Project: BiG>East

(EIE/07/214)

Estimation of the potential feedstock availability for biogas production in Eastern Europe

WP2 - Task 2.3

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With the support of:

1 Summary

2 Introduction

This document depict the assumptions, analisys and results aiming to assess the potential feedstock availability for biogas production in several European countries. In each of the target countries (Bulgaria, Croatia[1], Greece, Latvia, Romania, Slovenia) a detailed study on biomass/biogas potential was elaborated. An important part of the Big East project is based on a realistic estimation of the biogas production potential. Any policy regarding the introduction of the biogas into the energy strategy of different countries should be based on the real (reported) feedstock availability. Nevertheless, total biomass production alone (in terms of quantities) is not a strong indicator of the real biogas potential. In order to identify the categories of biomass available in each region under study, and their potential to become feedstock for biogas production, indepth insight on the agro-ecosystems material fluxes will be presented.

In order to estimate the feedstock availability in each target country different feedstock sources for biogas production like waste and energy crops have been evaluated.

A template including a software application (database with a help file) was created for all the partners in the project, by Mangus, in order to collect all the necessary data for the evaluation of the biogas potential based on the total biomass and biomass classes, on each area studied. In many cases the data was then extracted from Eurostat and data provided by the partners.

2.1 *Aim of the study*

This task assesses the feedstock availability in each target country. This includes the type of feedstock (e.g. municipal and agricultural waste, energy crops, and sewage sludge) and the distribution of feedstock in each target country. The results of this task are input data for other work packages.

One of the main roles of this report is also to evaluate the potential areas suitable for the development of biogas facility. The highest density biomass areas are considered the most appropriate for the development of biogas plants. The database developed in order to fulfill the task could be further improved (and used) for the identification of these areas.

2.2 *Assumptions and methodology*

2.2.1 Conceptual design

The availability and assessment of natural resources, renewable or non-renewable, is a complex issue and the category *biomass for energy production* make no exception. A plethora of studies have been carried out in order to evaluate the biomass potential for energy use. The results are in strict dependency with the different aims of the studies as well as with the different assumptions made. This study is no exception: it has a series of assumptions, and a series of limits.

[1] No data are yet reported in Eurostat for Croatia

The overall approach to assessing the biomass resource was to first estimate the quantity of material generated from municipal waste and agricultural practices in the area of eastern European countries. We then evaluated the quantity of material that could be recovered from these practices taking into account technical and environmental constraints associated with other site factors. Data sources for land management included monitoring and reporting information from national and European regional statistical institutions. We calculated agricultural residue generation based on annual average hectares harvested, yield values per hectare, and estimated residue generation factors or based on quantity per head of animal for animal breeding practices.

The municipal and sludge sewage wastes are estimated based on local reported values of production per inhabitant. The ecological approach of interrelated ecosystems complex (agro-ecosystem and man dominated ones) in their dynamics to support socio-economical development are generating products and wastes, some of them can be used as potential feedstock for future biogas facilities, witch is represented in Figure 1.

Suitable energy crops for co-digestion have been defined for all the target country. BiG>East consortium has defined the suitable energy crops and their specific yields. Basic assumption made in this study is that biogas potential will be proportional with the total biomass potential in each target area. From the total potential (seen as total biomass), certain classes of biomass (as defined below) are more suitable for biogas production than others, and also different biomass classes are differently *available* (in terms of quantities) and differently *technically available* (in terms of real access to this biomass as biogas feedstock). Disambiguation: in this material, references to *energy crops* should be seen as references to *total biomass produced on agricultural lands*, and not as crops cultivated for energy production. Basically, all the biomass produced on agricultural areas is virtually an energy crop, meaning that is theoretically a possible feedstock for biogas production (or other energy from biomass processes). This is not meaning it will actually be used as or become feedstock for biogas production.

In general, as already mentioned, the data used for analysis of potential feedstock is the data from the European statistic institute (www.eurostat.eu). As a conceptual background, Figure 2 is presenting the proposed approach.

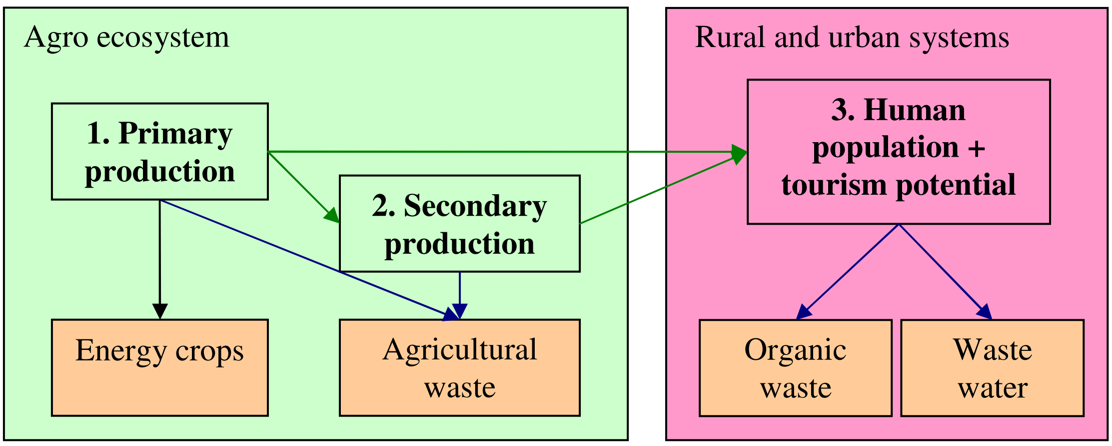


Figure 1 Approach for feedstock potential analysis

The main intention was to use the data from the primary production (vegetal production) and secondary production (animal products) having as main source the agro systems but also human population and third stage anthropic activities).

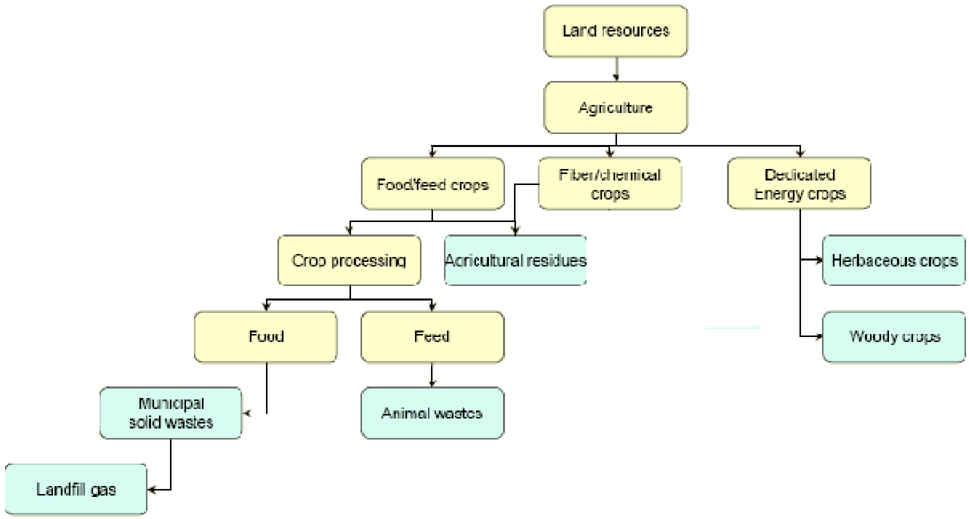


Figure 2 Relationship between primary and secondary production[2]

2.2.2 Methods

To reflect the heterogeneity in agricultural practices, from all the six countries used in our investigation was developed an integrated informational systems to support acquiring data and to establish a common approach of data analysis. Actual facilities of geographical information system (GIS) will permit us to assess structures and functionalities of complex systems, to reflect spatial distribution and to permit accurate identification of administrative units with high potential. For the feedstock potential based on data availability was performed integrate national analysis at national territorial unit (NUTS) level II or level III (Figure 2).

The input data for analysis will be represented by data from EUROSTAT:

- Agriculture
  - Crops
  - Production level
  - Cultivated surface
  - Animals grow and animal wastes
- Demography (urban+ rural atrophic systems)
  - Human population
  - Tourism potential
- Waste disposal/treatment
  - Solid waste
  - Water waste

[2] Adapted after U.S. DEPARTMENT OF ENERGY

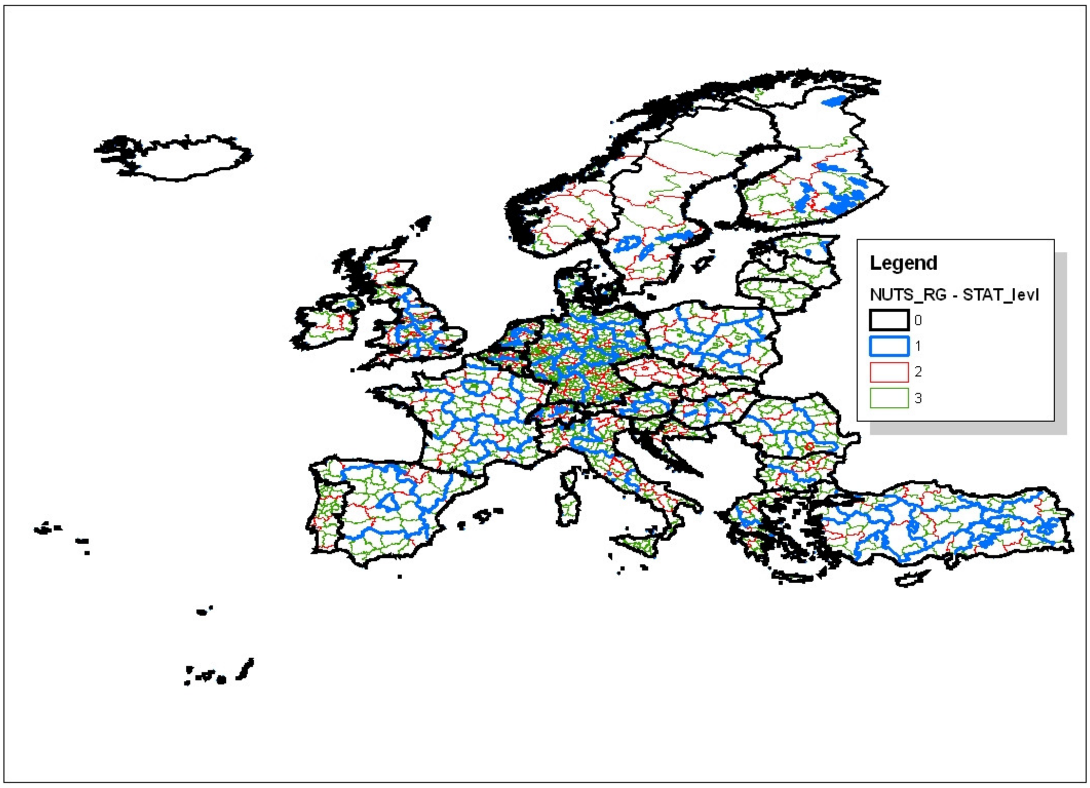


Figure 3 Nomenclature of Territorial Units for Statistics (NUTS)

2.2.3 Nomenclature

There are three levels of NUTS defined, with two levels of local administrative units (LAUs) below. These were called NUTS levels 4 and 5 until July 2003, but were officially abolished by regulation, although they are sometimes still described as such. Note that not all countries have every level of division, depending on their size. In the following pages we analyse each country with their potential distribution and specific factors and at the end of the report a comparative analysis was carried out to support the common approach in potential assessment.

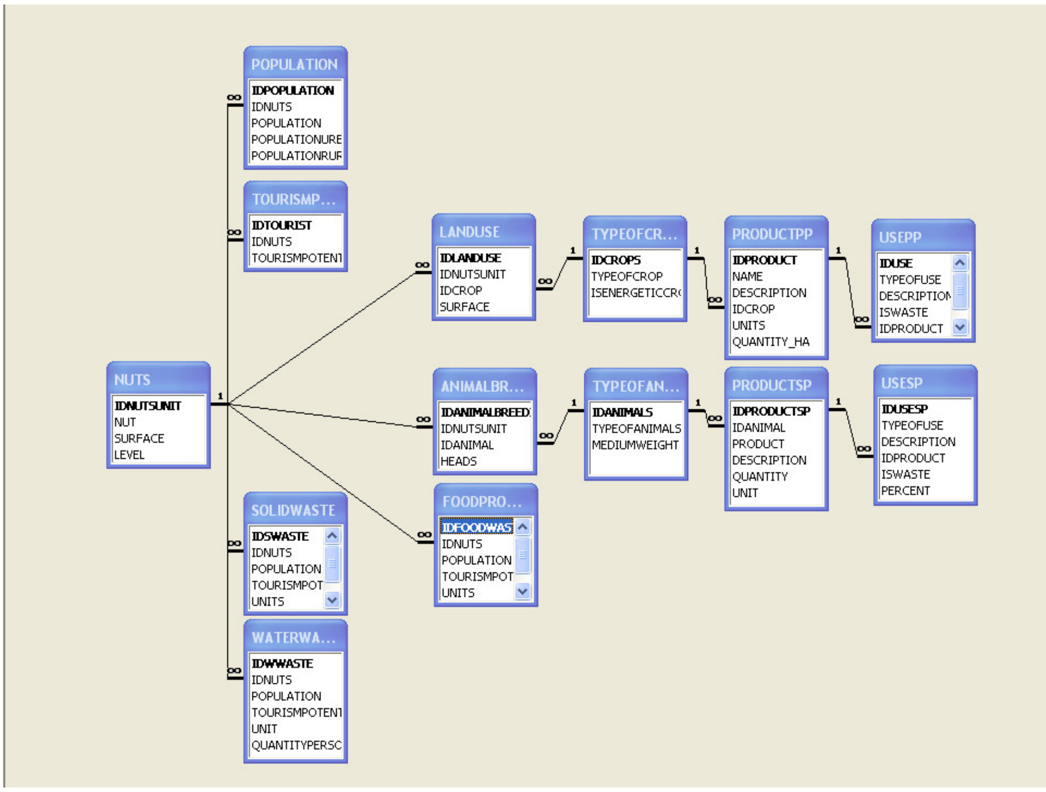


Figure 4 Database structure for the potential feedstock assessment

Abbreviations:

PP – primary production
SP – secondary production
AW – agricultural waste
EC – energy crops
TEC - type of energy crops
SPC – consumption for animal feeding
HC – human consumption

2.2.4 Data set

Primary production

Primary production was assessed using an aggregate function of crops and their spatial extent at NUTS level 2 or 3 (see figure 2). The production was assessed to cover the vegetal structure (herbaceous) in order to identify the biomass quantity with and without market values.

Secondary production - (animal waste - liquid manure of pigs and cattle, chicken dung, food waste, kitchen waste)
The second order information will be to assess the secondary production based on national statistical data number of animals per NUTS level 2 units.

Socio-economic systems

Waste water treatment plants- bio-waste, old cooking oil, flotation sludge, glycerin, and slaughter house waste.

Organic waste: municipal solid waste

Food processing industry: residues from this economical sector.

A detailed structure of the primary production categories of raw materials could be found in Deliverable D6.1 and in the Biogas Manual – Big-East.

Tools used in task results:

1. In order to process the large sets of data involved in analysis, the partners decided to develop a special input data tool (some data were provided by Eurostat data base, other sets of data were summarized from national statistical bulletins);
2. An application (software) based on GIS tools and coded by task leader allowed the assessment of biomass feedstock (primary production, secondary production and also residues coming from human systems) using a relational database system and special (country by country fitted assumptions) for the evaluation of potential biogas production.

Outputs:

Available feedstock (reported at a certain degree of spatial distribution, according to availale national details:

a) Energy crops potential (herbaceous crops) spatially distributed;
b) Agricultural waste potential and inferences for biogas potential- spatially distributed;
c) Organic waste (municipal solid waste, animal waste) potential - spatially distributed;
d) Waste water potential - spatially distributed;
e) **All biomass quantities are uniformly represented in graphs and images presented in the document as *tones/year*.**
f) If special assumptions were made, they are presented in the national chapters under chapter 3.

3 Assessment of national biomass potential

3.1 Assessment of biomass potential in Bulgaria (BG)

3.1.1 Regions analysis and special assumptions

The Nomenclature of Territorial Units for Statistics (NUTS) was established by Eurostat more than 30 years ago in order to provide a single uniform breakdown of territorial units for the production of regional statistics for the European Union (http://ec.europa.eu/eurostat/ramon/nuts/introduction_regions_en.html). The historical data of agricultural practices was in principal acquired from National Institute of Statistics, but they are using a different aggregation of NUTS 3. For these reason the data was reported based on the NUTS 2 used in Bulgaria up to 2005. (see figure 4) .
Assumptions made under the general chapter should be correlated with the references about former territorial organization of Bulgaria, as follows. In order to correct the discrepancy between reports of the national statistical bureau and Eurostat data, we considered NUTS from Eurostat (see Table 1) as assimilating the former territorial structure (Table 2). Very few differences were observed through numerical analysis, hence for the reasons of simplicity the two statistical units structures were considered similar at the NUTS level 2.

Table 1 NUTS of Bulgaria (EUROSTAT)

NUTS 1		NUTS 2		NUTS 3	
Region	Code	Region	Code	Province (Oblast)	Code
Northern and Eastern Bulgaria	BG3	North-Western	BG31	Vidin Province	BG311
				Montana Province	BG312
				Vratsa Province	BG313
				Pleven Province	BG314
				Lovech Province	BG315
		North-Central	BG32	Veliko Tarnovo Province	BG321
				Gabrovo Province	BG322
				Ruse Province	BG323
				Razgrad Province	BG324
				Silistra Province	BG325
		North-Eastern	BG33	Varna Province	BG331
				Dobrich Province	BG332
				Shumen Province	BG333
				Targovishte Province	BG334
		South-Eastern	BG34	Burgas Province	BG341
				Sliven Province	BG342
				Yambol Province	BG343
				Stara Zagora Province	BG344
South-Western and South-Central	BG4	South-Western	BG41	Sofia City	BG411
				Sofia Province	BG412

Bulgaria				Blagoevgrad Province	BG413
				Pernik Province	BG414
				Kyustendil Province	BG415
		South-Central	BG42	Plovdiv Province	BG421
				Haskovo Province	BG422
				Pazardzhik Province	BG423
				Smolyan Province	BG424
				Kardzhali Province	BG425

Table 2 NUTS level 2 used in analysis

Former statistical region level 2	Code used in analysis	Actual NUTS level 2 correspondence
BG01	BG11	BG31
BG02	BG12	BG32
BG03	BG13	BG33
BG04	BG21	BG41
BG05	BG22	most of BG42
BG06	BG23	most of BG34

ADMINISTRATIVE-TERRITORIAL DIVISION OF THE REPUBLIC OF BULGARIA - 28 DISTRICTS

БЪЛГАРИЯ - РАЙОНИ ЗА ПЛАНИРАНЕ, НИВО 2 (NUTS)
BULGARIA - STATISTICAL REGIONS LEVEL 2

Figure 5 NUTS level 2 and 3 used for analysis

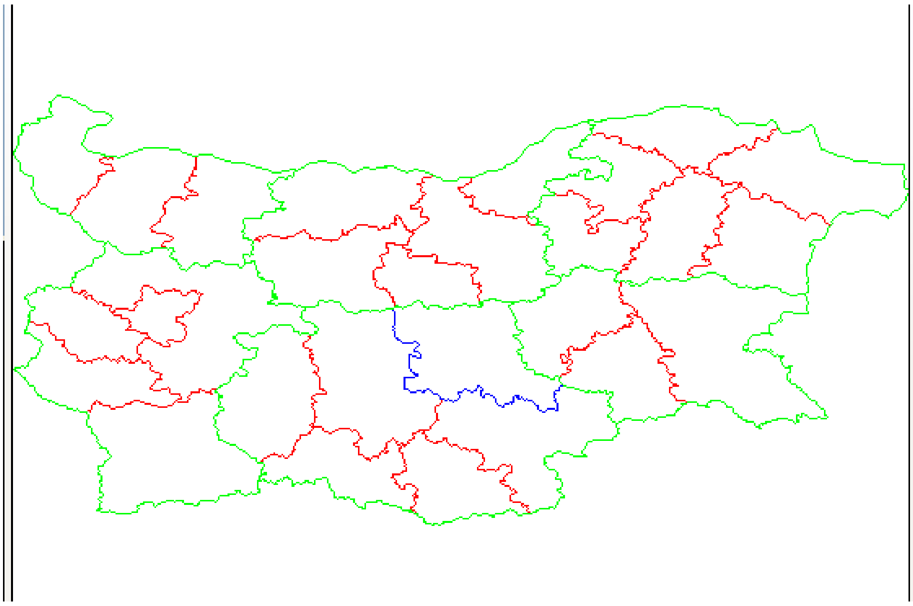


Figure 6 NUTS level 2 (green)

3.1.2 Primary production - Energy crops potential

The data from primary production shows that the biggest biomass potential that could be obtained from energy crops are characteristic to the region BG 13 (aprox. 490000 tones/year) and that the lowest values are expected in BG 21 (aprox. 85000 tones/year).

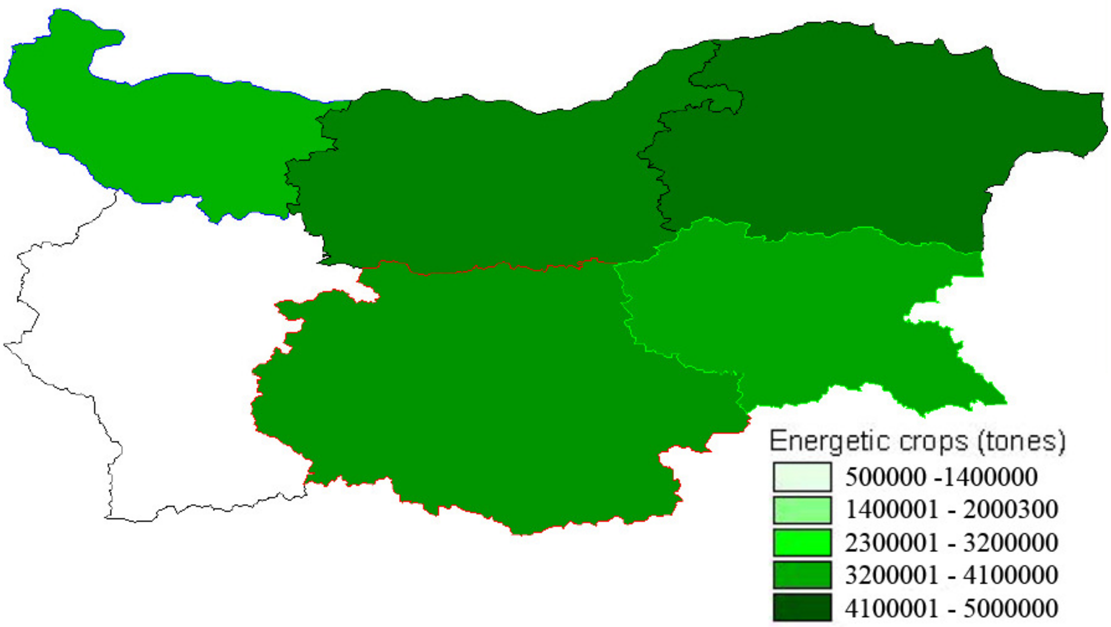


Figure 7 Distribution of feedstock potential from energetic crop in Bulgaria

Known energy crops were selected from all available crops and their biomass assumed to be the vegetation potential. It is already know that if this is the total estimated potential, the real biomass potential for biogas production can be estimated if we are extracting biomass used for human and animal's food. Figure 6 is presenting the potential vegetation including the biomass that will be transferred to secondary production and directly to human population

3.1.3 Agricultural waste

The agricultural waste is based on *primary production wastes* and also from *secondary production (animal breeding).*

Primary production could have the following use type: human and animal consumption, food industry, and residues from this industry. From the total products, the last category of waste has high potential in the production of biogas in Bulgaria. The total quantity per hectare is estimated at 3.1 tones for cereal straw, 1.6 for rape and 2.2 tones for sunflower. Based on this data we can estimate that the agricultural waste from primary production to be maximum for region BG13~52040 tones, and minimum for region BG21~ 6633. (see figure 7)

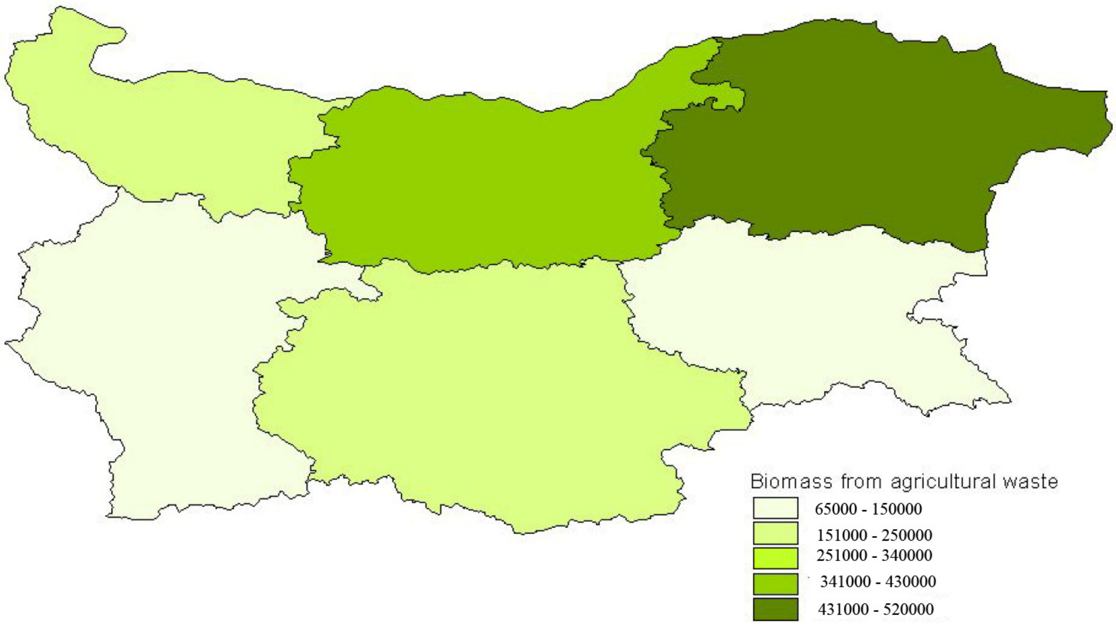


Figure 8 Biomass from agricultural waste from primary production estimates

Secondary production is represented by: human food, industrial use and wastes. Based on mean numbers of animals at regional scale and the estimations of quantity of product and wastes, it was possible to determine the total animal waste as well as meat and milk processing industry waste. Figure 7 is presenting the regional distribution of total biomass (wastes) with potential use as feedstock for biogas production.

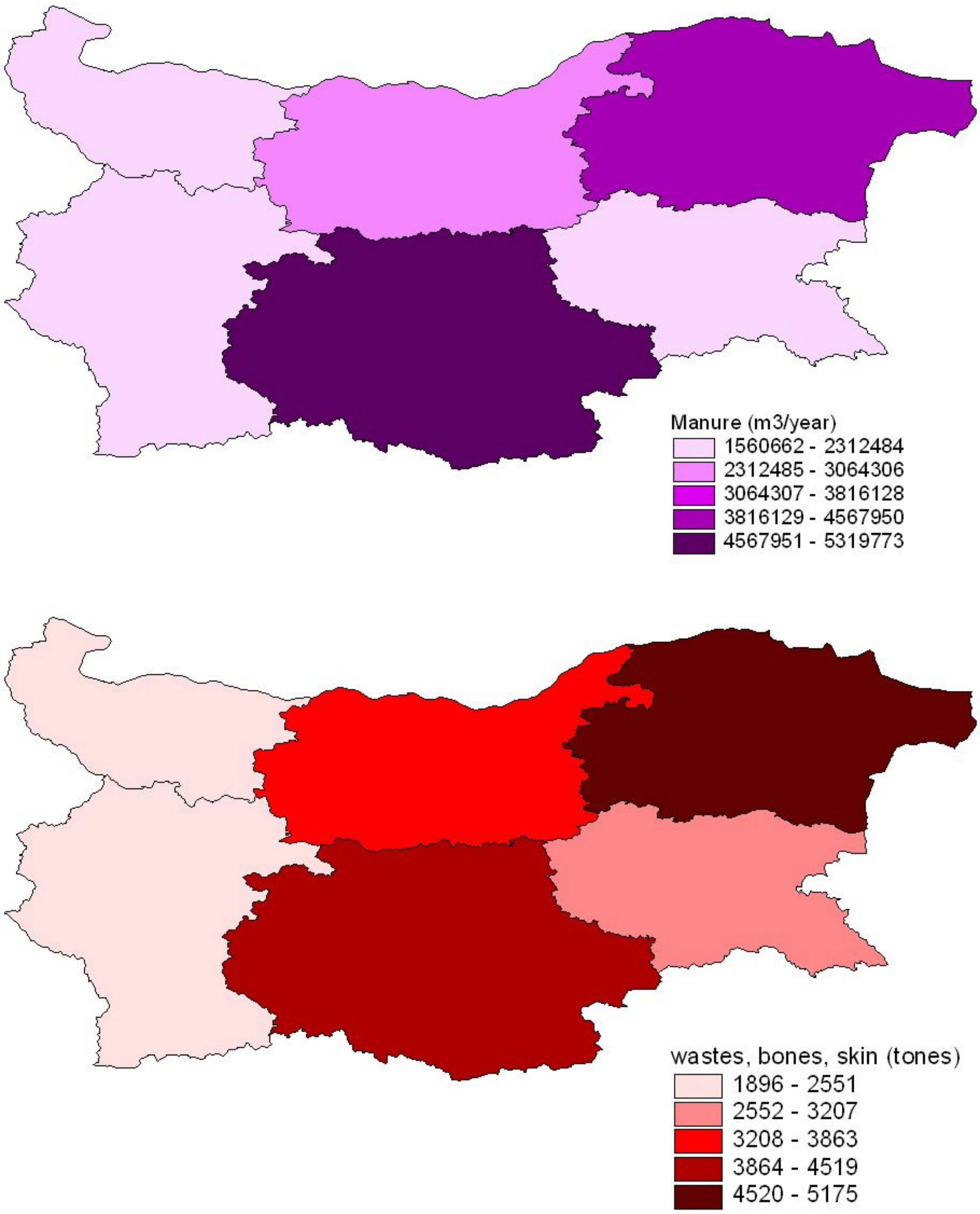


Figure 9 Wastes from animal breeding and meat processing industry

3.1.4 Municipal waste

The total municipal waste was assessed based on the direct relationship with population density and on the percent of organic waste from the total municipal waste. Number of local population in relation with tourism potential was used to reflect the volume of organic waste for each region from the entire country. Solid waste generation is 446 kg /year per person with an content of 40% of organic waste.

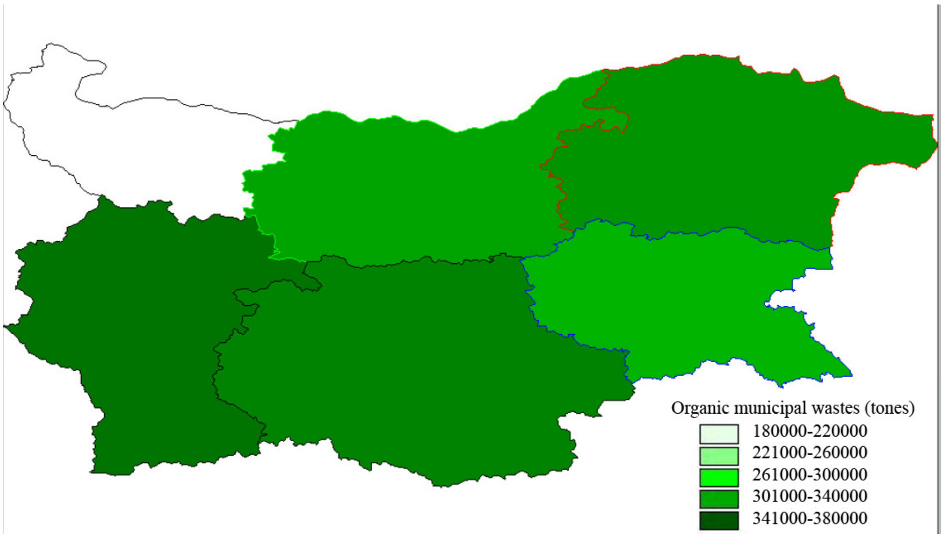


Figure 10 The distribution of organic municipal waste in Bulgaria

3.1.5 Sewage sludge

National population connected to urban waste water collecting system is almost 69%. Total sludge production (in dry solids) is 5.39 kg/capita with a volume of 165000 m3 meaning 0,021 m3/capita. Total waste water generated by domestic sector is around 257,7 millions m3 per year. Waste water generated by domestic sector, households is around 232 millions m3 per year. The highest potential for biogas production appear to be in the south-western part of Bulgaria where the density of population is high.

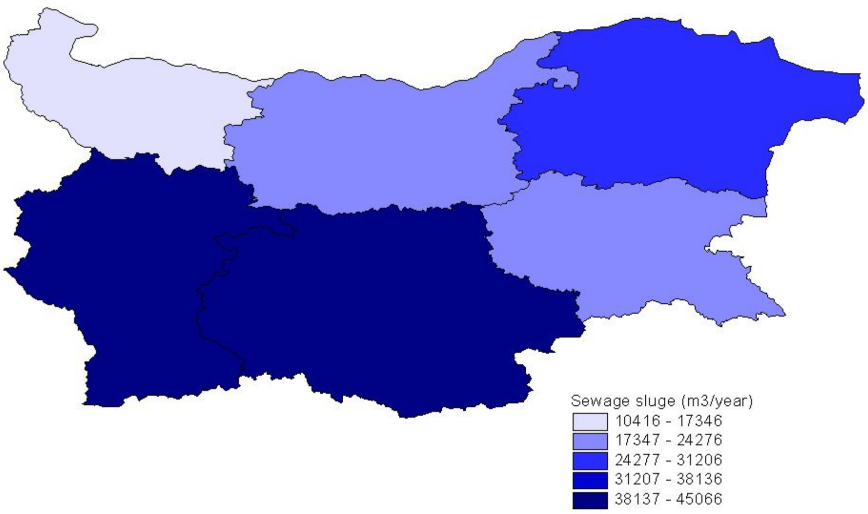


Figure 11 Sewage sludge for Bulgaria

3.1.6 Food industry waste

We have included here the wastes from restaurants; for Bulgaria a rate of generation of 40kg/year per person was used.

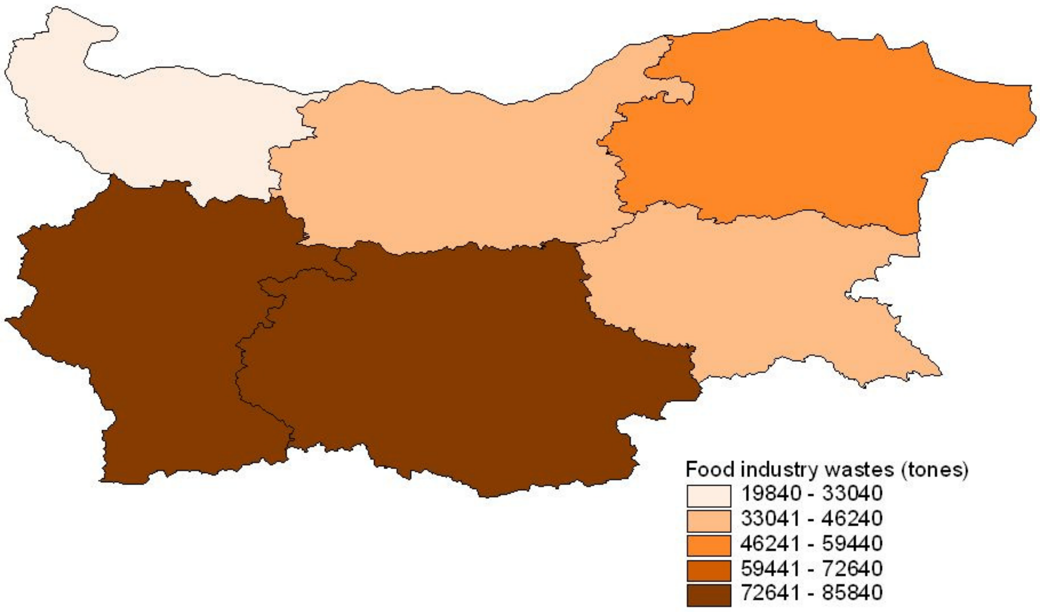


Figure 12 Food industry wastes distribution

3.2 Assessment of biomass potential in Greece (GR)

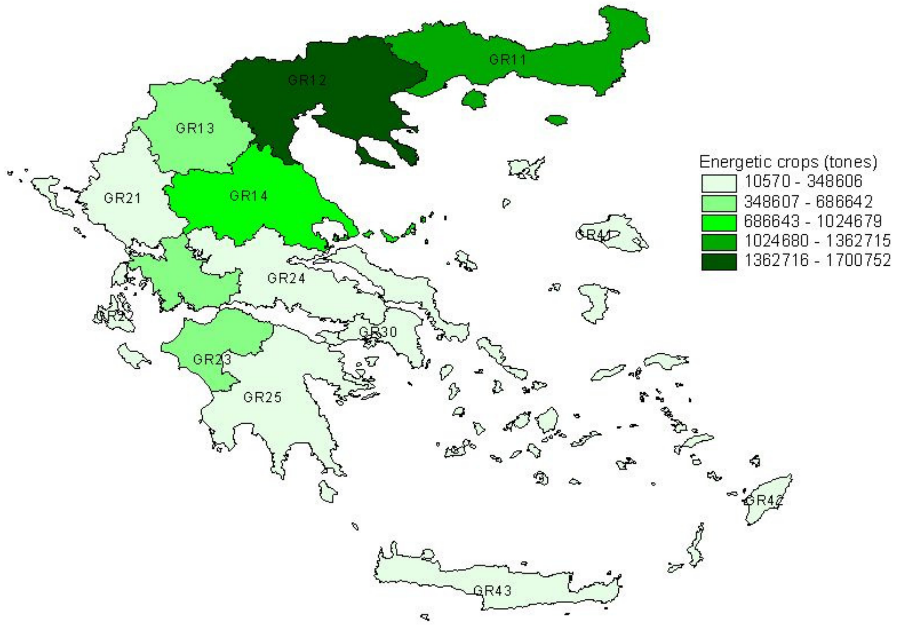
3.2.1 Regions analysis and special assumptions

We used data about the surface of the Greek territory at level 0, 1, 2, and 3 from the Greek National Surveys. The surface is in Ha. In Greece there is no biogas application based on crops or even agricultural residues. From the total agricultural residues produced in Greece a part is already exploited and used in several energy and non-energy markets (e.g. cereal straw is used for various purposes such as feeding and animal bedding). Based on CRES reports (Christou et. al. WP1: Current situation and future trends in biomass fuel trade in Europe, Country report of Greece under EUBIONET II, June 2007) it is assumed for Greece too that only a ratio of the total biomass can be used for bio-energy applications (availability factor). The availability factor and assumptions made in this matter will be disscused in the last chapter of this report.

Figure 13 NUTS level 2 (green) and 3 (red)

3.2.2 Energy crops potential

In figure 13, we are presenting the theoretical potential of energy crops witch can be used for biogas investments. Energy crops stands here for total biomass generated on agricultural lands. Most of the part of these potential is used for human food and animal breeding. The spatial distribution will reflect the higher potential on nuts level 2 GR12 and the lower GR22.



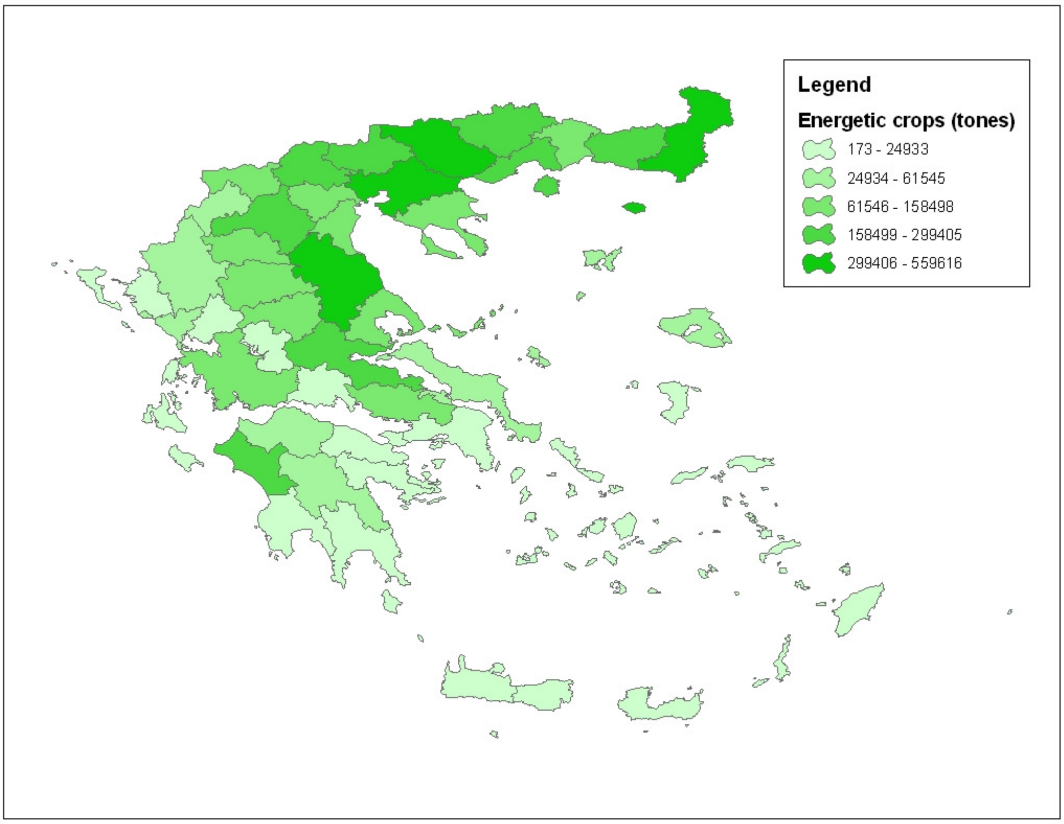


Figure 14 Distribution of potential feedstock based on energy crops (NUTS2-up, NUTS 3 down)

3.2.3 Agricultural waste

The agriculture wastes may be used for energy production. Some of them could be also suitable for biogas production. The total agricultural wastes define the *"theoretical availability"*. Not all this wastes are technically available (aspect to be discuss in the chapter "conclusions").

The residues from the annual (e.g. maize, cotton, cereals) and perennial (e.g. olives, vineyards) crops are the main categories of the agricultural residues in Greece. A portion of these residues can be used for energy purposes in general and some of them for Biogas production (theoretical availability). The residues production per Ha is based on the literature[3] and on the data registered at Eurostat.
The manure was estimated taking into consideration the different type and weight of cattle and the manure specific production per animal and year, in liters. The most promising animal manure for biogas exploitation is cattle, pigs and poultry. The manure of the other animals, like sheeps and goats is spread to the grazing land so it can't be exploitable (extensive breeding).

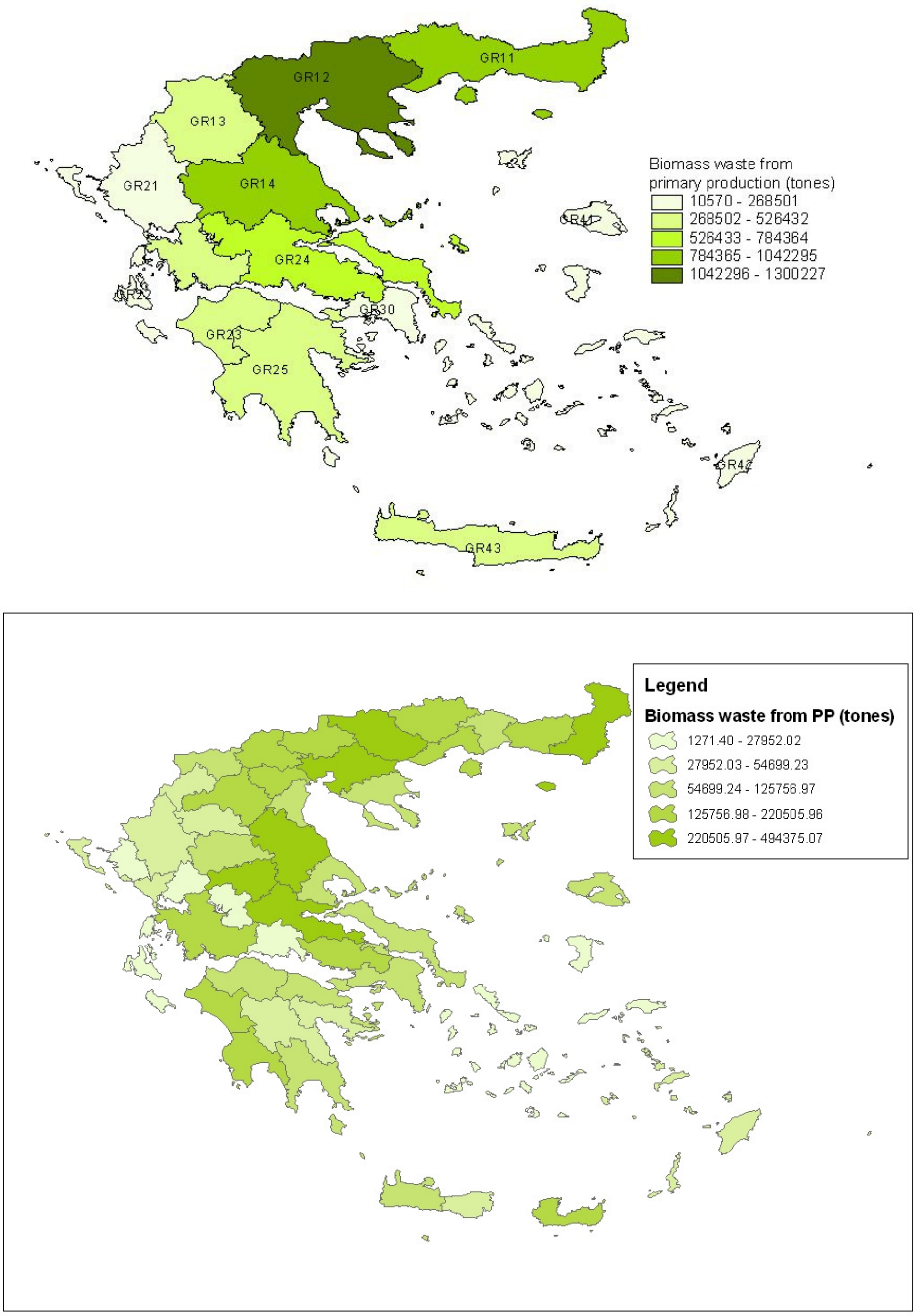
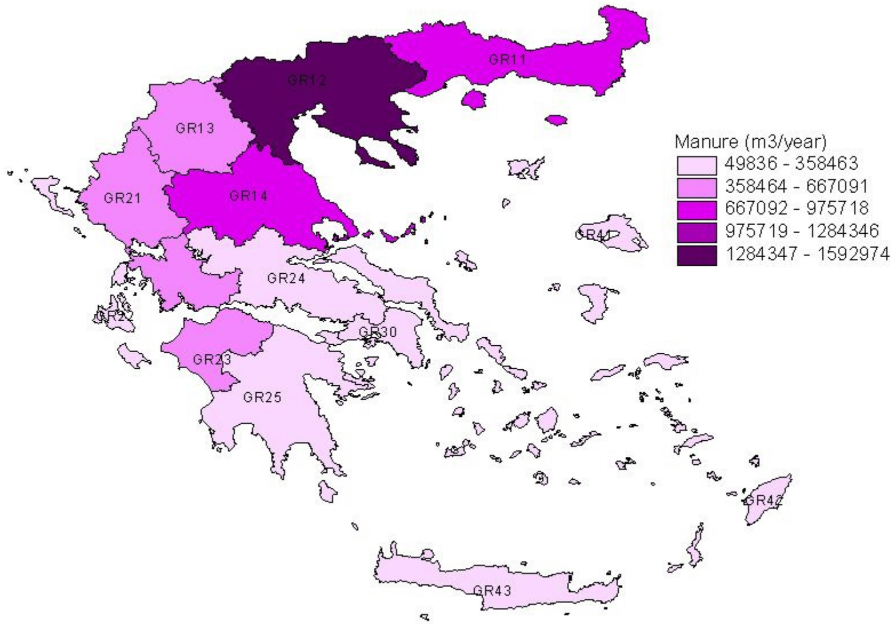


Figure 15 Agricultural wastes from primary production (NUTS2-up, NUTS 3 down)

[3] Energy Potential of Biomass – research in Greece region, Apostolakis – Kyritsis – Souter, 1987



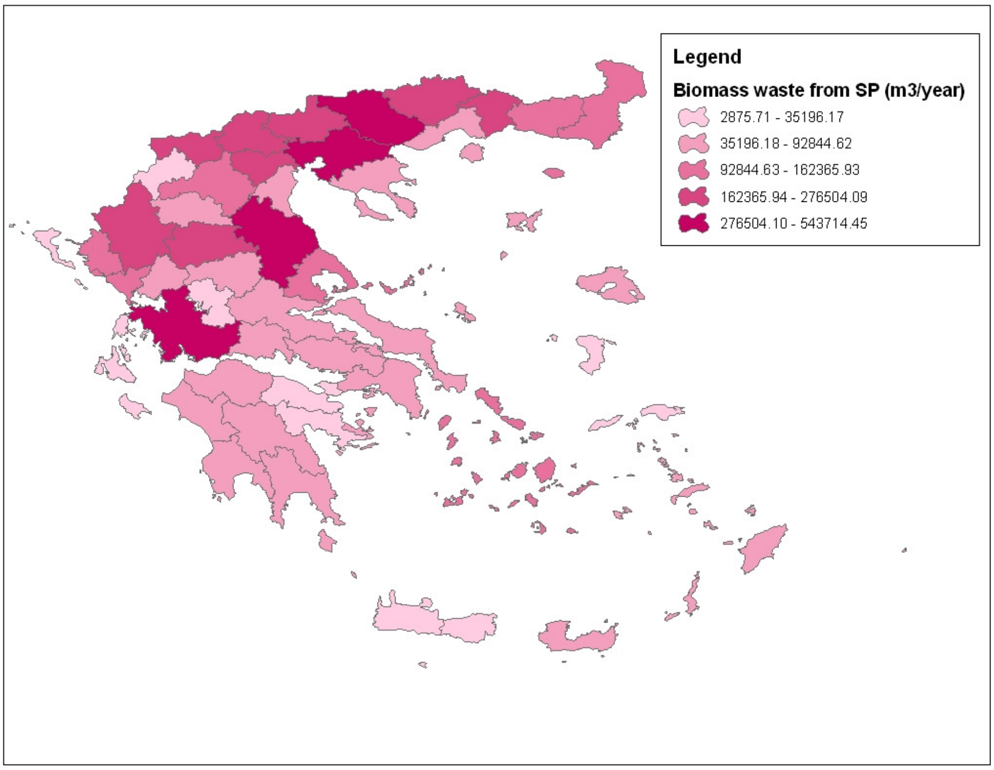


Figure 16 Agricultural waste from secondary production (NUTS2-up, NUTS 3 down)

3.2.4 Municipal waste

The average production of domestic solid wastes in Greece is 1.14kg/residence/day for the year 2001 (CMD 50910/2727/23.12.2003). We can roughly assume the same waste production for tourists. The proportion of food wastes is 47% for the year 2001[4].

[4] CMD 50910/2727/23.12.2003

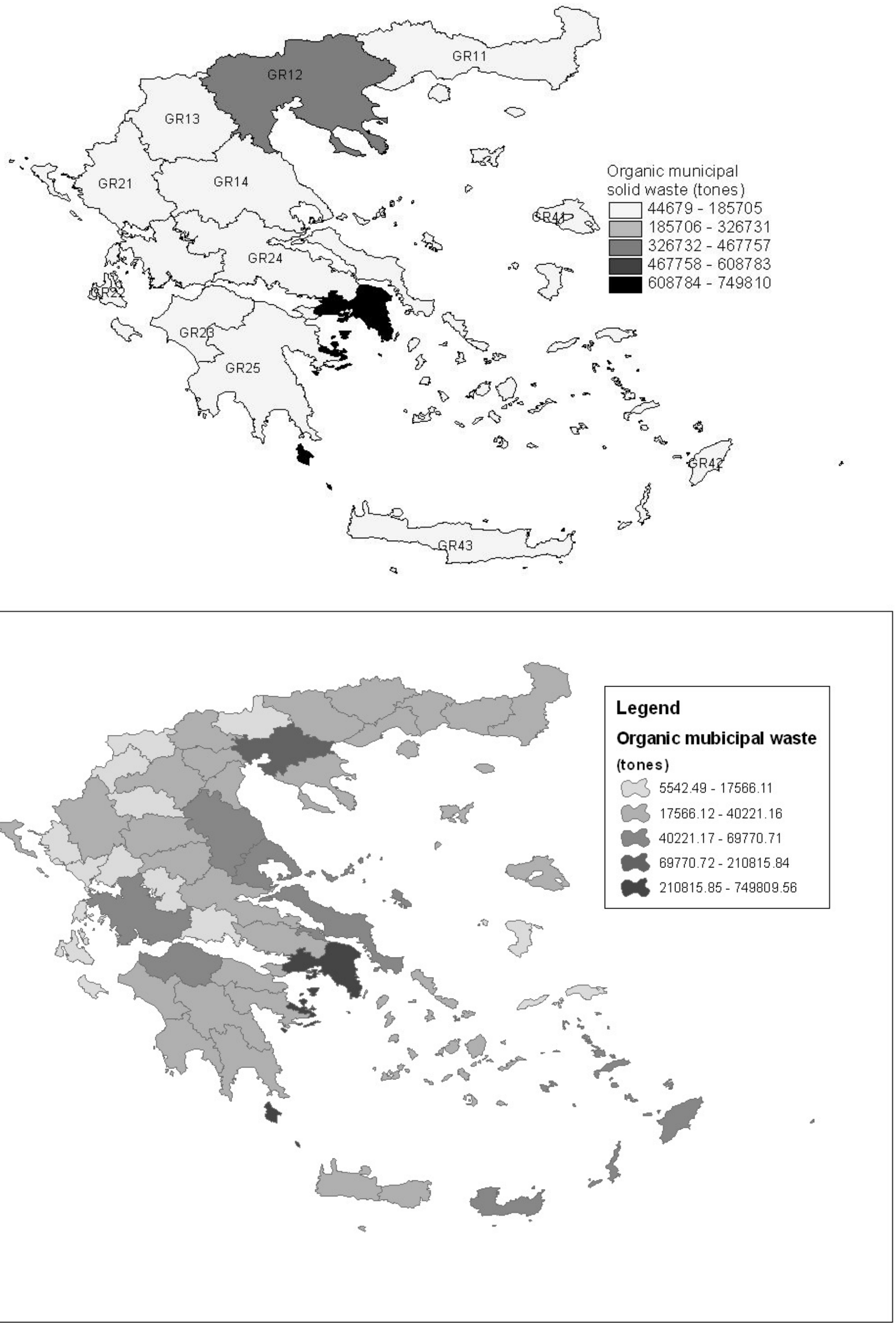


Figure 17 Organic municipal solid waste (NUTS2-up, NUTS 3 down)

3.2.5 Sewage sludge

The sewage sludge production in Greece fluctuates due to many factors (eg. seasonality, area characteristics, tourism). For the scope of the Big>East project a mean value of 200lt/ residence/day can be assumed. For uniformity the data were transformed in the dry matter equivalent.

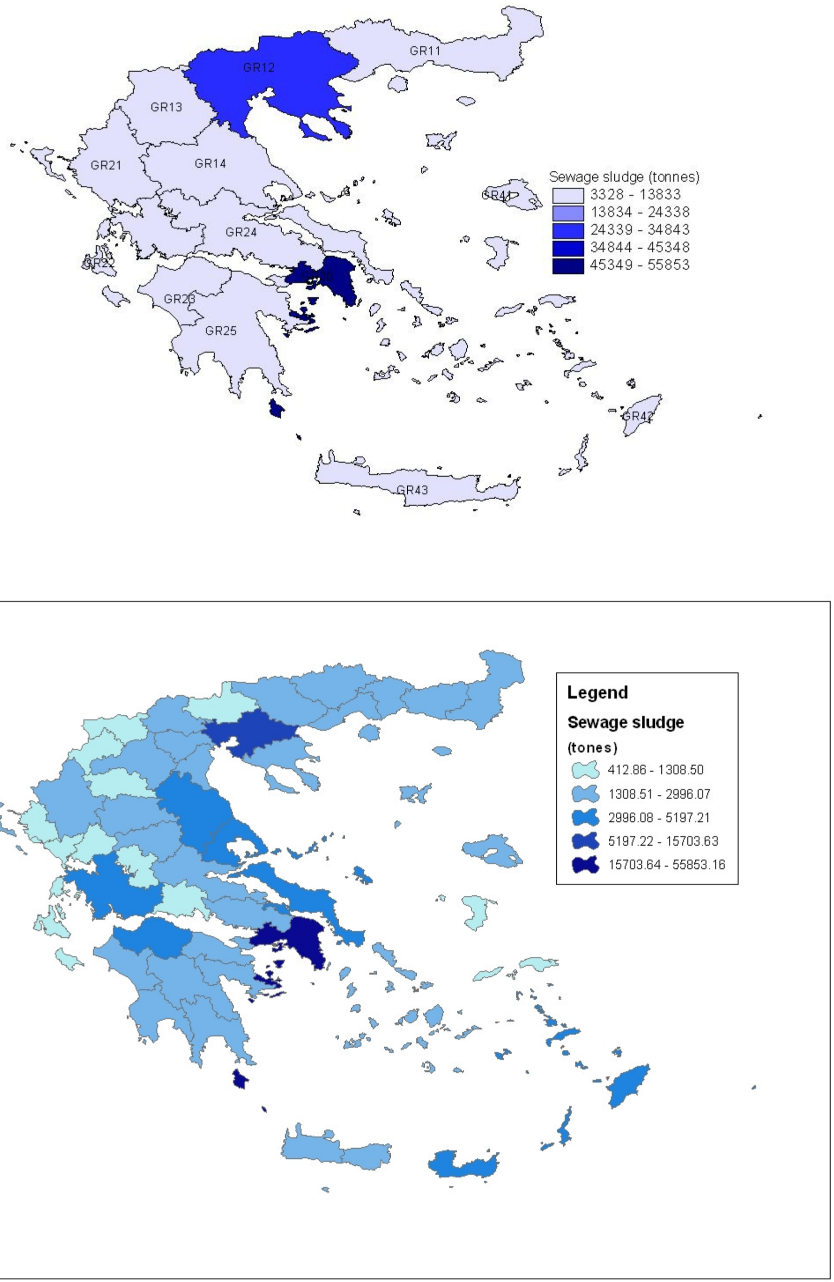


Figure 18 Sewage sludge waste (NUTS2-up, NUTS 3 down)

3.3 Assessment of biomass potential in Croatia (HR)

3.3.1 Regions analysis

Notes on methodology of data collection from Croatia
Data provided are publicly available data gathered from the Croatian Bureau of Statistics. Only data on solid waste were retrieved from Strategy of Waste Management (OG 130/05).

In that sense, notes on methodology for data provided are explained according to the tables in the present report.
There are no publicly available spatial data at the NUTS 3 level. Thus, data are provided for NUTS 2 level that encompasses 3 regions as explained in the table below:

Table 3 Nomenclature of Territorial Units for Statistics - Croatia

Code	Country	NUTS 1	NUTS 2	NUTS 3
HR	Croatia			
HR 0		Croatia		
HR 01			Sjeverozapadna Hrvatska (North-West Croatia)	
HR 011				Grad Zagreb
HR 012				Zagrebačka county
HR 013				Krapinsko-zagorska county
HR 014				Varaždinska county
HR 015				Koprivničko-križevačka county
HR 016				Međimurska county
HR02			Središnja i Istočna (Panonska) Hrvatska (Central&East (Pannonian) Croatia)	
HR 021				Bjelovarsko-bilogorska county
HR 022				Virovitičko-podravska county
HR 023				Požeško-slavonska county
HR 024				Brodsko-posavska county
HR 025				Osječko-baranjska county
HR 026				Vukovarsko-srijemska county
HR 027				Karlovačka county
HR 028				Sisačko-moslavačka county
HR 03			Jadranska Hrvatska (Adriatic Croatia)	
HR 031				Primorsko-goranska county
HR 032				Ličko-senjska county
HR 033				Zadarska county
HR 034				Šibensko-kninska county
HR 035				Splitsko-dalmatinska county
HR 036				Istarska county
HR 037				Dubrovačko-neretvanska county

Croatia is a particular case in this analysis as at European level no data concerning biomass was reported to EUROSTAT.

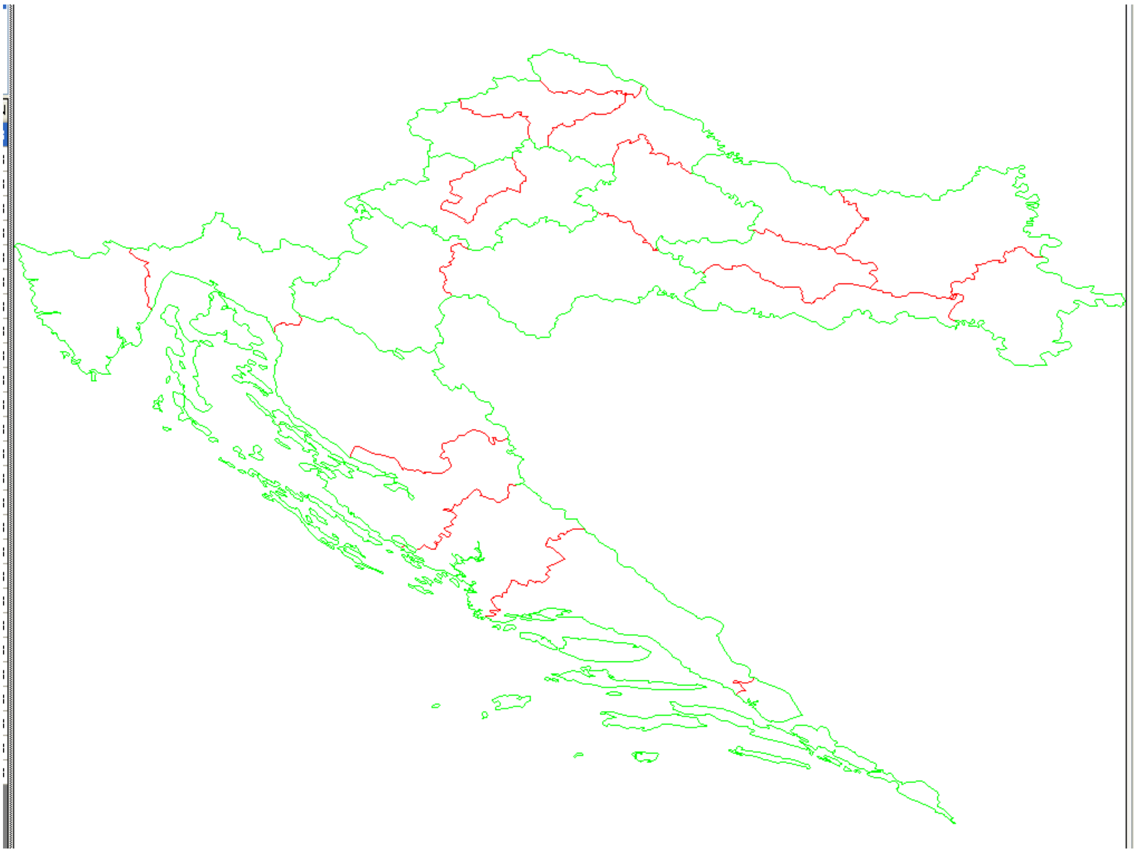


Figure 19 NUTS for Croatia

In Figure 19 a series of regional statistic units are represented in order to reflect the available statistical data for the biomass – biogas available feedstock.

Based on availability and characteristics of data a grouping was realized in order to allow the analysis of the feedstock as source for biogas production (Figure 20).

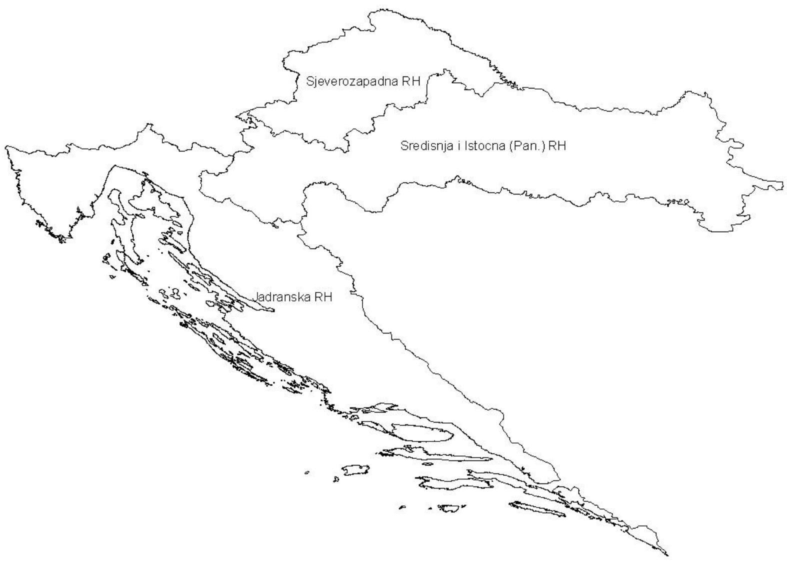


Figure 20 Assessed selected region

3.3.2 Energy crops potential

The highest potential for energy crops in Croatia is in the region HR2 with an average of about 16 million tones per year (for the entire region) (Figure 21).

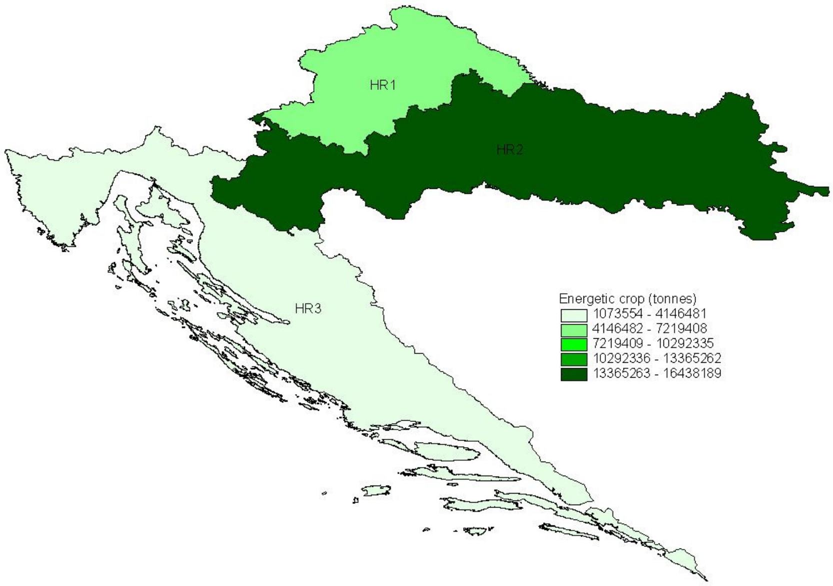


Figure 21 Distribution of potential feedstock based on energy crops - Croatia

3.3.3 Agricultural waste

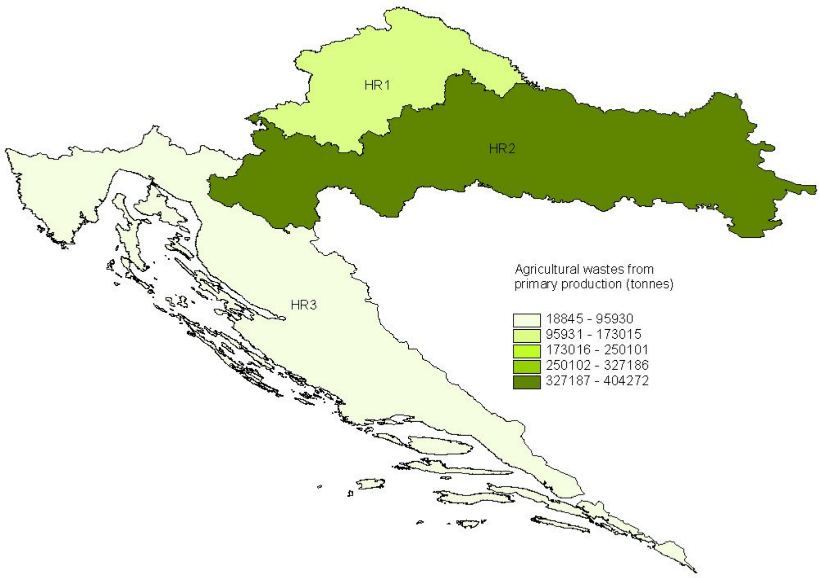


Figure 22 Agricultural wastes from primary production

The main types of residues from primary productions (agricultural wastes) are vegetable residues, grass silage, cereal straw etc). The potential biogas production based on these agricultural wastes could by very important as from 1 tone of for e.g. cereal straw over 300 cubic meters of biogas could be generated (IBBK).
The most important area, in Croatia, for agricultural wastes is again HR2.

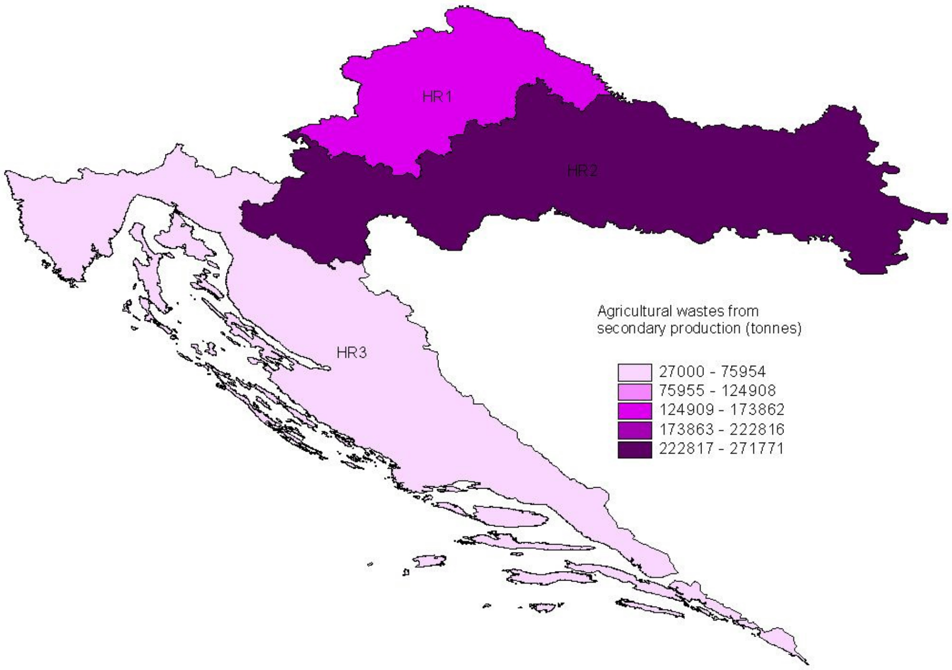


Figure 23 Agricultural wastes from secondary production

The main types of residues from secondary productions (in principle this are dung and other non-dried excreta of cattle, pigs, poultry and other animals). The potential biogas production based on these secondary production wastes is also quite important but the quantities of biogas that could be obtained are much lower that from the primary production as from 1 tone of for e.g. chicken manure only 58 cubic meters of biogas could be generated (IBBK).
The most important area, in Croatia, for secondary wastes is again HR2.

3.3.4 Municipal waste

All of the data are in fact confirmation of the main economic interest in different areas: agriculture as the main activity in HR2 and tourism in HR3. In the last region over 400000 tones is the average for the last years.

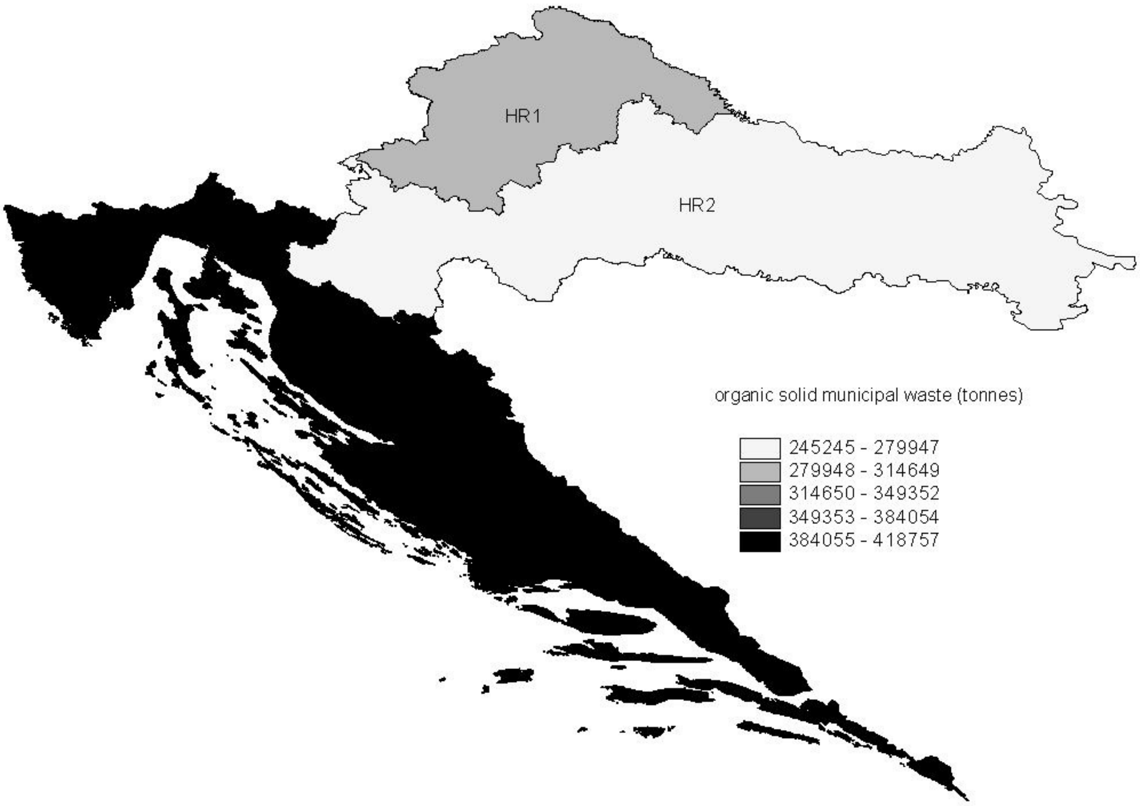


Figure 24 Organic solid municipal waste (tones)

3.3.5 Sewage sludge

The residual semi-solid material coming especially from wastewater treatment processes is in fact sewage sludge. Again the most important quantity is linked with the main tourist area in Croatia. The analysis could be realized at different levels (if data is available) and based on the new input data exact location (based on economic evaluation) could be established for new biogas production facilities, taking into consideration the most effective economic transport paths). Again the region HR3 is the main producer of sewage sludge with over 500000 tones.

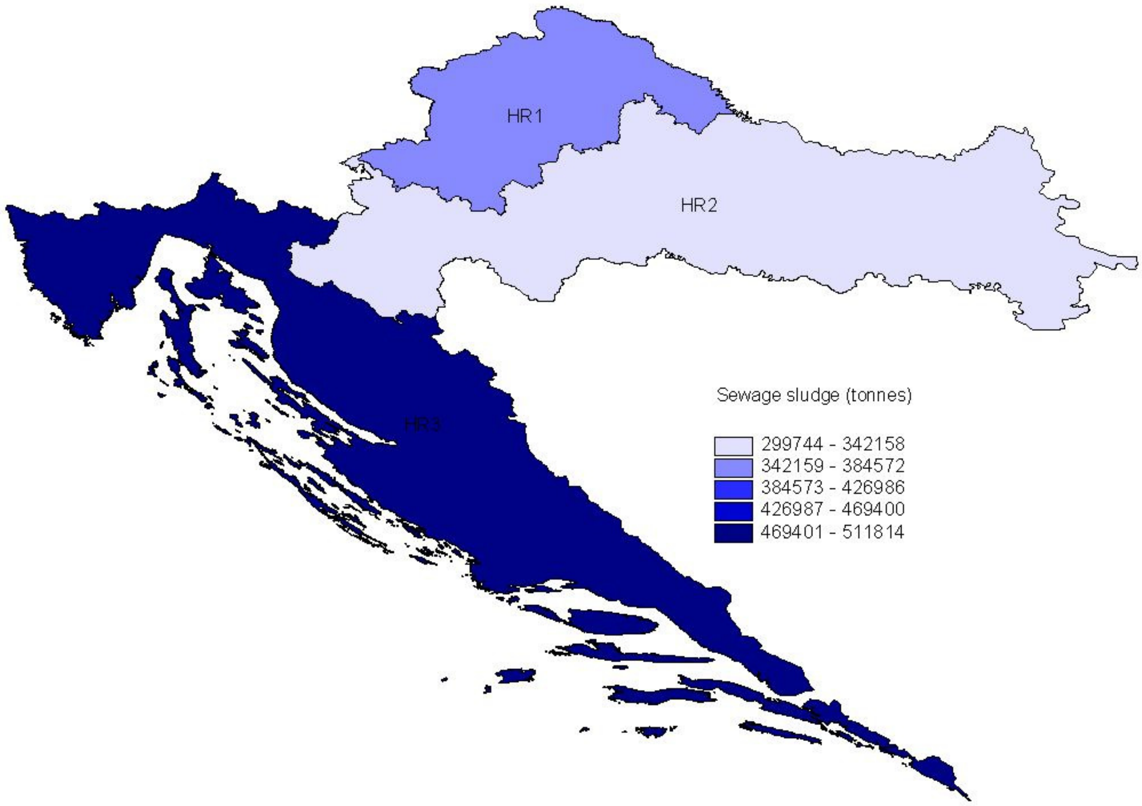


Figure 25 Sewage sludge (tones)

3.3.6 Food industry waste

First of all the wastes from the food industry it is possible to be counted twice as they (in this moment) are transferred as municipal waste and then treated. It could happen also that the food industry wastes to be counted also as agricultural wastes from secondary production. So this data must be used with caution.

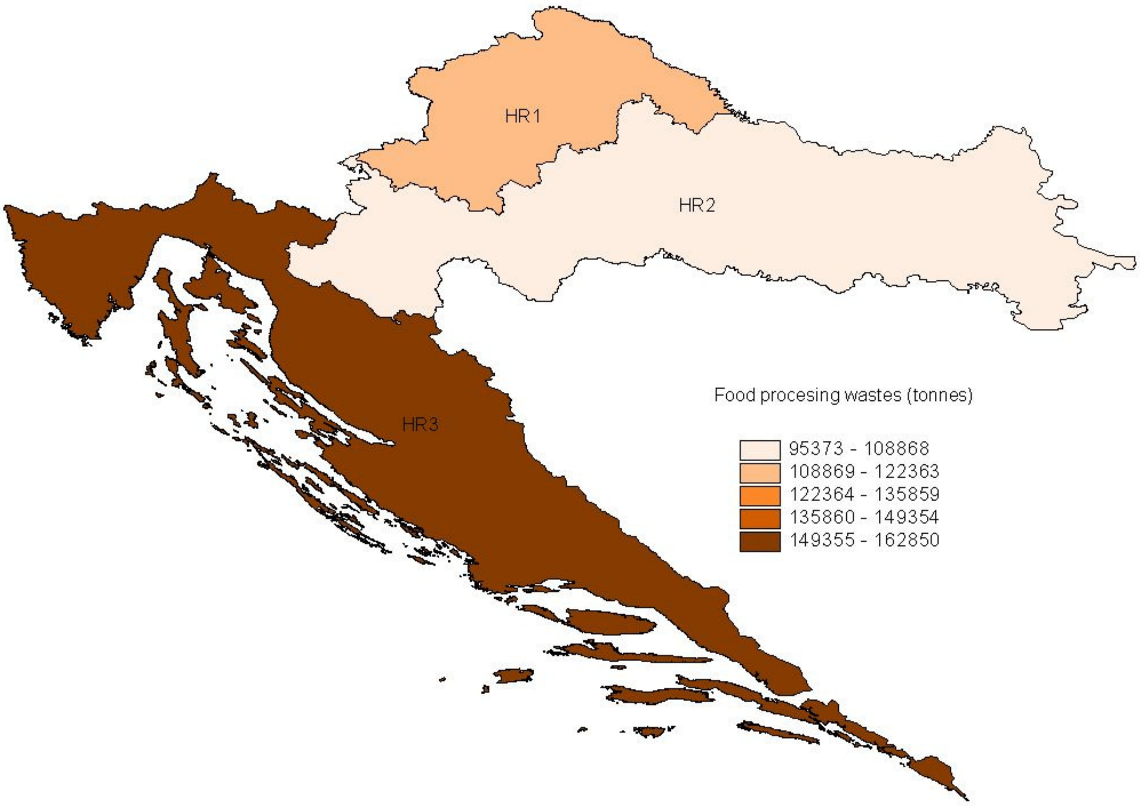


Figure 26 Food processing wastes (tones)

As a **conclusion** two regions in Croatia have a great potential for biogas production HR2- based on crops (primary and secondary production) and HR3 – mainly based on sewage sludge and food processing residues.

3.4 Assessment of biomass potential in Latvia (LV)

3.4.1 Regions analysis

The Latvia has the same extent of NUTS level 0 to NUTS level 2 the national extent for these reasons we are made the analysis at NUTS level 3. In Figure 27 you can see the distribution of NUTS for Latvian territories.

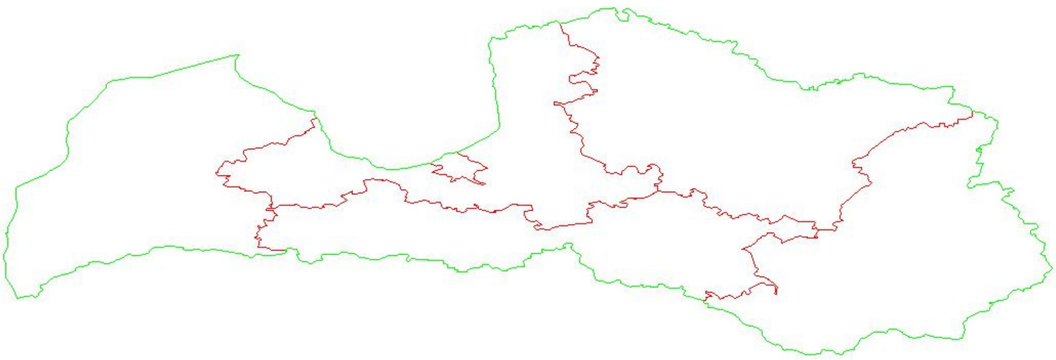


Figure 27 NUTS level 0-1-2 (green) and NUTS level 3 (red)

3.4.2 Energy crops potential

Since in Latvia there are only a few biomass plants using specially grown energy crops like cereal straw, maize silage, grass silage and rape, in calculation of energy crop potential all kind of crops that could be used as energy crops are included (as well as those currently used for human food and animal feeding). Crops included in calculation of energy crops potential are different kind of cereals, potatoes, pulses, rape, flax, sugar beets and other traditionally grown in Latvia.
Data on sown area for each kind of crop and yield of agricultural crops were obtained from Central Statistical Bureau of Latvia (Collection of Statistical data – Agriculture in Latvia in 2006) as well as from online statistical databases to evaluate the spatial distribution of crops by NUTS 3 regions in Latvia. The average figures from data collected in 2001-2006 were used.
Spatial distribution of energy crop potential in the territory of Latvia is given in Figure 28

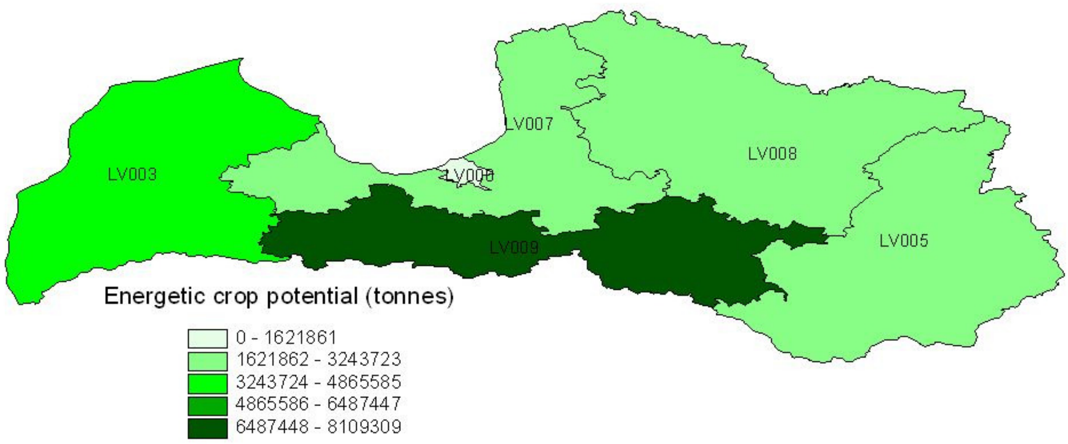


Figure 28 Energy crop potential in Latvia

An important potential for energetic crop is found in one region in Latvia (LV009). This region traditionally is characterized with the high agricultural intensity and productivity

3.4.3 Agricultural waste

The amount of agricultural waste products from primary production (incl. cereal straw, waste from grain drying and processing, potatoes stalks, beet leafs, rape seed processing residues etc.) was calculated based on Statistical data (Supply balance sheets for crop products – Central Statistical Bureau of Latvia) average figures in 2000 - 2006. The set of assumptions were maid to define the percentage of waste that could be collected and used for biogas production.

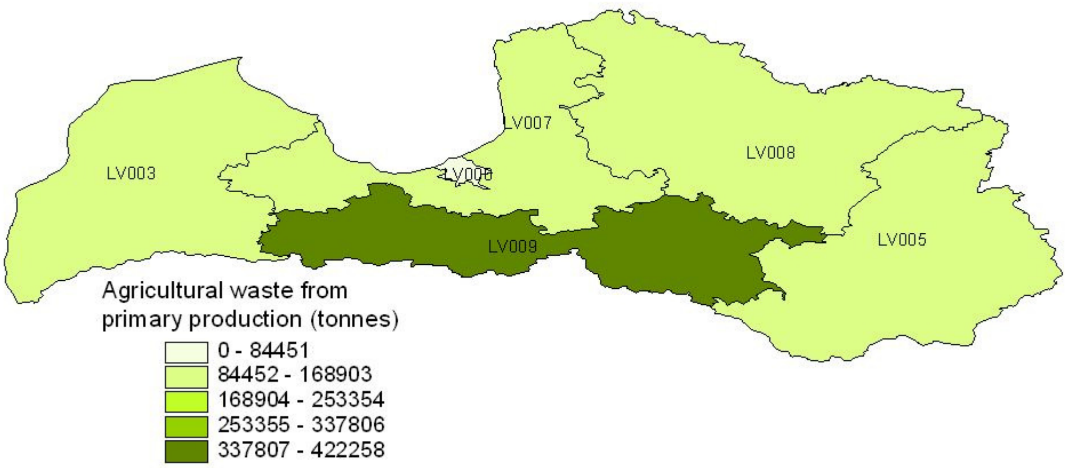


Figure 29 Agricultural waste from primary production in Latvia

The wastes from primary production are also to be found in the same area (LV009) as this is also the main primary production area for the country. Quantities of over 400 thousand tones of wastes in the last years are usual to this area (Figure 29).
Secondary agricultural wastes in Latvia include manure and organic waste from animal slaughtering. Secondary agricultural waste amounts were calculated based on annual number of livestock (including cattle, pigs, sheep, goats, horses and poultry). The number of livestock in each NUTS 3 region was obtained from State agency Agricultural Data Center (National Livestock register). Amount of byproducts from each type of animal was calculated based on waste factors obtained from Latvian Meet Producers Association and according to information collected from different animal breeding associations and farmers.

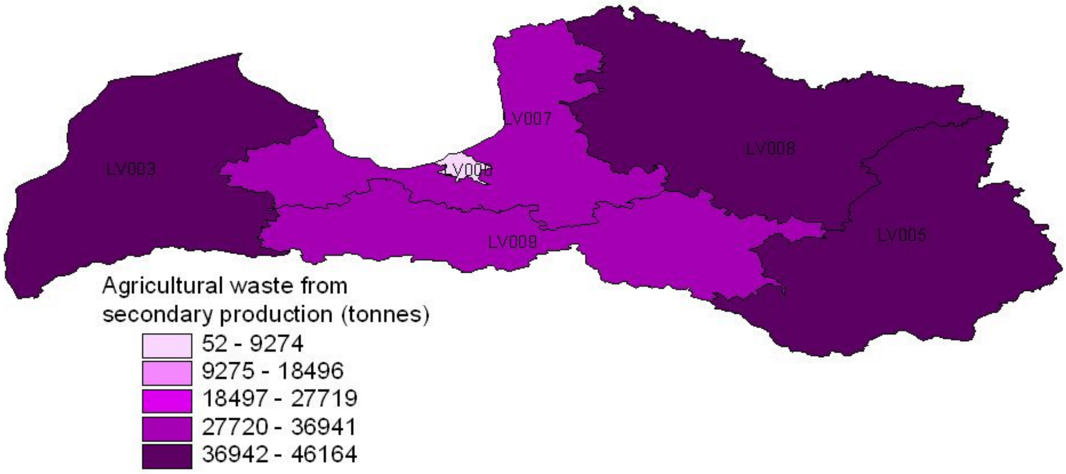


Figure 30 Agricultural waste from secondary production in Latvia

The secondary agricultural wastes are based in 3 different areas (LV003, LV005 and LV008). Wastes up to 46164 tones (an average over several years) are to be found in all of these regions, making these regions potential attractive for the development of biogas facilities (Figure 30).

3.4.4 Municipal waste

The municipal waste in Latvia was of about 600 000 tones in 2000. The highest amount could be found in Riga (LV006) were actually is located the biggest landfill (Getlini).The region around Riga is also an important provider of municipal solid waste (Figure 31).

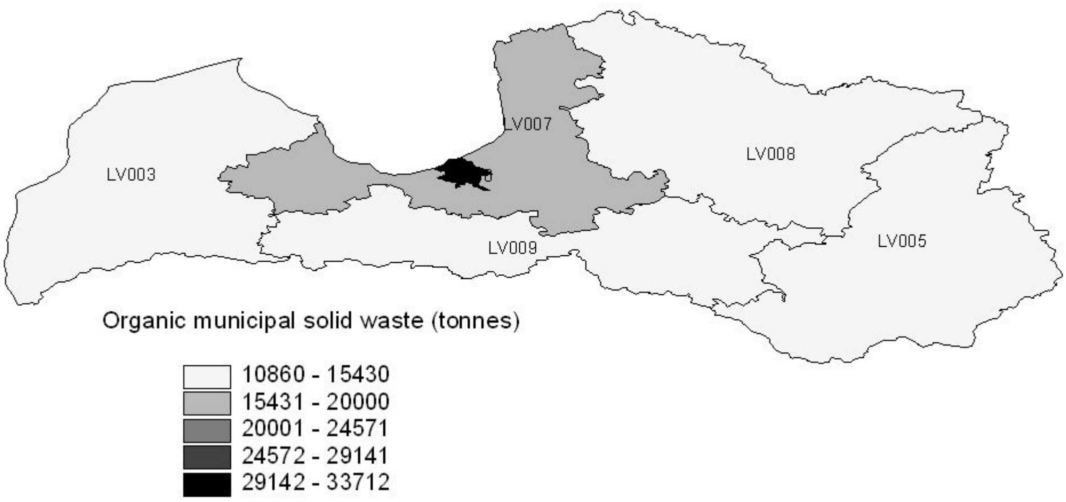


Figure 31 Organic municipal solid waste in Latvia

In order to calculate the amount of municipal solid waste in each region the information from regional waste management plans were used. The difficulty in using those data was in fact that division of waste management regions in Latvia is different from statistical levels of NUTS 3. Thus different assumption was made to divide the total organic municipal solid waste amount by regions. Moreover since waste separation practice in Latvia is still on very low level of implementation, exact amount of organics in municipal waste is not known and it could differ from region to region.

3.4.5 Sewage sludge

Available sewage sludge amounts were calculated based on information obtained from Latvian Environment, geology and meteorological agency (database "Nr.2-Ūdens"). Data on sewage sludge amounts was taken as average from 2004-2007.

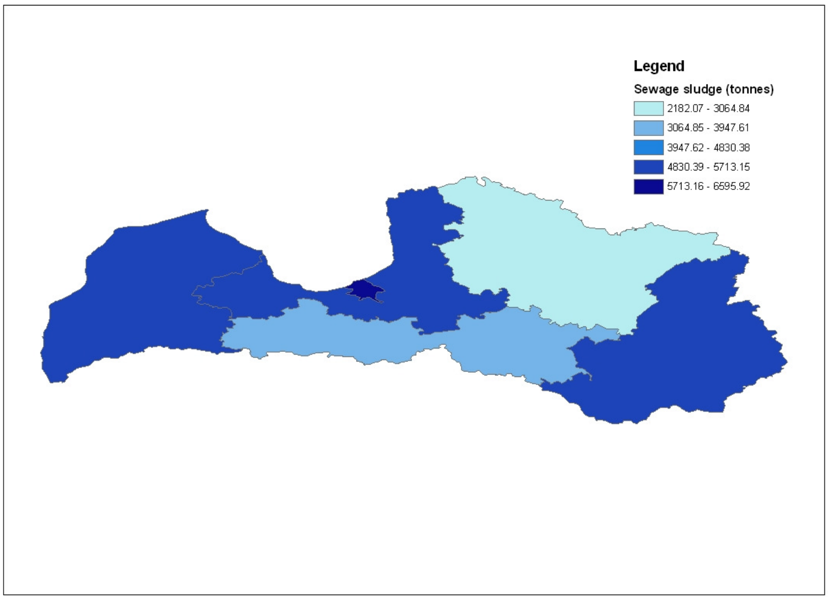


Figure 32 Sewage sludge in Latvia

The region providing the most of the sewage sludge in Latvia is Riga region (LV006). Since the most of population is located in the region, the highest amounts of sewage sludge are generated here. In average there is 6,6 thousand tones of sludge generated in Riga region each year.

3.4.6 Food industry waste

The food industry waste is also having a great impact upon the production potential of biogas in Latvia. The amount of food waste was obtained from Latvian Environment, geology and meteorological agency (national waste database). Waste amounts from database were extracted based on number of particular waste in classifier. However, in some cases there is only one company giving a majority in waste amount in region and often their waste amounts are significantly changing from year to year. Thus changes in operation of waste producer can significantly influence the distribution of overall food industry waste potential. Based on available data from 2004-2006, the highest potential is related to region LV009 with more than 60 thousand tons of food industry waste.

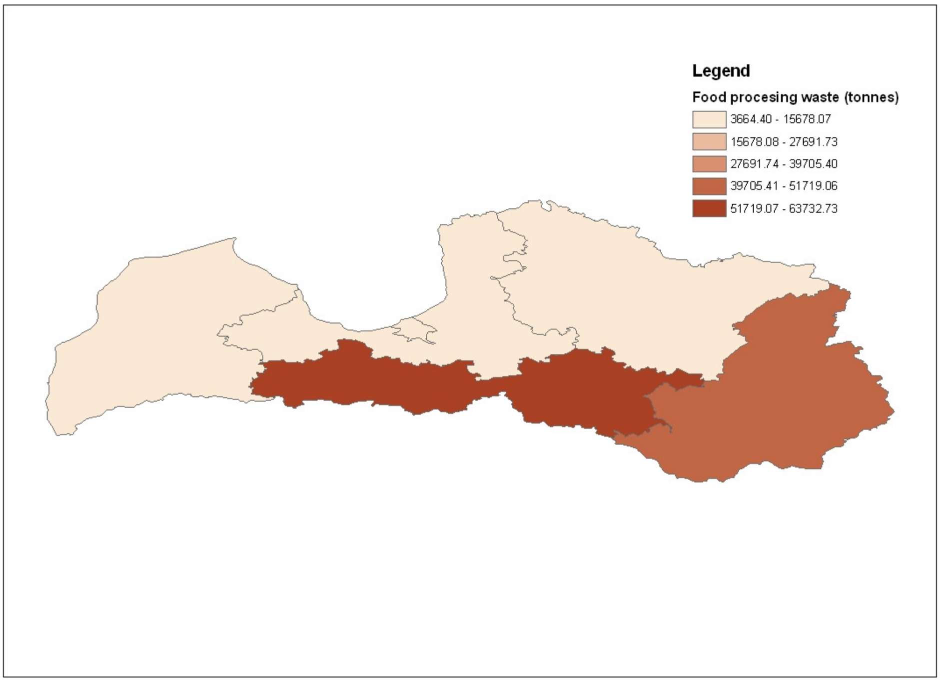


Figure 33 Food processing waste in Latvia

Concluding two regions could play an important role in establishing new biogas facilities in Latvia (regions that have an important potential) LV009 and the LV005.

3.5 Assessment of biomass potential in Romania (RO)

3.5.1 Regions analysis

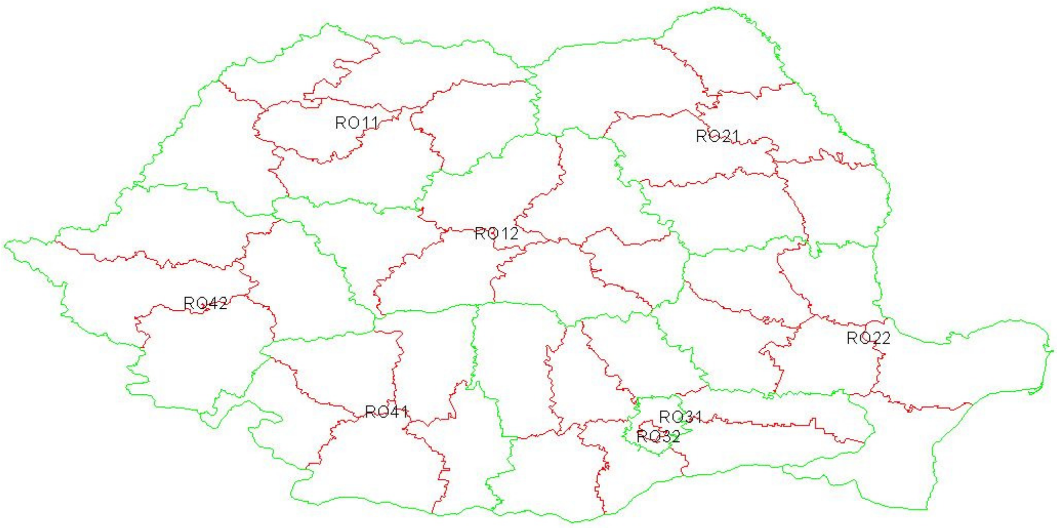


Figure 34 Assessed nuts region in Romania

The NUTS level 2 (in green) and NUTS level 3 (in red) are presented in Figure 34. No special assumptions, other than general described were made for Romania.

3.5.2 Energy crops potential

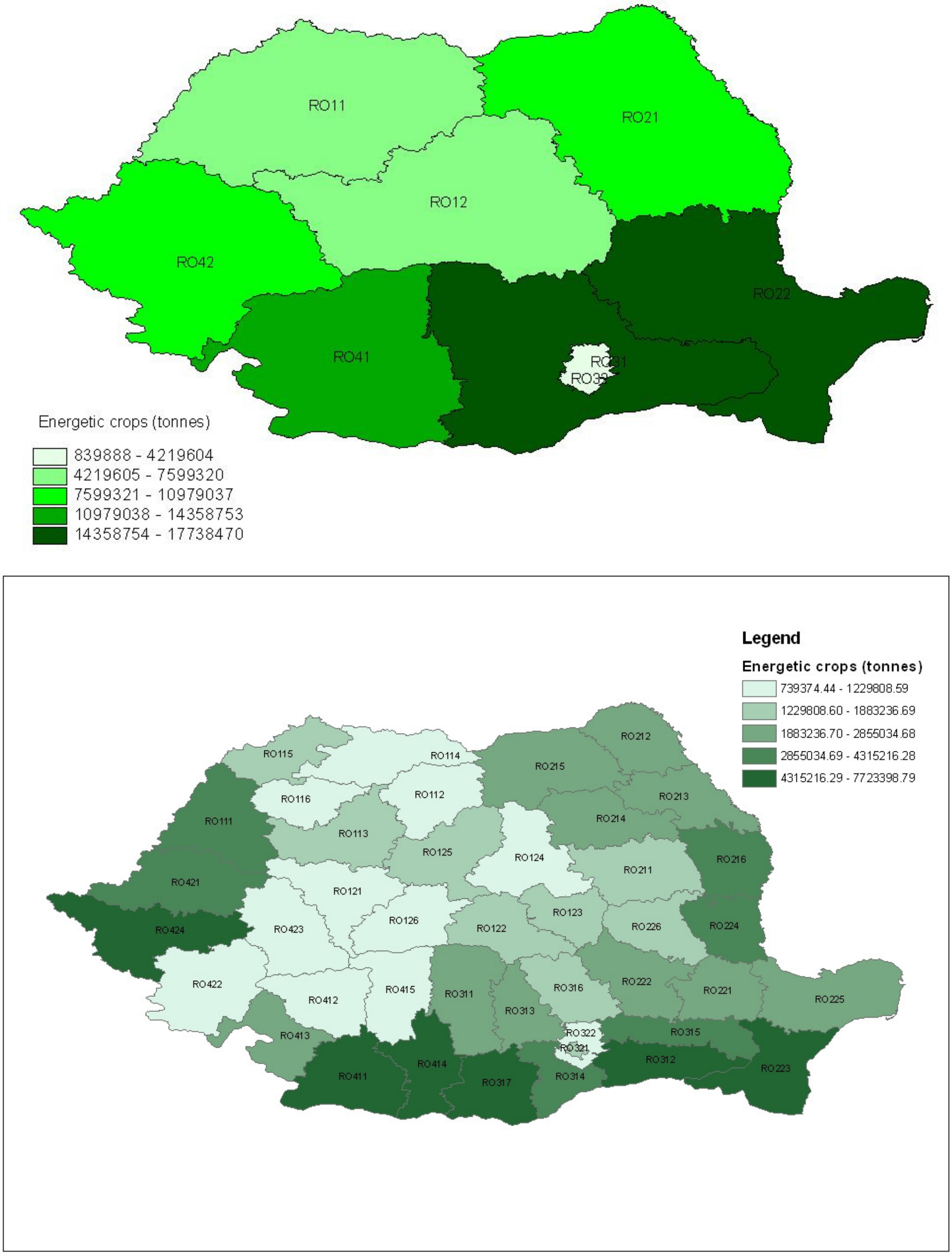


Figure 35 Energy crops in Romania (NUTS2-up, NUTS 3 down)

Romania has an important potential for primary production (including energy crops). There are several area well suited for large productions, especially in the South and South-Eastern part of the country, with an average (for the entire region) of over 17 million tones (Figure 35). Other area could also contribute significantly to the overall production, and for some crops with even a greater potential. The Western plain around Timisoara has a great potential for energetic crops, notably the area is also suitable for oleaginous plants production, hence better placed for biodiesel production.

Eastern plains situated around Buzau to Focsani cities line is a zone suitable for corn production and hence a promising area for biogas from energetic crops.

3.5.3 Agricultural waste

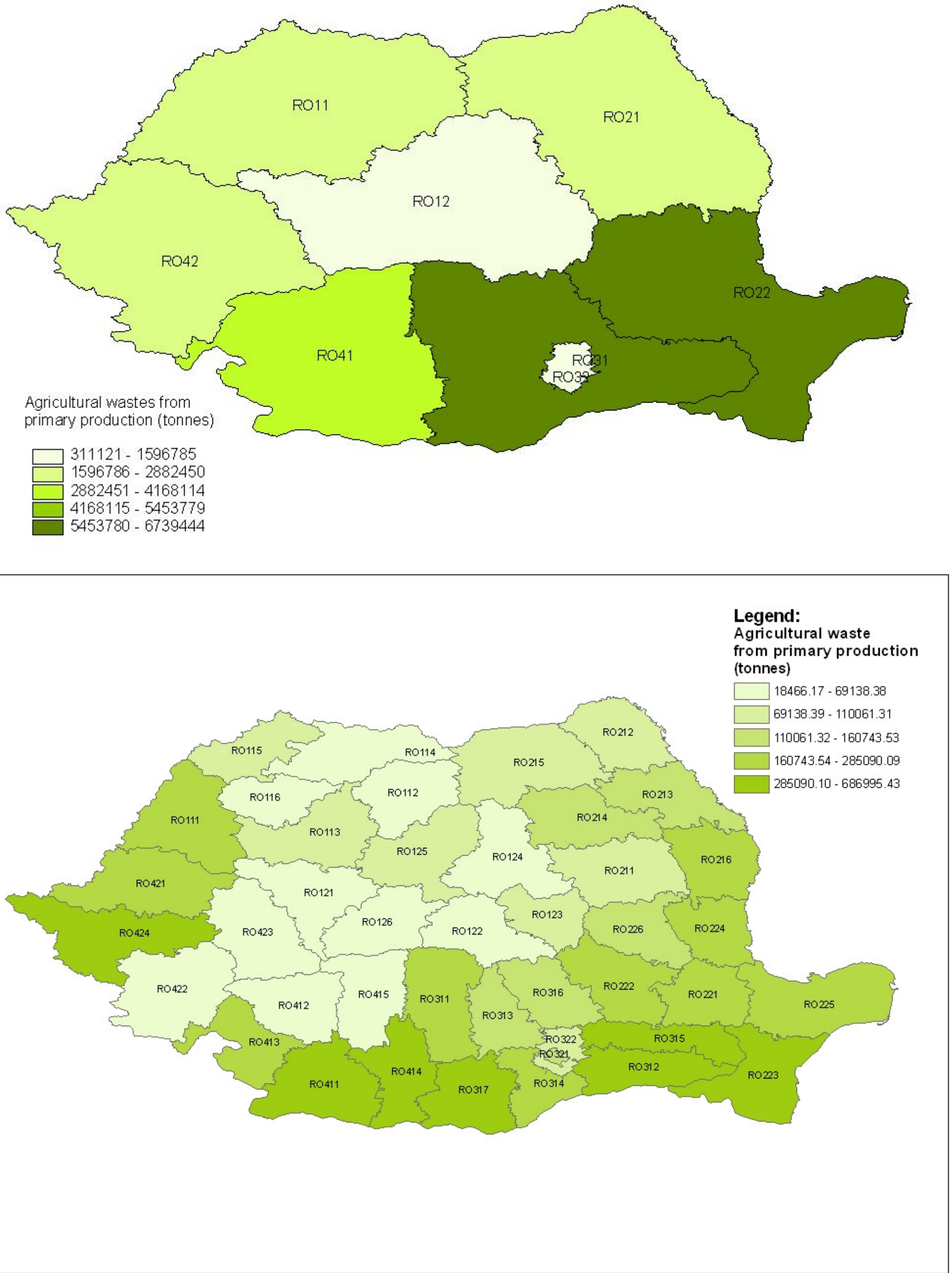


Figure 36 Agricultural wastes from primary production in Romania (NUTS2-up, NUTS 3 down)

It is obviously that the same areas involved in the total energetic primary production are also very important agricultural waste production zones. The maximum capacity for agricultural wastes is around 6 million tones per year, over the last several years (Figure 36).

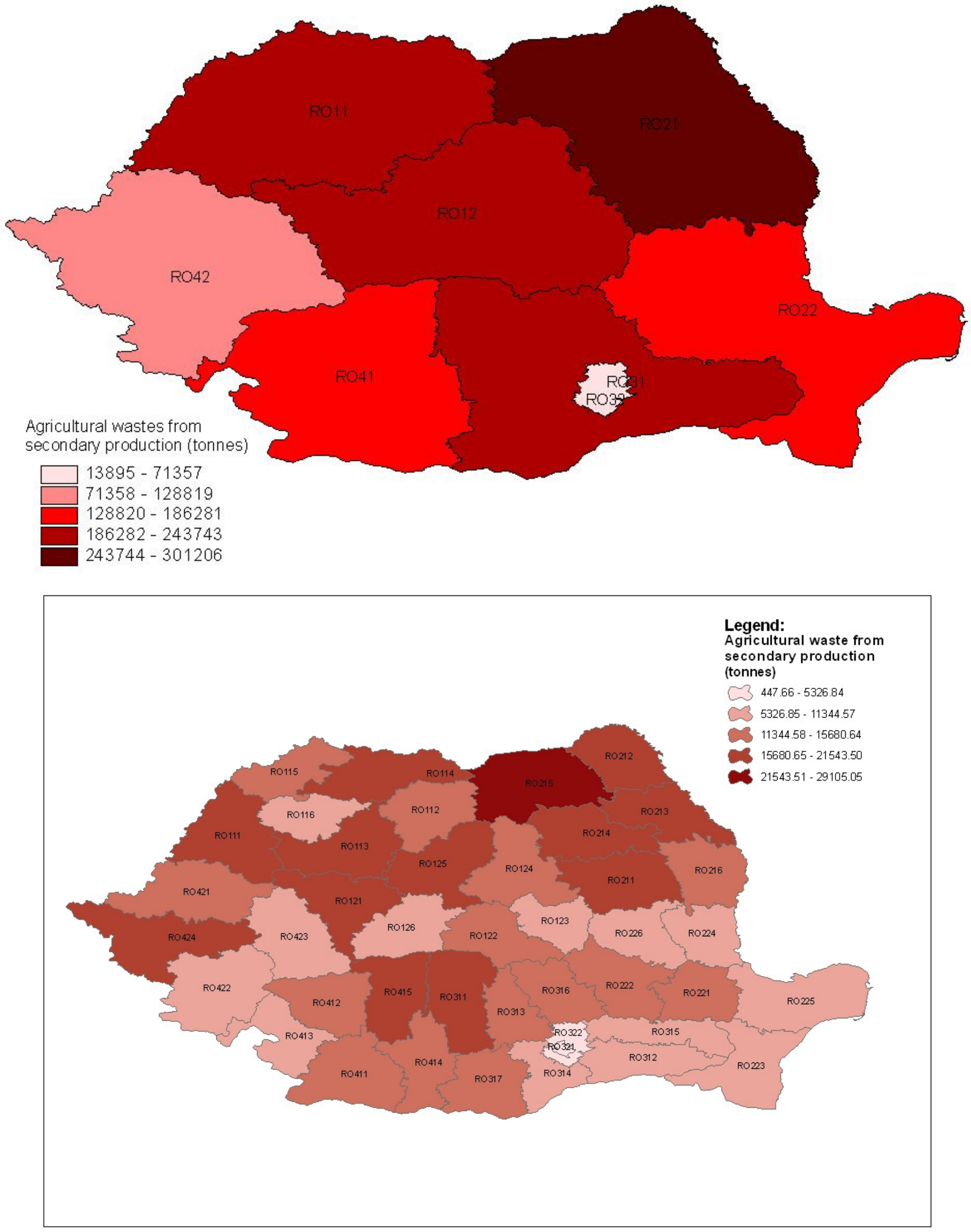


Figure 37 Agricultural waste from secondary production in Romania (NUTS2-up, NUTS 3 down)

The agricultural waste from secondary production is the highest in the Northern part of Romania (RO21). The higher potential is in the region RO 21 (better represented in R215) in the North-Eastern Romania, with a total around 300000 tones per year. There are also other regions with high potential for biogas facilities (Figure 37).

3.5.4 Municipal waste

The same region RO 21 is also the region with the highest municipal waste production in Romania with an average over the last years of about 550000 tones per year. Very close to these values are the regions RO 31 and RO32, near the Bucharest city. Agricultural waste from secondary production in Romania. The estimation shows in fact the municipal agglomerations, easy to observe in the NUT3 analysis (Figure 38).

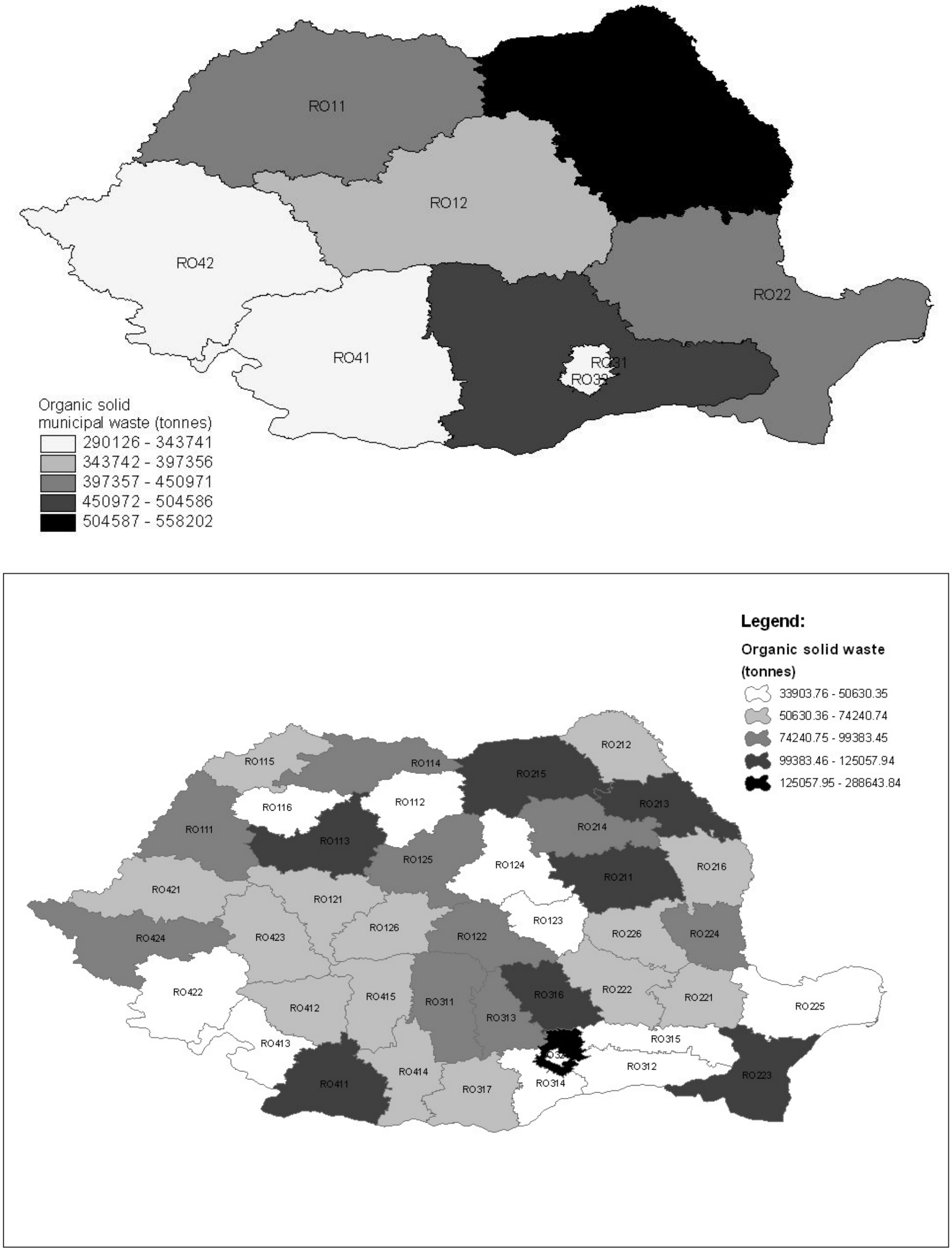


Figure 38 Organic solid municipal waste in Romania (NUTS2-up, NUTS 3 down)

Again two areas are the most important from the production point of view RO11 and RO 21, with quantities over 1 millions tones per year. Many other regions are almost as important as this already two mentioned ones. Bucharest, Brasov, Constanta, Iasi, Cluj-Napoca and Craiova areas are also promising sites.

3.5.5 Sewage sludge

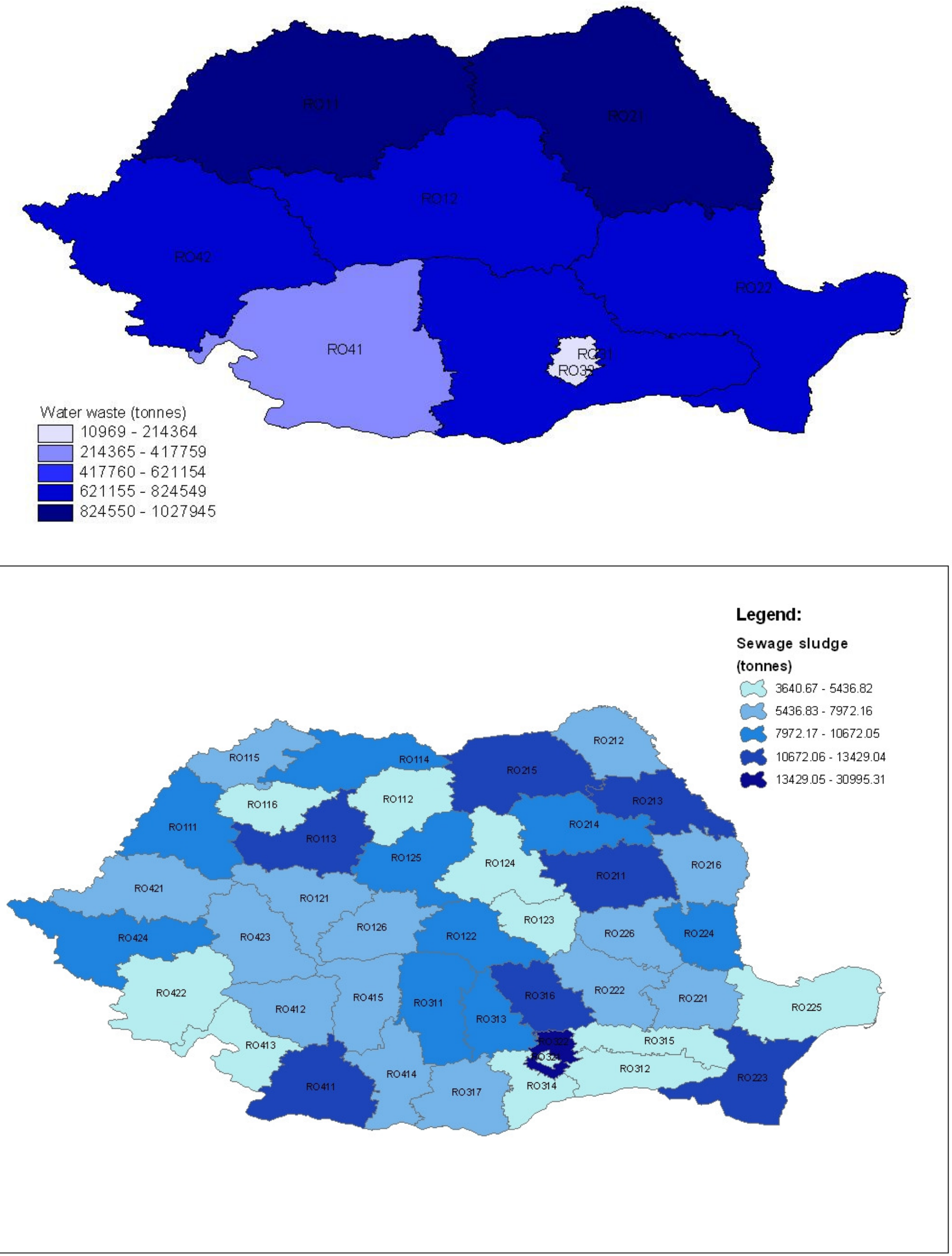


Figure 39 Sludge municipal waste in Romania (NUTS2-up, NUTS 3 down)

3.5.6 Food industry waste

Two important regions in terms of food waste coming from industry are “producing” around 150000 tones per year.

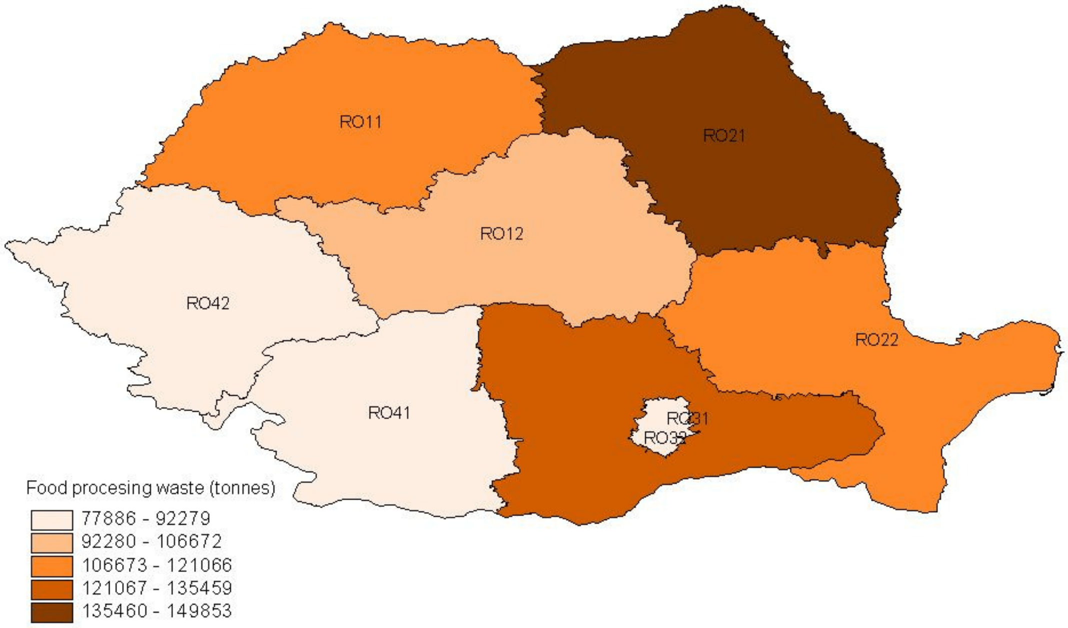


Figure 40 Food processing waste (tones) in Romania

3.6 Assessment of biomass potential in Slovenia (SI)

3.6.1 Regions analysis and special assumptions

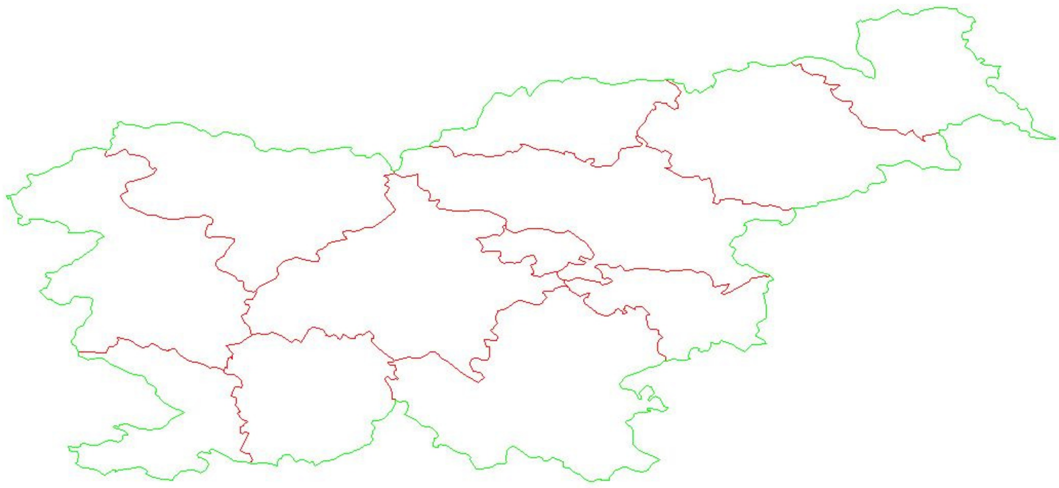


Figure 41 NUTS level 0-1-2 (green) and NUTS level 3 (red)

Slovenia has a particular NUTS classifications. Names and disposition of the NUTS with their codes are presented in Table 6. due to small absolute surface of the agricultural land, NUTS level 2 correspond to all country, as NUTS level 3 is in fact the detailed territorial unit depicted in the analysis.
Slovenia reported the biomass potential referring to the higher processed materials, hence data for primary production are not included in this analysis.

3.6.2 Agricultural and energy crops potential

One of the biggest potential for the biogas production lies in agricultural sector. The whole potential was estimated in the study which was prepared for HSE (Holding of Slovenian Power Plants), where options till 2012[5] were studied.

According to the data from the study there are 20 projects in the early phase (feasibility study, project planning, permission and building permits gathering) with the 23 MW of total power installed:

- Pomurska region: 5 power plants total power 8,5 MW,
- Podravska region: 4 power plants total power 5,3 MW,
- Savinjska region: 5 power plants total power 4 MW,
- Southeastern Slovenia: 1 power plant total power 1MW,
- Notranjsko kraška: 1 power plant total power 1,5 MW,

[5] Source: Dušan Jug: Ocena potenciala izrabe ocena potenciala izrabe bioplina v slovenskem bioplina v slovenskem prostoru, BioPLIN – izziv za trajnostno kmetijstvo in energetiko, Gornja Radgona, avgust 2007

• Osrednjeslovenska region: 2 power plants total power 2 MW,
• Gorenjska region: 2 power plants total power 0,7 MW.

Potential of the raw material form agriculture (substrates, green biomass in manure), which could be used for the biogas production was analysed by Kmetijsko gozdarski zavod
Celje. The analysis was done according to the statistical regions of Slovenia (as mentioned above). Study comprised analysis of 1.707 stockbreeding farms and 24 cattle breeding companies that all together have:

• 75.000 heads –cattle,
• 27.320 heads -pigs,
• 2.400 heads–hen,
• 2.123 heads - chicken,
• 2.878 heads -turkeys.

Alysis comprised also 375 farms that are cultivating land and 18 arable farming companies that together are working on 15.701 ha arable land, which represents 10 % of all arable land in Slovenia.

3.6.3 Municipal waste

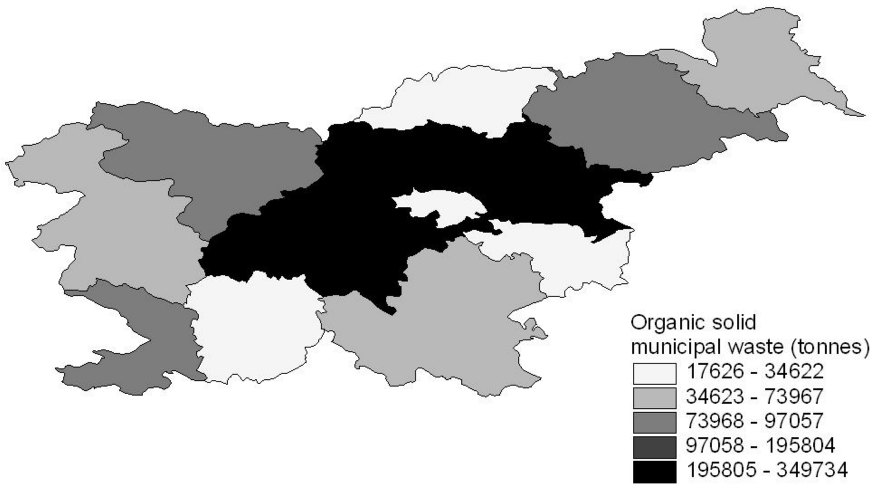


Figure 42 Organic municipal waste (tonnes) distribution in Slovenia

We took the whole population in the region and the number of tourists. Because it is relatively the same during the whole year we used the following formula: collected wastes / (number of people in the region + num. of tourists). The highest quantity of organic solid wastes is around 350000 tones per year in the central region of the country.. Other Slovenian regions have also potential for providing solid municipal waste.

A small part of these wastes are already being used for biogas production in bigger biogas plants, e.g. in KOTO. The rest represent the possible potential for further biogas production, which are best used in the so called waste management centres. The usual share of the biodegradable waste goes up to 60 %, from these a good half is composed of paper, cardboard, wood and green waste and the other half are the food remains.

Until the year 2002 biogas was captured on five landfills: Ljubljana, Maribor, Velenje, Celje and Izola. For energy purposes was used only in Ljubljana. The installed electrical power was 1,2 MW. According 2007 data biogas is now used on three locations: Ljubljana, Maribor, and Celje. The whole (CHP) electrical power is 3,5 MW.

In the study Dolgoročne energetske bilance Republike Slovenije za obdobje 2006-202612
(Longterm Energy Balance of Republic of Slovenia) the whole potential of electricity production from biodegradable waste (households, industry, animal excrement's, and other) up to the year 2030 as shown in the Table 4.

Table 4 - Estimation of power installed and electricity production for technologies of biogas production from biodegradable waste.

Year	2010	2015	2020	2025	2030
Conservative Scenario					
Average Power Installed (MW)	15	21	26,25	28,5	30
Average Annual Production (GWh)	90	126	157,5	171	180
Optimistical Scenario					
Average Power Installed (MW)	25	35	48,13	58,9	70
Average Annual Production (GWh)	150	210	288,8	353,4	420

3.6.4 Sewage sludge

We took the data from the waste water treatment plants for year 2006 and the number of people and tourists in the region.

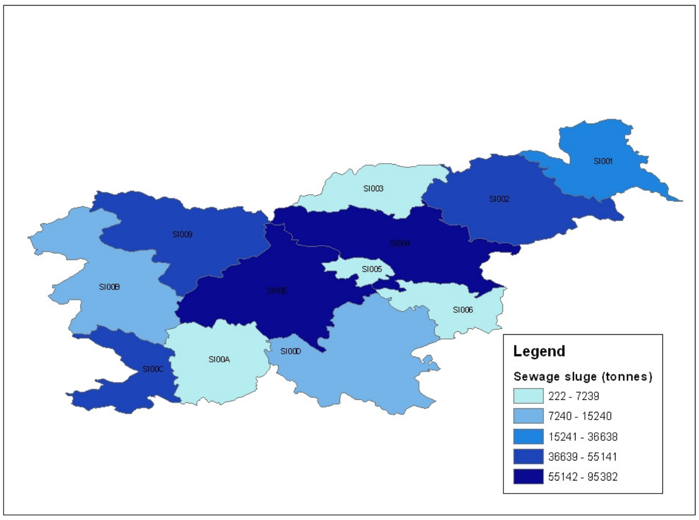


Figure 43 Sewage sludge waste (tones) distribution in Slovenia

Until 2002 there were eight central waste water treatment plants that used biogas production through fermentation, however only four of them make use of it through a CHP plant. The rest it burns on torch. The whole installed power was less than 1 MW.

After the Decree on feed–in tariffs[6] for the electricity produced from the so called qualified electricity producers was adopted in 2002 the interest rose significantly. According to 2008 data there is now production of biogas on six central waste water treatment plants: Domžale-Kamnik, Kranj, Ptuj, Škofja loka, Velenje and Jesenice. There are also some new in construction on new waste water treatments plants; e.g. Ljubljana 300.000 PE, Maribor 130.000 PE, Celje 70.000 PE and others. The whole electrical power installed is 2,1 MW.

3.6.5 Food industry waste

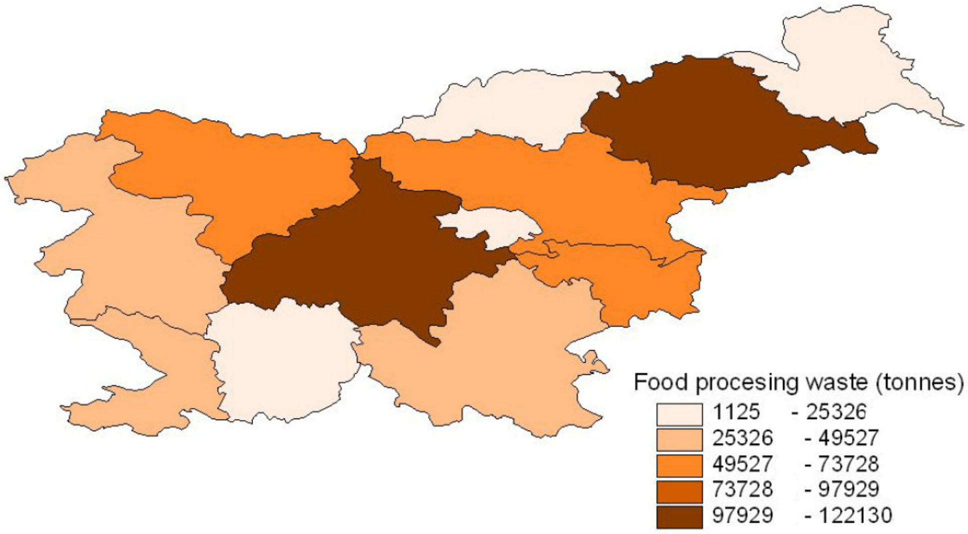


Figure 44 Food waste distribution in Slovenia

Based on the available data (only from waste management) we could conclude that the most suitable area for biogas production is the central region of Slovenia.

6 Uredbo o pravilih za določitev cen in za odkup električne energije od kvalificiranih proizvajalcev električne energije: Uradni list RS št. 25/2002.
10 Sklep o cenah in premijah za odkup električne energije od kvalificiranih proizvajalcev električne energije: Uradni list RS št. 65/2008.

4 Comparative assessment of national biogas potential

4.1 Biogas potential based on different classes of organic matter

Only the theoretical potential, based on total biomass production has been assessed in this study. The total quantities of crops (maize, rapeseed, soybean, sunflower, etc) were considered as potentially energy crops. The total sum was then reported. This is of course not the real case but this could help identify the potential places for biogas facilities as the areas with the great potential in production of energy crops is identified using this approach.
More frequently, we hear discussions expressing concerns that biofuel industry could interfere with the food price and availability. In fact, only 3 % of the total production land is used for the biofuels, including biogas, in EU.
Anyway, it is important to note that agricultural production and related industry/consumption patterns generate important amounts of organic materials that are to be considered waste, hence their utilization in biogas production is viable and a political desiderate.
The “real-life” assessment of potential for biogas production in the target countries is analyzed in the next chapter, based on the assumption that biogas plants will be mainly developed firstly based on organic wastes more then on energy crops.
Next six pictures describe the comparative potential for biogas in the target countries for those organic matters considered as waste materials.
Based on the assumption made in the first chapter, we identified the next classes of organic matters with relevance for biogas production:

Class	Description	Code
1	energy crops	EC
2	agricultural waste	AWPP
3	Animal waste	AWSP
4	food industry waste	FPW
5	organic solid waste	SW
6	sewage sludge	WW

Table 5 Classes of organic matter and their codes in the analysis

For each class we calculated a media of the biogas production in cubic meters per tone of organic matter (based on literature data and the already available results of the WP 6 from the Big-East project).
This allowed us to calculate a total production of biogas for every described region (NUT) in the target countries per class of organic matter and then normalize the results in order to obtain a value for m^3 biogas/Ha.
Finally, we represented the biogas potential for every class of organic matter described in Table 5 for all the studied countries together, giving a fair estimation of the comparative potential of each country per organic matters classes and finally total potential.

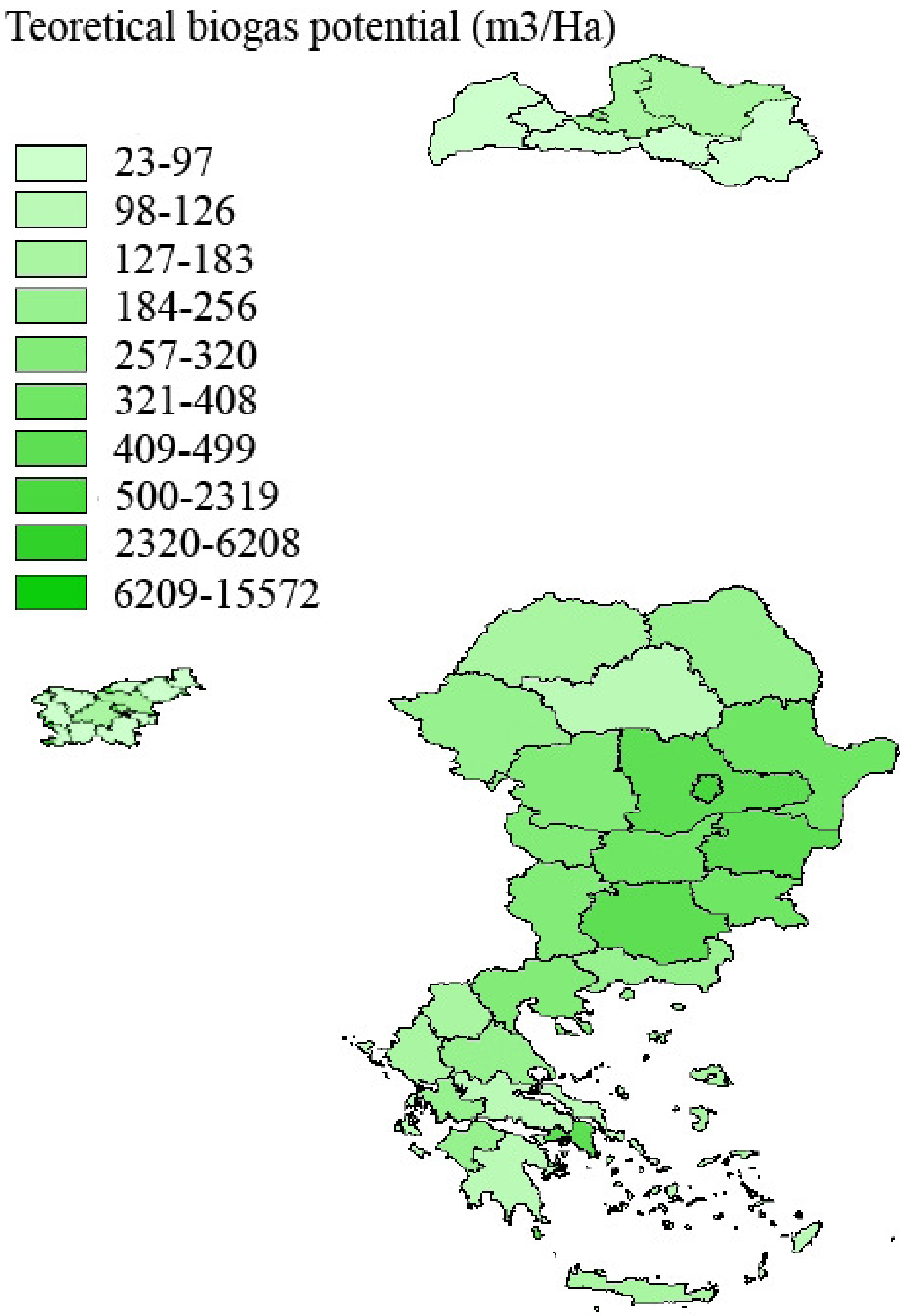


Figure 45 Overall comparative biogas potential

5 Conclusions

5.1 General conclusions

Biomass currently accounts for approximately 14% of world's final energy consumption. About 25% of the usage is in industrialized countries, while the other 75% is used in developing countries. Developing countries as a whole derive 33% of their energy from biomass. In many of these countries biomass provides over 90% of total energy use in the form of traditional fuel such as fuel wood, residues and dung (Fagernäs, 2006).

The estimations are only provided in terms of biomass and no estimated biogas potentials were made. This nevertheless could be made, but in that case a series of limitations/constrains must be taken into consideration. These limitations are especially linked with the available (not theoretical) raw material from agriculture, with technical availability and also with socio and economic constrains. The political background could play the main role in lifting this constrains and limitations. Specific support mechanisms could help promoting and further developing the use of biogas.

The support mechanisms in use are feed-in tariffs for bioelectricity, government subsidies for bio-energy investments, grants and soft loans from special environmental funds, and tax relief on bio-energy investments. In newly EU states the support is coming also from support governmental and EU structural funds. Furthermore, bio-energy is regarded as a key to encouraging sustainable development in rural areas, non-food production is supported, and energy crops cultivation and forestation of abandoned land are also given priority.

Conclusions on countries, based on overall potential of each feedstock class:

1. Romania has the largest potential for biogas production from agricultural wastes derived from primary production, followed by Greece and Bulgaria.
2. Bulgaria has the largest potential for biogas production from agricultural wastes derived from secondary production, followed by Greece and Romania.
3. Bulgaria, Greece (partly) and Romania have the largest potential for biogas production from solid municipal waste, followed by Slovenia.
4. Romania and Croatia have the largest potential for biogas production from sewage sludge, followed by Slovenia.
5. Latvia and Croatia have the largest potential for biogas production from food processing industry wastes, followed by Romania and Slovenia.

First choice for investors in Romania should be biogas facilities situated in areas of agricultural production (South and South-East of the country), based on potential generated by primary production and solid organic waste. For facilities developed in the north, sewage sludge should be considered as first choise raw material. For Bulgaria, first choise biogas area would be the secondary production waste and solid organic waste, situate in Eastern and Central area. Latvia and Croatia primary goal for biogas plants should be the use of food processing industry wastes situated in Eastern region, respective coastal line for Croatia.

5.2 *"Real-life" biogas potential assessment*

5.2.1 Theoretical potential

The net primary production (NPP), expressed in the equivalent radiation energy emanating from the Sun on the Earth surface, that is biologically absorbed in biomass amounts to approximately 57 billion tones of crude oil equivalent units every year (2140 to 2440 EJ/yr [7], according to different authors [8,9,10]). Mankind's current primary energy requirements is approximately 9.7 billion tones of crude oil equivalent units every year. Of course, only part of the biomass that grows can actually be supplied for energy use, both for ecological, technical and economic reasons. Yet there remains a huge amount of biomass that is suitable for exploitation.

Total bio-energy potential in Germany, for example, is the equivalent of 56 million tones of crude oil units (Mtoe), being 651 TWh. In theory this would be enough to meet 50% of the total automotive fuel consumption needs in Germany – including air traffic[11].

On the other part, biomass in the EU-25 is estimated at an equivalent of 115 million t of synthetic automotive fuels every year[12]

A renewable share of about 20 % of total energy in 2020 (European Union target policy) would necessitate about 210-250 Mtoe of primary biomass, according to energy projections[13,14]. Expressed in other energy units, this would be 2907 TWh.

The "real", practical potential for biogas production in the target countries has to be estimated based on the synthetic Table 6. Technical limitations for access to raw materials are widely discussed in specialty journals articles.

"*Part of the arable land resources, in the range of 10-20-30 percent of the categories of arable land, fallow and nonfood areas, will in the next two decades be utilized for energy farming, cultivation systems aiming at maximum energy storage in organic biomass with acceptable quantities of medium to high net yielding crops per hectare… In the coming 10 -20 years it will not be unrealistic to see an increasing utilization of crops for energy and industrial purposes. Scenarios of 10-20 -30 %. of arable land shifting from food and feed towards energy farming will gradually occur.*"[15].

[7] Exajoule/year

[8] Cramer, W., Kicklighter, D. W., Bondeau, A., Moore III, B., Churkina, G., Nemry, B., Ruimy, A., Schloss, A., Kaduk, J., The Participants of the Potsdam NPP Model Intercomparison, 1999. Comparing global models of terrestrial net primary productivity (NPP): overview and key results. Global Change Biology 5(Supplement 1), 1-15

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We found that many author's [16,17,18,19] trend is to set a 30 % threshold of the real maximum potential for biomass to energy (based on the total biomass potential studies).

REGIONS	SURFACE	BIOMASS PRODUCTION (tonnes * 10^3)						BIOGAS EQUIVALENT (m3*10^4)					TOTAL
NUTS	Ha*10^3	EC	AWPP	AWSP	OSW	SS	FPW	AWPP	AWSP	OSW	SS	FPW	GWh
SI005	26				18	0	6	0	0	358	3	145	30
SI00A	146				26	7	3	0	0	533	109	69	43
SI003	104				35	4	3	0	0	703	64	62	50
LV006	31				34	5	4	0	1	684	77	86	51
GR22	230	11	11	50	59	4	0	202	880	1204	66	0	141
SI001	134				96	37	1	0	0	1948	550	26	151
SI00D	268				97	15	26	0	0	1970	229	598	168
SI006	89				74	5	58	0	0	1502	73	1362	176
SI00B	233				93	12	45	0	0	1878	173	1058	187
LV007	1013	2516	110	29	16	5	9	2092	504	331	80	205	193
LV008	1526	3063	127	42	12	2	6	2416	743	251	29	131	214
LV003	1360	3562	137	37	11	8	14	2615	660	232	116	326	237
SI00C	104				165	55	31	0	0	3358	827	724	295
GR41	384	38	137	78	45	3	0	2606	1374	907	50	0	296
SI009	214				196	53	55	0	0	3975	796	1279	363
GR42	532	37	76	185	93	7	0	1446	3270	1886	104	0	402
SI002	217				188	53	120	0	0	3818	793	2822	446
LV005	1455	2965	117	46	14	4	233	2225	815	275	64	5466	531
SI004	238				350	95	57	0	0	7100	1431	1343	592
SI00E	256				293	90	122	0	0	5942	1343	2862	609
LV009	1074	8109	422	37	11	5	64	8061	651	220	69	1493	630
GR43	831	12	401	106	147	11	0	7659	1870	2984	164	0	761
GR21	916	107	107	649	72	5	0	2038	11461	1468	81	0	903
GR13	947	581	320	438	60	4	0	6116	7741	1218	67	0	909
RO32	182	840	311	14	335	11	90	5939	245	6793	165	2105	915
GR25	1551	83	500	226	135	10	0	9536	3988	2734	150	0	984
GR24	1555	341	542	253	125	9	0	10343	4464	2542	140	0	1049
GR30	381	19	81	79	750	56	0	1544	1393	15221	838	0	1140
HR1	867	5922	125	169	301	368	117	2380	2984	6118	5526	2746	1185
GR23	1132	352	416	547	150	11	0	7935	9666	3046	168	0	1249
HR3	2471	1074	19	27	419	512	163	360	477	8501	7677	3816	1250
HR2	2322	16438	404	272	245	300	95	7718	4799	4978	4496	2235	1454
GR11	1418	1247	899	762	124	9	0	17166	13449	2527	139	0	1997
GR14	1405	854	983	791	154	11	0	18761	13965	3117	172	0	2161
BG11	1029	1620	190	1561	221	10	20	3619	27561	4491	156	465	2178
RO12	3410	4757	721	189	381	681	102	13763	3329	7742	10217	2399	2247
BG23	1465	1459	267	2253	387	18	35	5091	39785	7859	273	814	3229
GR12	1917	1701	1300	1593	389	29	0	24821	28132	7902	435	0	3677
RO11	3416	7329	1825	229	411	850	110	34841	4045	8336	12749	2583	3753
RO42	3203	7882	2231	122	290	734	78	42588	2155	5890	11005	1825	3808
BG21	2031	663	219	2305	957	45	86	4177	40706	19430	676	2011	4020
BG12	1827	3836	378	2842	513	24	46	7216	50188	10422	363	1079	4156
RO21	3685	9676	2230	301	558	1028	150	42565	5319	11332	15419	3511	4689
RO41	2921	11743	3315	154	343	290	92	63287	2711	6960	4347	2156	4768
BG13	1997	5204	518	4368	616	29	54	9879	77135	12511	428	1274	6074
BG22	2752	1985	400	5320	867	41	78	7636	93947	17610	613	1823	7298
RO22	3576	16279	6332	165	442	696	119	120875	2917	8975	10441	2781	8759
RO31	3445	17738	6739	217	496	809	133	128656	3824	10059	12132	3117	9467
TOTAL	62283	140042	32906	26453	11815	7072	2424	628171	467157	239840	106082	56797	89883

Table 6 Biomass yearly production and corresponding theoretical biogas potential[20].

[16] Nielsen C., Larsen J., Iversen F., Morgen C., Holm Christensen B. (2005), Integrated biomass utilization system. Baltic Biorefienry Symposium, Aalborg University Esbjerg

[17] Kim. S., Dale B.E., (2004), Global potential bioethanol production from wasted crops and crop residues. "Biomass and Bioenergy",Vol.26, 361-375

[18] Sanders J., (2005) Biorefinery, the bridge between Agriculture and Chemistry. Wageningen University and Research centre. IEA Workshop: Energy Crops & Bioenergy, Utrecth, NL, 22.th ofSeptember, 2005.

[19] Robert D. Perlack, Lynn L. Wright, Anthony F. Turhollow, Robin L. Graham, et al. Environmental Sciences Division, Oak Ridge National Laboratory: Biomass as feedstock for a bioenergy and bioproducts industry: the technical feasibility of a billion-ton annual supply, 2005

[20] EC – energy crops, AWPP – agricultural waste from primary production, AWSP – agricultural waste from secondary production, OSW – organic solid waste (other than AWPP and AWSP), SS – sewage sludge, FPW – food production wastes, SURFACE stands for total area, not only agricultural area; for the equivalent volumes in biogas, a ponderate media was calculated, taking in account the proportion of each type of feedstock and correspondent biogas yields per mass unit.

Table 7 Yearly biogas potential function of NUTS and feedstock class - millions cubic meters).

Total		AWPP		AWSP		OSW		SS		FPW	
SI005	5,07	SI005	0,00	SI005	0,00	LV009	2,20	SI005	0,03	GR22	0,00
SI00A	7,10	SI00A	0,00	SI00A	0,00	LV003	2,32	LV008	0,29	GR41	0,00
SI003	8,29	SI003	0,00	SI003	0,00	LV008	2,51	GR41	0,50	GR42	0,00
LV006	8,48	LV006	0,00	SI001	0,00	LV005	2,75	SI003	0,64	GR43	0,00
GR22	23,52	SI001	0,00	SI00D	0,00	LV007	3,31	LV005	0,64	GR21	0,00
SI001	25,24	SI00D	0,00	SI006	0,00	SI005	3,58	GR22	0,66	GR13	0,00
SI00D	27,97	SI006	0,00	SI00B	0,00	SI00A	5,33	GR13	0,67	GR25	0,00
SI006	29,37	SI00B	0,00	SI00C	0,00	LV006	6,84	LV009	0,69	GR24	0,00
SI00B	31,10	SI00C	0,00	SI009	0,00	SI003	7,03	SI006	0,73	GR30	0,00
LV007	32,11	SI009	0,00	SI002	0,00	GR41	9,07	LV006	0,77	GR23	0,00
LV008	35,70	SI002	0,00	SI004	0,00	GR22	12,04	LV007	0,80	GR11	0,00
LV003	39,48	SI004	0,00	SI00E	0,00	GR13	12,18	GR21	0,81	GR14	0,00
SI00C	49,10	SI00E	0,00	LV006	0,01	GR21	14,68	GR42	1,04	GR12	0,00
GR41	49,37	GR22	2,02	RO32	2,45	SI006	15,02	SI00A	1,09	SI001	0,26
SI009	60,50	HR3	3,60	HR3	4,77	SI00B	18,78	LV003	1,16	SI003	0,62
GR42	67,05	GR42	14,46	LV007	5,04	GR42	18,86	GR11	1,39	SI00A	0,69
SI002	74,34	GR30	15,44	LV009	6,51	SI001	19,48	GR24	1,40	LV006	0,86
LV005	88,46	GR21	20,38	LV003	6,60	SI00D	19,70	GR25	1,50	LV008	1,31
SI004	98,73	LV007	20,92	LV008	7,43	GR11	25,27	BG11	1,56	SI005	1,45
SI00E	101,46	LV005	22,25	LV005	8,15	GR24	25,42	GR43	1,64	LV007	2,05
LV009	104,94	HR1	23,80	GR22	8,80	GR25	27,34	RO32	1,65	LV003	3,26
GR43	126,77	LV008	24,16	GR41	13,74	GR43	29,84	GR23	1,68	BG11	4,65
GR21	150,47	GR41	26,06	GR30	13,93	GR23	30,46	GR14	1,72	SI00D	5,98
GR13	151,42	LV003	26,15	GR43	18,70	GR14	31,17	SI00B	1,73	SI00C	7,24
RO32	152,47	BG11	36,19	RO42	21,55	SI00C	33,58	SI00D	2,29	BG23	8,14
GR25	164,07	BG21	41,77	RO41	27,11	SI002	38,18	BG23	2,73	SI00B	10,58
GR24	174,89	BG23	50,91	RO22	29,17	SI009	39,75	BG12	3,63	BG12	10,79
GR30	189,96	RO32	59,39	HR1	29,84	BG11	44,91	BG13	4,28	BG13	12,74
HR1	197,54	GR13	61,16	GR42	32,70	HR2	49,78	GR12	4,35	SI009	12,79
GR23	208,14	BG12	72,16	RO12	33,29	RO42	58,90	SI001	5,50	SI004	13,43
HR3	208,30	BG22	76,36	RO31	38,24	SI00E	59,42	BG22	6,13	SI006	13,62
HR2	242,26	GR43	76,59	GR25	39,88	HR1	61,18	BG21	6,76	LV009	14,93
GR11	332,81	HR2	77,18	RO11	40,45	RO32	67,93	SI002	7,93	BG22	18,23
GR14	360,14	GR23	79,35	GR24	44,64	RO41	69,60	SI009	7,96	RO42	18,25
BG11	362,92	LV009	80,61	HR2	47,99	SI004	71,00	SI00C	8,27	BG21	20,11
RO12	374,51	GR25	95,36	RO21	53,19	RO12	77,42	GR30	8,38	RO32	21,05
BG23	538,23	BG13	98,79	GR13	77,41	BG23	78,59	SI00E	13,43	RO41	21,56
GR12	612,91	GR24	103,43	GR23	96,66	GR12	79,02	SI004	14,31	HR2	22,35
RO11	625,54	RO12	137,63	GR21	114,61	RO11	83,36	RO41	43,47	RO12	23,99
RO42	634,61	GR11	171,66	GR11	134,49	HR3	85,01	HR2	44,96	RO11	25,83
BG21	670,00	GR14	187,61	GR14	139,65	RO22	89,75	HR1	55,26	HR1	27,46
BG12	692,68	GR12	248,21	BG11	275,61	RO31	100,59	HR3	76,77	RO22	27,81
RO21	781,46	RO11	348,41	GR12	281,32	BG12	104,22	RO12	102,17	SI002	28,22
RO41	794,61	RO21	425,65	BG23	397,85	RO21	113,32	RO22	104,41	SI00E	28,62
BG13	1012,28	RO42	425,88	BG21	407,06	BG13	125,11	RO42	110,05	RO31	31,17
BG22	1216,29	RO41	632,87	BG12	501,88	GR30	152,21	RO31	121,32	RO21	35,11
RO22	1459,89	RO22	1208,75	BG13	771,35	BG22	176,10	RO11	127,49	HR3	38,16
RO31	1577,88	RO31	1286,56	BG22	939,47	BG21	194,30	RO21	154,19	LV005	54,66

Color codes of NUTS specific for a country in Table 7 offers a synthetic "map" of best potential areas (ordered ascending function of biomass class). The codes for biomass classes are the same used in Table 6. Columns 1, 3, 5, 7, 9, 11 shows the order of NUTS potential (ascending), for the six countries included in comparative study (BG – Bulgaria, GR – Greece, HR – Croatia, LV – Latvia, SI – Slovenia). The numbers shown together with country code stands for the NUT number region. Columns 2, 4, 6, 8, 10, 12 shows the equivalent NUT/biomass class yearly potential for biogas production (in millions cubic meters). The potential is calculated against medium yields per class of biomass, considering 100 % of the biomass class.

5.2.2 Practical potential

Biomass considered to be potentially available for biogas production is to be discussed, as only some classes are technically considered suitable in terms of sustainable development (see bellow the two classes, and their subclasses, considered in the estimation). Considering the A. and B. (classes of biomass described bellow), we could consider that the circumvent biomass is to be directed mainly to biogas.

Corresponding to cited studies, considering 30 % of the organic wastes from agriculture and urban wastes to be used for biogas production, this gives us a result in the order of 30 TWh/year as the real potential for biogas production, altogether for the five countries included in the comparative analysis. Due to technical reasons, Croatia was not included in comparative analysis, This energy amount means around 10 % of the electrical power consumed in the region, very close to the EU 2020 year target share for renewable energy. This estimation is NOT based on energy crops, but ONLY on:

A. ***organic wastes from agriculture (both primary and secondary production)***
B. ***other organic residues (urban waste, food industry and sewage sludge)***

This should be seen as the highest level to be practically considered available on long term (beyond 2030 horizon), in theory, but also as **real potential**, after taking in account technical availability restraints (with the **assumption** that a percent of 30 % of the total "dedicated", *according to class A. and B.* feedstock is technically available). Assumption was made in accordance with the general literature trend and is not including a measurable index of factors affecting this percent Certain factors, as for example emerging concurrent technologies (gasification, bio-ethanol production) or political will, could change dramatically the course of the estimated trajectory (being at the moment to double the level of bio-energy at every 10 years). As shown in report of the task 2.4 of the BIG>East project, a numerical estimation of the real usable percent from total potential available biomass is not the goal of this study, but could be an interesting and useful future development.

As a comparative measure, 30 % of the total energy crops minimal potential of EU-27 is estimated to an equivalent of 137 Mtoe (1600 TWh)[21], meaning all potential energy biomass available.
Meanwhile, at the moment, this potential is used only at the level of 1-5 %[22,23].

[21] Jens Bo Holm-Nielsen, Head of Department, University of Southern Denmark, The Department of Bioenergy The future of biogas in Europe:Visions and Targets 2020 -European Biogas Workshop "The Future of Biogas in Europe III" 14-16. June 2007
[22] Jens Bo Holm-Nielsen, MSc. & Teodorita AI Seadi, MSc. South Jutland University Centre, Bioenergy Department
[23] Kaltschmitt, 2001

In the growing context of legitimate debates regarding competition between food resources and bio-energy production, we believe that a responsible assessment of biogas potential in Europe should be based on the mentioned categories of biomass (A and B). Organic wastes from agriculture, food industry and sewage sludge could be used for energy production not only through anaerobic digestion, but also through gasification or simple combustion. Other transformation patterns could also redirect this potential to bio-ethanol or other bio-products resulted from the complex concept of "bio-rafineries".
The 30 TWh estimation as a potential for the area includes also high range of complex variables and details that have to be further studied, being:

1. Co-fermentation patterns limitations and technically availability of potential to optimize anaerobic digestion in complex mixes of feedstock.
2. Technical limitations related to special logistics, political and economical barriers and social limitations related to investors willingness to develop biogas projects.
3. Margins of the accuracy of previous studies related to real (technical) availability of biomass.

A multifactorial analysis of the technical limitation related to those complex variables could be considered as an interesting goal for further studies.

6 Summary of graphical representations

6.1 Figures

6.2 Tables