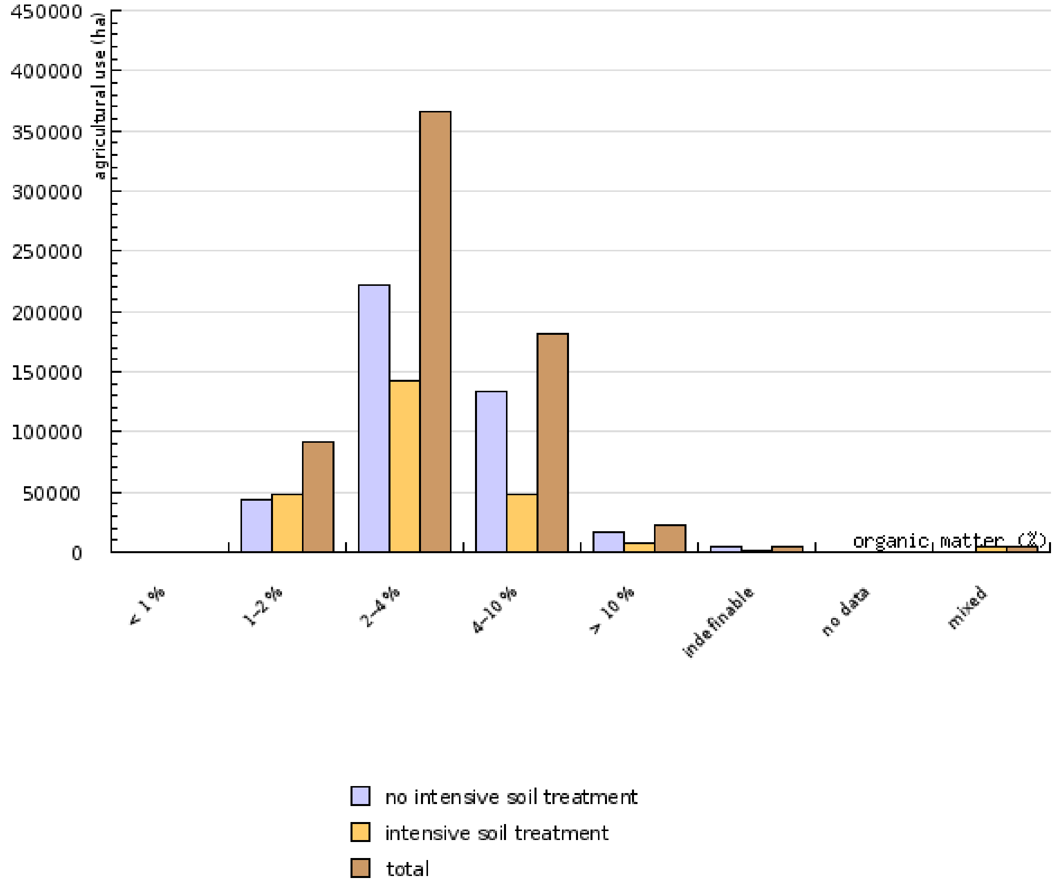

Figure 17: Structure of different types of agricultural land use in terms of organic matter; Source: ARSO

Furthermore animal manure, municipal sewage and agro-industrial waste can contain potentially harmful substances (bacteria, viruses, parasites, heavy metals, harmful organic substances) that can be a threat to the public health and/or environment.

8.1.3 Landscape and land use

Land use relates to the exploitation of land caused by human activity in the landscape, and is one of the best indicators of landscape structure and processes. Basic categorisation distinguishes simply between rural and urban land uses. Land cover demonstrates the physical aspect of land surface, irrespective of its purpose. It comprises the following categories: artificial areas, agricultural areas, forest and semi-natural areas, wetlands and water bodies. The indicator offers answers to the questions as in what way and to what extent the landscape is changing, as well as where the most intensive processes are taking place. Brought to the fore are the relationships among various types of use (urban, agricultural, etc.) that are driven by social and economic activities. The nature of settlement distribution indicates whether the scope of impact is broad (covers the entire region) or narrow (limited to a specific area).

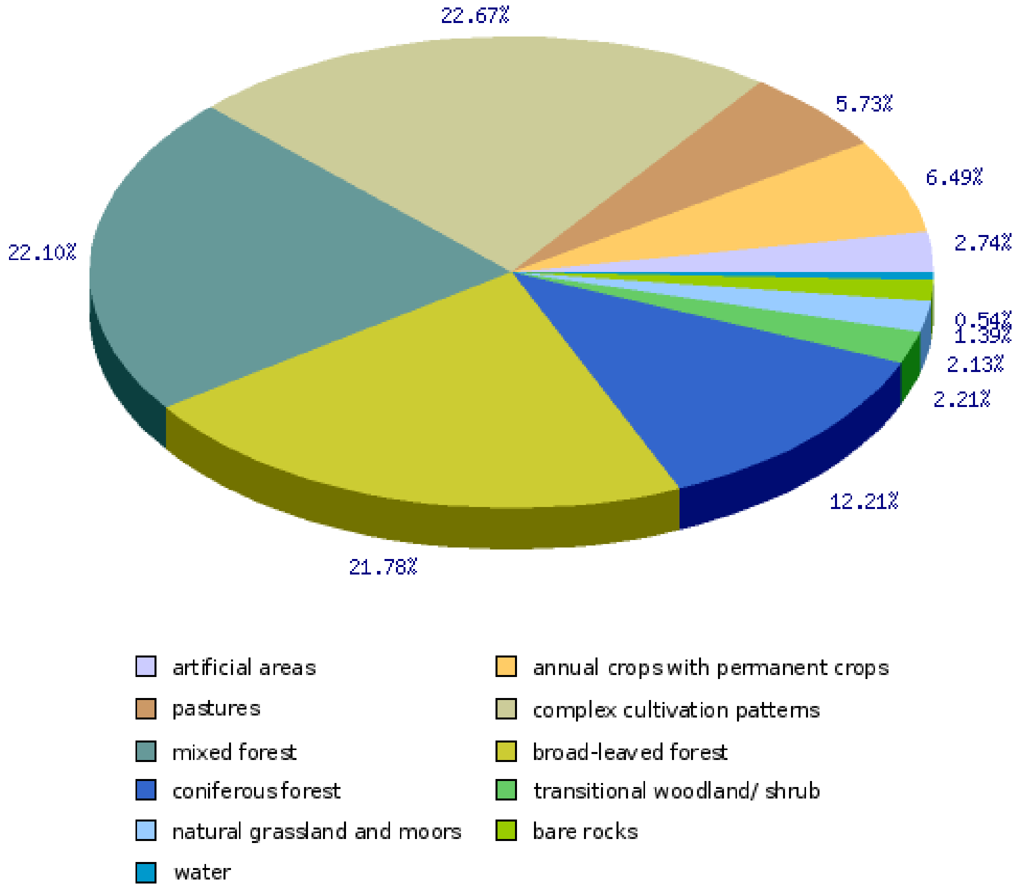

Figure 18: Structure of land cover and land use categories in Slovenia in 2006; Source: ARSO, 2007

For the land cover and land use change, the period between 1995 and 2000 is a brief one and the changes demonstrated small, since the applied methodology covers only major changes (above 5 ha). A detailed overview by individual categories indicates that during the period in question, the shares of discontinuous urban fabric as well as industrial, road and rail network units increased, while the share of mineral extraction sites, dump sites and construction sites decreased. The greatest expansion with regard to agricultural land occurred in pastures, while the extent of non-irrigated arable land, complex cultivation patterns and land principally occupied by agriculture, with significant areas of natural vegetation, decreased. In forests, only transitional woodland shrub experienced an increase, while the share of broad-leaved, coniferous and mixed forests decreased. During the period 1995-2000, the ratio between forest areas, on the one hand, and agricultural and artificial surfaces land, on the other, was maintained at 1:1.64 in favour of the former.

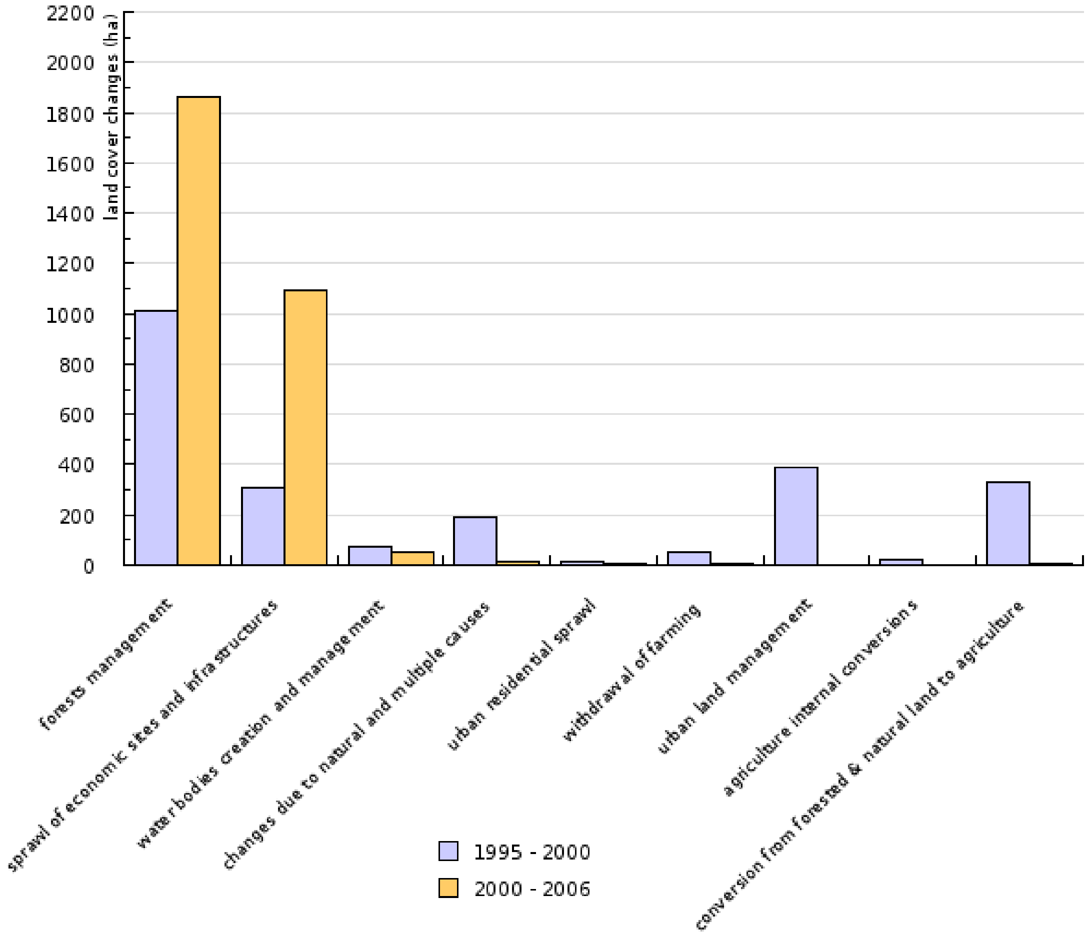

Figure 19: Changes in total area of land cover-land use categories between 1996 and 2000 and 2000 and 2006; Source: ARSO, 2007

Like elsewhere proposals to use the agricultural land for energy crops have started quite some dispute about pros and cons and a final common agreement has yet to be made. Nevertheless, there are some estimation from the part of agricultural experts that about 10 % of the arable land could be used for energy purposes and 20 % of the grassland. In some areas this could mean a viable replacement for former crops production that is no longer taking place e.g. sugar beet in Pomurje.

Exploiting biogas from agriculture and also from landfill and wastewater treatment plants is rather new approach in Slovenia. First installations were set on two bigger farms (mainly for the purpose of a purification plant) in 1980's and the interest has increased after the system of feed-in tariffs was introduced in 2002. Since then the biogas use is promoted by higher price of the produced electricity. Mainly the bigger farms and their investors saw an opportunity for building a biogas plants and the result is that they are planning larger plants, 1 MWe and above.

The new EU regulation on soil contamination affected also Slovenian farmers and landfills hence biogas is becoming more and more an interesting option.

According to the *Targets, strategies and measures till the year 2020 on the field of green electricity production in Slovenia* report of the (University of Ljubljana, Faculty of Mechanical Engineering Center for Energy and Ecological Technologies (CEET) the theoretical potential of animal waste is calculated on the way that from all animal waste biogas is produced which is then transformed into electricity. If therefore all animal waste is used for biogas production and then that biogas is burnt, theoretical potential on annual level would amount to 7,083 GWh, which represents 2,125 GWh/a of electricity production. NEP on the other hand talks about 5 MW in 2010 and 10 MW in 2020. According to estimates made by ApE, for the same document and based on a conservative scenario, it is estimated that the biogas production from manure and organic waste could feed CHP plants of total installed capacity of 28 MWe and 33 MWe respectively for the same periods.

Biogas production could play an important role in GHG reduction and particularly CO_2, since biogas exploitation offers the opportunity for the substitution of fossil fuels. CH_4 conversion to CO_2 has a positive input to GHG effect since a molecule of methane is nearly 30 times as effective as a molecule of CO_2 in trapping the earth's radiated heat. Storage and application of animal manure increase the methane emissions. Biogas exploitation mitigates the total methane emissions from agriculture. Furthermore, biogas could reduce nitrogen leaching from animal manure and guarantee sustainable fertilization of fields. This would have very positive impacts on ground water quality.

Use of biogas from central wastewater treatment (CWWT) is necessary, especially from the aspect of reducing methane emission. Energy of biogas covers partly the energy need of the wastewater treatment. The energy produced is used in the plant for heating the digesters and partly covers the electricity needs. In Slovenia exist eight central wastewater treatments (CWWT) installed systems for biogas production, but only four of them use biogas for production of heat and electricity (CHP). In others, the biogas is burned on torches.

8.2 Socio-economic impacts

On the short-term, biomass is the most promising renewable energy resource in Slovenia both in terms of abundance and economic feasibility. This is true especially for woody biomass, however in lesser extent also for biogas production.

8.2.1 Employment and rural development

The socio-economic impacts concern social or economic consequences, or a combination of both. The boundary between social and economic impacts is often not clear. For example: new jobs are no doubt a social impact, for they essentially influence the life of an individual or community, but at the same time this is also an economic impact, considering that the income both of an individual and community is increased with new jobs. Especially for farming population in less developed regions a biogas production could represent a good supplement to the farming.

The possible impact is: increased public income in the region; total number of direct and indirect jobs; possible impact on unemployment; reduction of costs due to unemployment; increased power self-supply.

8.2.2 Substitute for fossil energy and energy imports

Slovenia has very limited energy resources of its own. The main sources for electrical energy production in Slovenia are fossil fuels and nuclear power, while renewable energy sources (excluding big hydro power plants) represent a very small part. Besides renovation an old hydro power plants and construction of a few new one, the main potential is indicated in the field of combined heat and power from biomass.

Due to a substantial potential of animal waste, a big emphasis will be also given on electrical energy production from animal waste. For stimulation of electrical energy produced by renewable energy sources, a feed-in tariff system (in place from 2002 and changed according to the state aid principles in 2009) as well as subsidies and soft loans (from 2007 for the agricultural sector) there are the most suitable mode. Because the share of electrical energy produced from RES in Slovenia is small and it has not been increasing in the last 10 years, the Green certificate is not a suitable system momentarily. When the share of the qualified electrical energy increases, this system will be more suitable because of the possibility of international trading.

Thus, the production of biogas as renewable energy source in Slovenia could be a small but nevertheless important step in reducing dependency of the fossil energy imports, enhancing local economy and reducing GHG emissions.

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Regulations and ordinanaces

The Ordinance of **Biofuels** Quality/*Uredba o kakvoći biogoriva* (OG 141/05)

Regulation on a minimum share of electricity produced from renewable energy sources and cogeneration in the electricity supply (OG 33/07)

Pravilnik o načinu postupanja s nusproizvodima životinjskog podrijetla koji nisu za prehranu ljudi (OG 56/06)

Pravilnik o dobroj poljoprivrednoj praksi u korištenju gnojiva (OG 56/08)