Intelligent Energy Europe

REDUBAR

EIE/06/221/SI2.442663

REPORT

Work package: WP03
Biogas production potentials, market chances, competitors and regulations
Start date of the action: 1st of April 2007
End date of the action: 30st of June 2008

Deliverable: D07
A computer aided database
"Estimation of the existing biomass potential for the conversion into biomethane taking into account the shares of all existing competitors"
Month of completion: 7 (30st of June 2007)

Responsible partner:
University of Miskolc (UNI MISKOLC)

Date: 30th of April 2009
2nd revised version

Document connected:
Excel Spreadsheet with data from EU 27, Czech Republic, Germany, Greece, Hungary, Italy, Lithuania, the Netherlands and Poland (WP03 D07 REDUBAR 30042009.xls).
This document can be reached in the partner area of REDUBAR homepage:
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REDUBAR
WP03 D07

Investigations targeted to the creation of legislative instruments and the reduction of administrative barriers for the use of gaseous fuels produced from renewable energy sources for heating and cooling

Agreement N^{o}: EIE/06/221/SI2.442663

Co-ordinator: DBI Gas- und Umwelttechnik GmbH

WP03 D07
Edited by University of Miskolc, Hungary, 2009

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Foreword

The consortium opinions that have arrived since the previous report (15 November 2008) as well as the Redubar Project Meeting of 27 March 2009 have confirmed the perception of the UNI MISKOLC that the Excel spreadsheet serving as the basis of the calculation of the theoretical biogas potential should be revised also in term of the sources of the data. This has resulted from the fact that the national data supplied for the previous versions did not lend themselves for comparison appropriately, for the publicly available statistical data for the individual nations were built on different methodologies. Another reason for the revision is that there have become more recent data, data for 2008, available since the potential estimate originally prepared for 2006, and in other cases, the more recent data can be estimated with a good approximation. According to the feedback from the individual member states, it also seemed more expedient in terms of the raw materials suitable for biogas production to use a simpler approach and take into consideration the biogas sources based on agricultural and communal waste that are easily and continuously available. Such consideration resulted in excluding the calculation of biogas potential based on thermochemical gasification processes from the spreadsheet. In order to make the calculation method easier to understand, the individual steps in the calculation are included in the report in a mathematical format as well.

The processing method making an accurate comparison of the data possible appears as a new element: it uses the official statistics database of the European Union (EUROSTAT) as basic data. In this way the data for each of the consortium member countries make the potential values calculated by the model comparable with increased accuracy. The new database has also made it possible to estimate the accumulated biogas potential of not only the individual member countries of the consortium, but that of the countries of the EU 27, as well as to compare the potentials of the Redubar consortium with the latter.

The UNI MISKOLC is confident that the calculation method thus modified and updated for 2008 data has become more transparent, simpler and at the same time more accurate and will contribute to making the reports being prepared more accurate and anticipates a calculation method better suited for external experts as well.

1. Preliminaries

The objective of WP03 D07 was to develop an Excel spreadsheet suitable for using the biomass potential estimates of the countries in the consortium to determine the theoretical minimum and maximum values of bio-methane amounts that could be produced. The bio-methane amounts were estimated from the various types of solid and liquid biomass raw materials suitable for the production of biogas with fermentation processes. In the consortium there are eight European countries represented, therefore the estimates are made for those eight countries. The countries are as follows:

- the Czech Republic,
- Germany,
- Greece,
- Hungary,
- Italy,
- Lithuania,
- the Netherlands,
- Poland.

Under the contract the following institutions were involved in performing the task under the leadership of UNI MISKOLC:

- DBI,
- INIG,
- MAES,
- CRES,
- ECN,
- EEI.

The participants under the contract did not include Czech, Italian or Lithuanian partners. Since we found it necessary that data for the complete consortium should be available, we asked partners in countries not included in the contract for collaboration in the performance of the task.

The Excel spreadsheet together with the relevant detailed instruction manual and program description (‘*Instructions for Use and Description for the Excel Spreadsheet for Estimating the Theoretical Biogas Potentials that Can be Annually Produced from Biomass Raw*

Materials' (23 pages)) was completed on 31 October 2007, and it included the data for Hungary at the time.

On 5 November 2007 the Excel spreadsheet to be filled in, the instruction manual and the PowerPoint presentation on the spreadsheet were e-mailed to each project partner.

On 16 November 2007 a presentation was given in Amsterdam at the 2nd Project Meeting on information regarding the filling in of the database in the spreadsheet (*WP03 D07 REDUBAR 05112007.ppt*). Following the session in Amsterdam, on 19 November 2007 the spreadsheet to be filled in and the description were made accessible on the website www.redubar.eu at *Draft 01; WP03 D07 REDUBAR 31102007.xls and WP03 D07 REDUBAR Instructions 31102007.pdf*.

The biogas potentials collected with the help of the member countries of the Redubar consortium and the results calculated from them are included in the report and the Excel sheet closed on 30 April 2008 *(WP03 D07 REDUBAR 30042008.xls).*

After the first Revised Interim Report, D07 has been checked, the methodology used and the sources of data were specified in a new chapter, and another new chapter was introduced into the report to give information for actors and financial investors of the biogas markets to facilitate a choice between different uses of biomass. This 1st Revised Final Report of D07 was finished on 15.11.2008.

The present material is the 2nd Revised Final Report of D07, an evaluation of the theoretical biogas potential in the 8 consortium countries and the EU 27.

UNI MISKOLC wishes to express its thanks to all the partners who made a contribution to accomplishing WP03 D07, and is particularly grateful to the partners who, although under no obligation, provided national data for D07.

2. Methodology and data sources

The present section describes the computation principle of the Excel sheet developed by the University of Miskolc, which is a shortened version of the document *WP03 D07 REDUBAR Instructions 31102007.pdf,* which contains the detailed description as well as the instruction manual.

The calculations require only data to be found in the public statistical databases of the relevant countries (e.g. the number of the individual animal species in the given country in the previous year). The basic data for the calculations were collected from statistical database of the European Union (EUROSTAT).

The Excel spreadsheet consists of 9 worksheets with an identical structure for each country and EU 27 (worksheets 3-11), a worksheet summarising the data of the member countries of the consortium and EU 27 (Summary worksheet) and the Figures worksheet showing the summarised data.

The worksheets for the individual countries are of the same structure. The contents and structure of the worksheets follow the grouping of biogas according to the literature and the further classification according to the raw materials.

The worksheet of a country contains 12 cells that are mandatory to be filled in. These cells are to be filled in mainly with statistical data on agriculture, animal husbandry and the population. In addition to the cells mandatory to be filled in, the worksheet of each country includes 38 cells containing recommended, but modifiable specific values from technical literature. For information, the relationships for the calculation of the relevant cell are given in smaller letters in the rows.

In the worksheet of a country there are 4 main groups according to the origin of the biogas, and within each main group there are various subgroups according to the basic materials and the natural indicators. In developing the spreadsheet it was an important consideration that general, easily accessible statistical data should give the input. The input data of the worksheet are natural indicators describing the biogas potential of the given country, e.g. the animal stock of the country according to animal or the annual amount of biomass arriving at the sewage plants.

After putting in the basic data, using the specific values collected from the literature and practical experience, the theoretical amount of raw biogas that can be produced from the given basic material will be calculated.

Establishing the methane content of the different kinds of raw biogases is done according to worksheet DVGW G262. The methane content in agrarian biogas facilities is 50-85 %, in sewage-sludge facilities it is 65-70 % and in landfill biogas units it is 40-60 %. The software does not take into account any combustible gas component other than methane.

The approximate energy content of the raw biogas is given by the product of the volume from the total volume of biogas equivalent to the methane content and the gross calorific value (GCV) (37.706 MJ/m^3 at a pressure of 1013.25 mbar and at a temperature of 15 °C - gas technical normal state). In the case of a potential estimate at the national level it is not recommended to use a more accurate algorithm, for the composition of biogas, and together with it, its energy content may substantially vary depending on time.

The summarised value of the amount of biogas and renewable energy is shown in the Summary worksheet according to main groups, according to country and for the total of the consortium.

The input for the year 2008 can be used to calculate the current biogas potential. The estimate takes into consideration all the basic materials suitable for biogas production with fermentative processes and generated in one year, that is it supposes that all the available basic material is used for biogas production! In other words: this shows the 'theoretically exploitable technical potential' of the country concerned or the data summarised for the 8 REDUBAR member countries. The actual potential is a highly different, much smaller value.

Different biogases have different energy contents; therefore the energy amounts for a year that can be theoretically produced based on biogas are given in PJ as the unit of measurement.

Due to the uncertainties in the input data and the wide spectrum of the possible methane content of the raw biogas, in the D07 Excel spreadsheet a theoretical minimum and a theoretical maximum energy amount will be determined.

The theoretical minimum value means that the calculated potential is currently certainly available in the given country (technical potential), and more energy than the theoretical maximum value certainly cannot be extracted from the basic materials. The ratio of extreme values in agricultural biogases is approximately 1:2, but in other areas (e.g. the amount of biogas that can be produced from communal waste in a year) a significantly higher fluctuation is possible.

2.1. Data sheets

The computation steps for the individual rows are presented in the form of a detailed description and in mathematical formulas, for the sake of easier interpretation. In the tables each row and column are individually numbered, furthermore the calculation methods of the individual values are to be found in the relevant headings of the columns and in brackets in the relevant row of calculation.

The input of country data sheets is basic material of 3 different types suitable for biogas production. Biogas can be produced from plant cultivation products, animal husbandry by-products, and communal solid- and fluid wastes.

The production of biogas in practice generally takes place by using a variety of different basic materials simultaneously (e.g. animal by-products and plant by-products). However, this cannot be taken into account in estimating the annual potential. But is it possible to use the computation principle that by handling the basic materials as separate groups, it is possible to determine the total theoretical potential by calculating the amounts of biogas that can be produced separately – leaving the technical details of biogas production aside.

In the calculations it is primarily the organic matter content of the basic materials that is of significance, it is possible to determine the amount of biogas that can be produced specifically from the organic matter content of the particular basic material.

2.1.1. Plant cultivation core products

In determining the ratio of core products and by-products originating from agriculture it is difficult to estimate the ratio of products that are sold and those that appear as waste not utilised any more. While the total quantity data on the plant cultivation core products produced annually are accessible in every country and in EU level, the information on the share of core and by-products used specifically for energetics purposes is very deficient. As a result, the spreadsheet calculates the amount of by-products suitable for the production of the theoretical biogas quantity from the data on the plant cultivation core products.

The annual statistical amounts in measurement units of a thousand tons produced in the agriculture in 2008 are to be filled in the given group. These products are cereals – wheat, barley, maize, oat, rye, (1.1), sugar beet (1.2), sunflower (1.3), rape (1.4), and potatoes (1.5). For each product only the core product used is to be filled in (e.g. the fruit if maize). The boundary condition of the calculation is that the plant cultivation core products are not used for biogas production, only the by-products produced in the course of cultivation and utilisation!

Row (1.6) totals the annual amounts of the core products and then in row (1.7) the annual loss of the plant cultivation core products (transportation, storage, etc.) can be given in percentage. The product of row (1.6) and row (1.7) gives the annual amount of loss in a thousand tons/year as measurement unit in row (1.8), which is added to the amount of the plant cultivation by-products in row (2.7).

2.1.2. Plant cultivation by-products

Biogas can be produced from plant cultivation by-products, the amount of the by-products can be estimated in percentage from the amount of the core products.

Rows (2.1) … (2.6) show the amounts of by-products that can be deducted from the core products. Row (2.7) shows the amount generated from the losses of the core products (transportation, etc.) given in row (1.8).

The amount of biogas and its energy content can be calculated from the amount of the by-products generated in the following way. The amount of a particular core product is known, and so is the ratio of the by-product to the core-product (the core product is the base of comparison = 100 %). The ratio of the individual by-products, and their organic matter content can be found as a recommendation based on the literature in the column to the right of the column of the amounts of the by-products. The values can be changed at discretion.

The mass of plant cultivation by-products is calculated according to the ratio of the core products and the by-products in relation to the core products. When the organic matter content and the previously calculated mass of the given product are known, a multiplication determines the amount of organic matter suitable for biogas production. The amount of biogas formed can be determined when the amounts of organic matter and the amounts of biogas formed at theoretical level from a given kind of organic matter of unit mass.

It is known from the literature that 1 ton of vegetable organic matter can produce 240 … 400 thousand m^3 raw biogas. The specific values taken from the literature can be modified. Summing the theoretical minimum and maximum amounts of biogas developed from the individual by-product groups gives the amounts of raw biogas that can be produced annually (2.8).

According to the DVGW G 262 worksheet the methane content of agrarian biogases is 50 … 85 volume percent (2.9). As a matter of course, the smallest theoretical energy amount can be determined from the minimum amount of gas and the smallest methane volume percentage, and the maximum theoretical energy amount can be determined from the maximum amount of biogas and the largest volume percentage of methane.

The calculation method of the biogas amount which generated from plant cultivation products in a year in mathematical form is:

The mass of main products of plant cultivation:

$$Q_{mppc} = \sum_{i=1}^{n} Q_{mppci} \text{ [tons/year]}$$

where

$mppc_i$ - mean Cereals, Sugar-beet, Sunflower, Rape, Potatoes

The mass of secondary products of plant cultivation from main products:

$$M_{biomsp} = \sum_{i=1}^{n} Q_{mppci} \cdot \frac{R_i}{100} \cdot \frac{OM_i}{100} \text{ [tons/year]}$$

The mass of losses of main products:

$$M_{biomloss} = \sum_{i=1}^{n} Q_{mppci} \cdot \frac{L_{mp}}{100} \cdot \frac{OM_{avr}}{100} \text{ [tons/year]}$$

where

Q_{mppc} – the mass of main products (Cereals, Sugar-beet, Sunflower seed, Rape seed, Potato) of plant cultivation [tons/year]

R_i – ratio of secondary and main products of plant type (Cereals, etc.) [%]

OM_i – organic material content of plant type [%]

L_{mp} – loss ratio of main products [%]

OM_{ave} – average organic material content of main product losses [%]

Raw biogas quantity from secondary products and losses of plant cultivation:

$$V_{bg\,min}^{\;\;max} = \left(M_{biomsp} + M_{biomloss}\right) \cdot S_{srbo\,min}^{\;\;max} \text{ [m}^3\text{/year]}$$

where

$S_{srbo\,min}^{\;\;max}$ - specific raw biogas output from 1 ton of organic material [m^3/ton]

Energy content of the raw biogas from plant cultivation:

$$E_{bg}(1)_{min}^{max} = V_{bg\,min}^{\;\;max} \cdot GCV_{CH4} \cdot \frac{SH_{min}^{max}}{100} \cdot \frac{1}{10^9} \text{ [PJ/year]}$$

where

GCV_{CH4} – gross calorific value of combustible component (CH_4) of the raw biogas [37,706 MJ/m^3 at 15 °C and 101 325 Pa]

SH_{min}^{max} - share of methane in the raw biogas [%] (50-85 % at agricultural biogas plants – from literature DVGW G 262)

2.1.3. Animal husbandry by-products

The amount of by-products (liquid manure and manure with litter) from animal husbandry is again difficult to estimate. The computation has to start with the animal stock of the previous year of the given country.

In Table (3) the number of livestock according to animal in each country is to be given rounded off for a thousand heads. Row (3.1) includes the total number of cattle and dairy cows stock, row (3.2) gives that of pigs, row (3.3) gives that of sheep and lamb, row (3.4) gives that of poultry.

In addition to giving the number of animals, the daily amount of liquid manure taken from the literature was also given for unit animal. The recommended values given may be modified.

The product of the number of a given kind of animal and the amount of the liquid manure produced by one animal can be used to determine the annual amount of liquid manure produced by the particular kind. The values of biogas yields produced from unit liquid manure are: 4.5 … 6.5 $m^3_{biogas}/m^3_{liquid\ manure}$ on the basis of literature; and the recommended values may be modified. The minimum and maximum biogas yields produced and characteristic of the given individual animals can be calculated on the basis of the liquid manure amount and the values from the literature.

Row (3.5) sums the theoretical amounts of biogas that can be produced from animal husbandry annually. Following the logic used for the by-products of plant cultivation, row (3.6) can be used to give the extreme values of the methane content of biogas, which are 50 … 85 volumetric % according to the recommendations of the DVGW G 262 worksheet. The energy content of the gas produced appears in row (3.7), which can be derived from the product of the amount of biogas produced, the volumetric percentage of the methane and the calorific value of the methane in measurement units of GJ/year, and PJ/year.

This calculation procedure does not take manure with litter into account, for manure with litter is basically a mixture of an agricultural by-product and the liquid manure, and both of them have previously provided their input.

The calculation method of the biogas amount which generated from secondary products of livestock production in a year in mathematical form is:

Raw biogas quantity from secondary products of livestock production:

$$V_{bg}{}_{min}^{max} = \sum_{i=1}^{n} N_{splpi} \cdot LD_i \cdot \frac{365[day]}{1000[liter]} \cdot S_{srbo}{}_{min}^{max} \ [m^3/year]$$

where

N_{splp}- number of animal species in the country (cattle and dairy cows, pig, sheep, laying hens) [piece]

LD_i- quantity of liquid dung [liter/day/animal species]

$S_{srbo}{}_{min}^{max}$ - specific raw biogas output from 1 m^3 of liquid dung [m^3/m^3]

Energy content of the raw biogas from livestock production:

$$E_{bg}(2)_{min}^{max} = V_{bg}{}_{min}^{max} \cdot GCV_{CH4} \cdot \frac{SH_{min}^{max}}{100} \cdot \frac{1}{10^9} \ [PJ/year]$$

where

$V_{bg}{}_{min}^{max}$ - raw biogas quantity from secondary products of livestock production [m^3/year]

GCV_{CH4} – gross calorific value of combustible component (CH_4) of the raw biogas [37,706 MJ/m^3 at 15 °C and 101 325 Pa]

SH_{min}^{max} - share of methane in the raw biogas [%] (50-85 % at agricultural biogas plants – from literature DVGW G 262)

2.1.4. Communal waste

Communal waste is divided into 2 subgroups, the most significant are communal sewage- and communal solid waste.

Determining the total potential of biogas obtainable from sewage plants can be performed using the number of the population, the canalisation rate and an estimate of the per capita specific daily amount of biogas produced. A problem is presented, however, by estimating the sewage water conducted from the sewage system without purification or after minimum mechanical purification into live waters. A further problem is raised by the fact that the sewage sludge is generally deposited in more than 50 % after the appropriate treatment in the community landfill site, from which again biogas is formed. In order to resolve the problem, sewage sludge was taken into account in determining the theoretical biogas yields that can be obtained from sewage plants, and it was not taken into account in the amounts of the deposit gases in landfill sites.

Determining the amount of biogas produced in the communal landfills presents the most difficulties. On the one hand, biogas is not released in a steady rate from the organic matter deposited, but over many years with an intensity matching the lifecycle of the landfill site. In the meantime, newer and newer amounts are deposited in the sites in use. An approximating solution is to be used for calculating the potential.

It is a simpler case if the expected biogas amounts to develop are to be determined in a closed down landfill deposit site the age, composition and volume of which are known. In landfill sites the material gets compacted over the years, its density increases depending on time, and may even reach five times the original value, which increases the amount of biogas that can be extracted from a unit volume. Due to all this, it is only possible to estimate relatively exactly the potential amount of biogas that is accumulated in a year and can be extracted over a period of years from communal solid waste. Since biogas is formed currently in the waste deposited and biogas will be formed in the waste being currently deposited in the years to come, it is possible to use the simplifying assumption that approximately the same amount of biogas is formed annually as is accumulated. The assumption is also supported by the facts that in the population sector the per capita amounts of waste in the previous decade and currently show a very small level of difference, therefore it is possible to estimate the exploitable amount of biogas on the basis of inhabitant-equivalence with a good approximation.

Communal sewage water

In determining the amount of biogas obtainable from the amount of communal sewage water, we have to start from the assumption that the amount of sewage water that can theoretically reach through the communal sewage system the sewage plants can be used as the basis. Naturally a certain part of the communal sewage water does not reach the sewage plants, but after appropriate mechanical purification gets into live waters. In the calculation the total, potentially exploitable theoretical amount of sewage water was taken into consideration.

The basic material can reach the sewage plant in two ways: through the communal sewage system and by the road vehicles transporting sewage water. If the number of households with sewage system and the number of the population of the country, the amount of sewage water per inhabitant equivalent and the specific biogas output are known, it is possible to determine the amount of raw biogas that can develop.

Row (4.1.1) gives the number of the population of the country. Row (4.1.2) gives the number of households with sewage system. The inhabitant equivalent (IE) is obtained from the product of the number of the population and the ratio of the households with sewage system. Thus it is possible to find the amount formed daily from the specific daily amount of sewage water produced by that number of persons. Row (4.1.4) shows on the basis of literature the amount of organic dry waste produced daily by one person. This, the product of inhabitant equivalent and the number of days in a year gives the annual amount of dry waste in the measurement unit of ton/year (4.1.5). Again, relying on data from the literature it is possible to give the specific raw biogas output that can develop from one ton of dry material (310 … 740 $m^3/ton_{dry\ material}$) in row (4.1.6). The product of the annual amount of dry material and the specific biogas output gives the annual biogas amount (4.1.7). Row (4.1.8) gives the methane content of the biogas developed (for sewage gas it is 65 … 70 % according to worksheet DVGW G 262), then row (4.1.9) calculates the energy content of the gas obtained by means of the product of the biogas developed, the methane content and the calorific heat of the methane in the measurement units of GJ/year, and PJ/year, respectively.

The calculation method of the biogas amount which generated from communal waste water in a year in mathematical form is:

The mass of sewage sludge generated by inhabitants:

$$M_{ss\,min}^{max} = N_{ih} \cdot \frac{R_{uwcs}}{100} \cdot SSC_{min}^{max} \cdot 365[\text{day}]\ \ [\text{tons/year}]$$

where

N_{ih} - number of inhabitants of the country

R_{uwcs} - ratio of urban wastewater collecting systems in the country [%]

SSC_{min}^{max} - min and max specific solid contents of the collected waste water [kg/day/inhabitant]

Raw biogas quantity from communal waste water systems:

$$V_{bg_{min}}^{max} = M_{sg_{min}}^{max} \cdot S_{sbq_{min}}^{max} \text{ [m}^3\text{/year]}$$

where

$S_{sbq_{min}}^{max}$ - specific biogas output from 1 ton of solid contents of the waste water [m^3/tons of SC]

Energy content of the raw biogas from communal waste water:

$$E_{bg}(3)_{min}^{max} = V_{bg_{min}}^{max} \cdot GCV_{CH4} \cdot \frac{SH_{min}^{max}}{100} \cdot \frac{1}{10^9} \text{ [PJ/year]}$$

where

$V_{bg_{min}}^{max}$ - raw biogas quantity from communal waste water systems [m^3/year]

GCV_{CH4} – gross calorific value of combustible component (CH_4) of the raw biogas [37,706 MJ/m^3 at 15 °C and 101 325 Pa]

SH_{min}^{max} - share of methane in the raw biogas [%] (65-70 % at waste water systems – from literature DVGW G 262)

Communal solid waste

In determining the biogas that can be extracted from communal solid waste the basis was given by determining the potential amount of biogas accumulated in a year, for we are faced with considerable obstacles in determining the characteristic data of individual landfill deposits and the development rate of deposit gas.

Determining the theoretical potential requires only the number of the inhabitants of the country, the annual amount of waste per inhabitant, and the organic matter content of the waste. Row (4.2.1) includes the number of the inhabitants of the country, which was already given in row (4.1.1). Row (4.2.2) gives the amounts of household waste and communal waste produced by one inhabitant annually. The values can be modified according to the situation in the country. Row (4.2.3) gives the amounts of waste produced annually.

Row (4.2.4) is to be used to give the specific organic matter content resulting from the composition of the waste deposited. This is approximately 20 … 25 % in Western Europe, while in the countries of Central-Eastern Europe it may be as high as 40 %. The recommended range is 20 … 40 %.

Row (4.2.5) gives the specific biogas yield that can be produced from a unit mass of organic matter content. The recommended range is 240 … 400 m^3/ton of organic matter. The total amount of gas accumulated annually (4.2.6) can be determined using the mass of waste, its organic matter content, and the specific deposit gas yield. Taking into account the methane content of the deposit gas (40 … 60 volumetric % - DVGW G 262 worksheet) (4.2.7) and the calorific value of methane, the accumulated amount of gas can be used to determine the theoretical maximum and minimum energy content in units of measurement of GJ/year and PJ/year in row (4.2.8).

The calculation method of the biogas amount which generated from communal solid wastes in a year in mathematical form is:
The mass of solid wastes generated by inhabitants:

$$M_{sw\,min}^{\;\;max} = N_{ih} \cdot \frac{R_{uwcs}}{100} \cdot MWG \cdot \frac{1}{10^3} \text{ [tons/year]}$$

where
N_{ih} - number of inhabitants of the country
MWG – specific municipal waste generated by inhabitants [kg/person/year]

Raw biogas quantity from communal solid wastes:

$$V_{bg\,min}^{\;\;max} = M_{sw\,min}^{\;\;max} \cdot S_{sbq\,min}^{\;\;max} \text{ [m}^3\text{/year]}$$

where
$M_{sw\,min}^{\;\;max}$ - the mass of solid wastes generated by inhabitants [tons/year]
$S_{sbq\,min}^{\;\;max}$ - specific biogas output from 1 ton of organic material contents [m^3/tons of OMC]

Energy content of the raw biogas from communal solid wastes:

$$E_{bg}(4)_{min}^{max} = V_{bg\,min}^{\;\;max} \cdot GCV_{CH4} \cdot \frac{SH_{min}^{max}}{100} \cdot \frac{1}{10^9} \text{ [PJ/year]}$$

where
$V_{bg\,min}^{\;\;max}$ - raw biogas quantity from communal solid wastes [m^3/year]

GCV_{CH4} – gross calorific value of combustible component (CH_4) of the raw biogas [37,706 MJ/m^3 at 15 °C and 101 325 Pa]

SH_{min}^{max} - share of methane in the raw biogas [%] (40-60 % at solid waste deposit systems – from literature DVGW G 262)

2.1.5. Summary data

Aggregated theoretical minimum and maximum biogas potential of the country (Summary worksheet of Excel spreadsheet) is given in mathematical form:

$$E_{bg_{min}}^{\ max} = \sum_{i=1}^{n} E_{bg}(i) \ \text{[PJ/year]}$$

Average biogas potential of the country:

$$E_{bgav} = \frac{E_{bg_{min}} + E_{bg}^{\ max}}{2} \ \text{[PJ/year]}$$

Total biogas quantity of the country:

$$V_{bg_{min}}^{\ max} = \frac{E_{bg_{min}}^{\ max}}{GCV_{CH4}} \cdot 10^3 \ \text{[million m}^3\text{]}$$

3. Summary of the worksheets submitted

The summarising worksheet of the Excel spreadsheet (*Summary*) includes at present data for eight countries: the Czech Republic, Germany, Greece, Hungary, Italy, Lithuania, the Netherlands and Poland. The summarised data of Redubar countries and EU 27 countries can be seen in Figure 1.

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(I.0)	Average Gross Calorific Value (GCV) of the raw biogas:	**25,00**		MJ/m^3
(0)	**Total Annual Teoretical Biogas Potentials in EU 27 countries**			
		in 2008		
	Biogas from	min.	max.	
(0.1)	*Secondary products of plant cultivation:*	**2 926**	**8 290**	PJ in a year
(0.2)	*Secondary products of livestock production:*	**201**	**493**	PJ in a year
(0.3)	*Community waste water:*	**109**	**394**	PJ in a year
(0.4)	*Community solid wastes:*	**189**	**944**	PJ in a year
(0.5)	**Sum total of EU 27:**	**3 425**	**10 121**	**PJ in a year**
(0.6)	**Average of EU 27:**	**6 773**		**PJ in a year**
(0.7)	Sum total quantified in raw gas volume unit: ~	136 992	404 827	million m^3
(I)	**Total Annual Teoretical Biogas Potentials in the Countries of the REDUBAR Cons.**			
		in 2008		
	Biogas from	min.	max.	
(I.1)	*Secondary products of plant cultivation:*	**740**	**2 097**	PJ in a year
(I.2)	*Secondary products of livestock production:*	**79**	**194**	PJ in a year
(I.3)	*Community waste water:*	**56**	**201**	PJ in a year
(I.4)	*Community solid wastes:*	**84**	**420**	PJ in a year
(I.5)	**Sum total of the Consortium:**	**959**	**2 912**	**PJ in a year**
(I.6)	**Average of the Consortium:**	**1 936**		**PJ in a year**
(I.7)	Sum total quantified in raw gas volume unit: ~	38 361	116 490	million m^3

Figure 1 Total annual theoretical biogas potentials of Redubar consortium countries and EU 27 countries in 2008

In the countries of the consortium the theoretical biogas potential is minimum 959 PJ and maximum 2912 PJ, the average of these 1936 PJ. Expressed in biogas with a specific energy content of 25 MJ/m^3, the extreme values are minimum $38.361 \cdot 10^9$ m^3 and maximum $116.490 \cdot 10^9$ m^3, i.e. the amount of biogas raw material available in the countries in 2008 could have been used to produce theoretically that much raw biogas. The estimated amount of energy could have been actually extracted if all basic materials suitable for the production of biogas had been used to produce biogas. The potential actually used is much smaller than that, and a different methodology should be used to estimate its amount.

In the EU 27 countries the theoretical biogas potential is minimum 3425 PJ and maximum 10121 PJ, the average of these 6773 PJ. Expressed in biogas with a specific energy content of 25 MJ/m^3, the extreme values are minimum $136.992 \cdot 10^9$ m^3 and maximum $404.827 \cdot 10^9$ m^3, i.e. the amount of biogas raw material available in the EU 27 countries in 2008 could have been used to produce theoretically that much raw biogas. Figure 2 shows the biogas potential ratios of EU 27 countries in 2008. The Redubar consortium has the share of it 28,6 % in all.

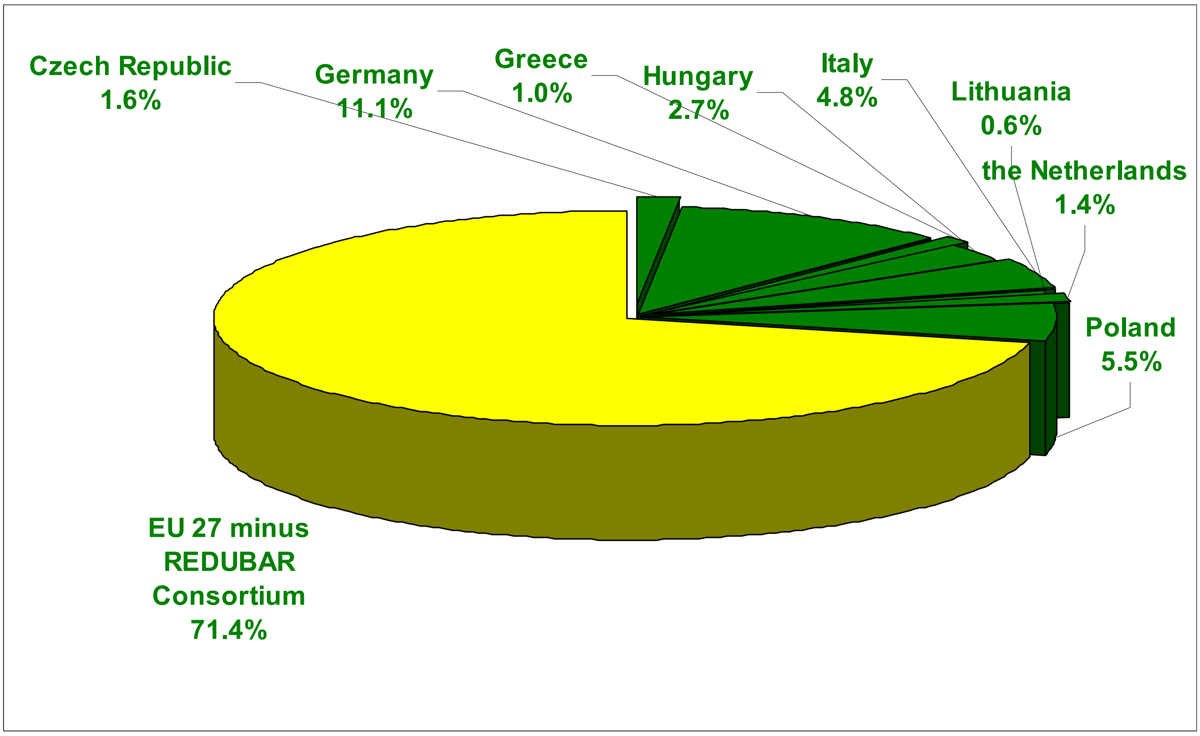

Figure 2 Theoretical biogas potential ratios in EU 27 countries

The summary sheet of the Excel spreadsheet it can be seen that the production of biogas is feasible in the highest percentage from plant cultivation by-products. Figure 3 can be used to quantify these ratios, i.e. 73.3 % of the average biogas potential is accounted for by plant cultivation by-products, 13.0 % by communal solid wastes, 6.6 % by communal waste water and 7.0 % is accounted for secondary products of livestock production.

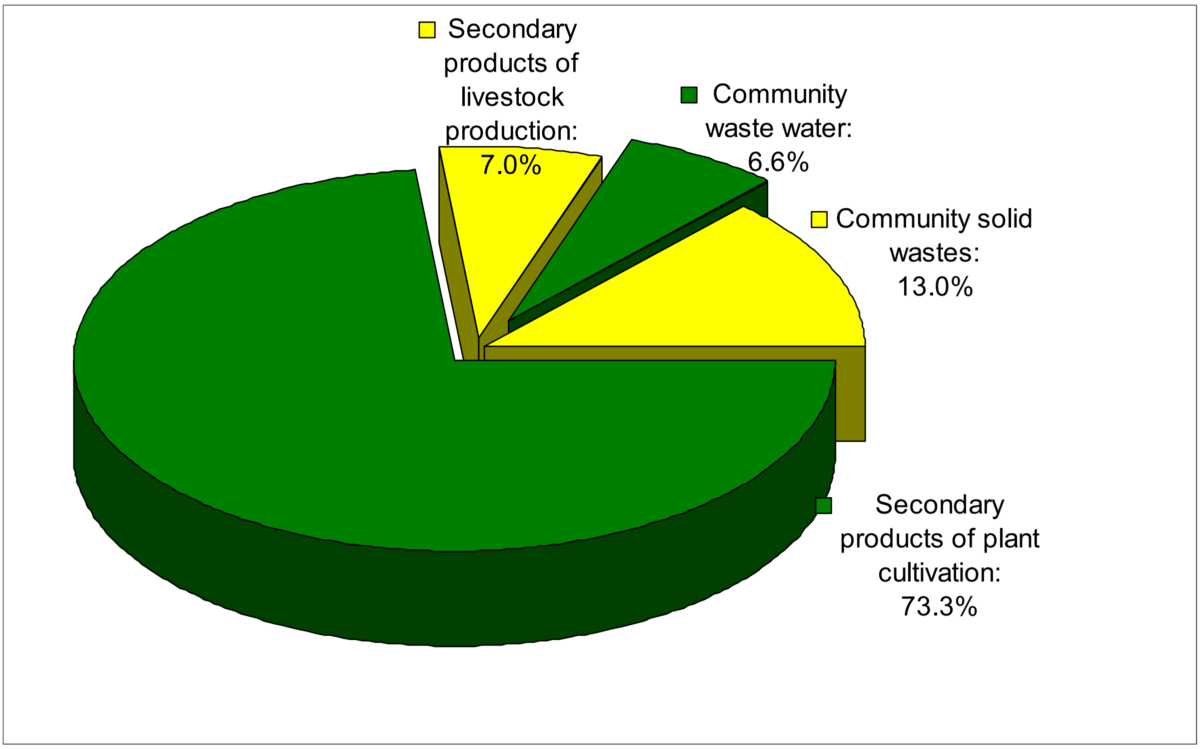

Figure 3 Biogas potential ratios in the eight countries according to raw material

If the sizes of the average biogas that can be produced are examined in a comparison of the eight countries, it can be established Germany has the largest share with 38.7 % in the summarised potential of the eight countries (Figure 4). The average value for Poland is the second highest value at 19.1 %, Italy has the third highest value at 16.6 %, and the shares of the other four countries each are below 10 %: Hungary with 9.5 %, the Netherlands with 4.9 %, the Czech Republic with 5.5 %, Greece with 3.5 % and Lithuania with 2.2 %. The ratios reflect the geographical sizes, locations, topographies, agriculture and economic features of the countries as well.

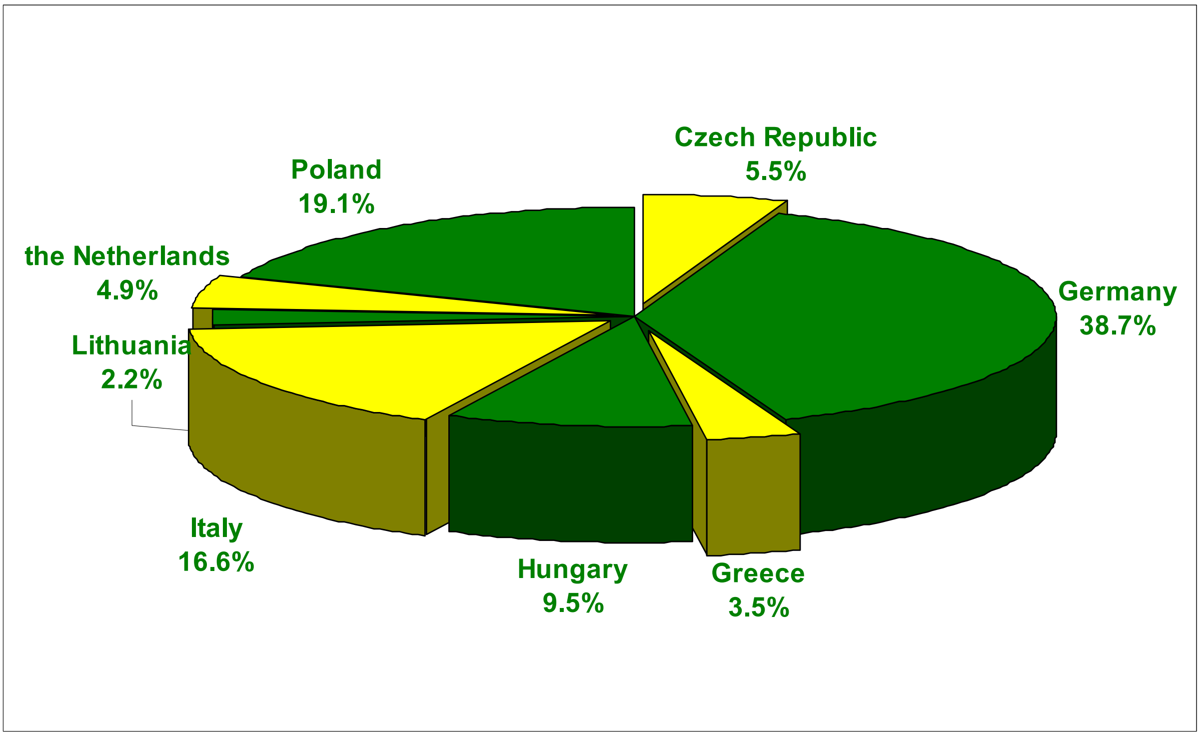

Figure 4 Average biogas potential ratios in Redubar countries

Figure 5 shows the diagram seen in Figure 3 with detailing the minimum and maximum data. It can also be seen here that the theoretical biogas potential of Germany is far ahead of those of the other countries. The Czech Republic, Greece, Lithuania and the Netherlands do not even reach the minimum or maximum average values calculated from the data of the eight countries. Among the four countries the Netherlands and the Czech Republic are closest to these values.

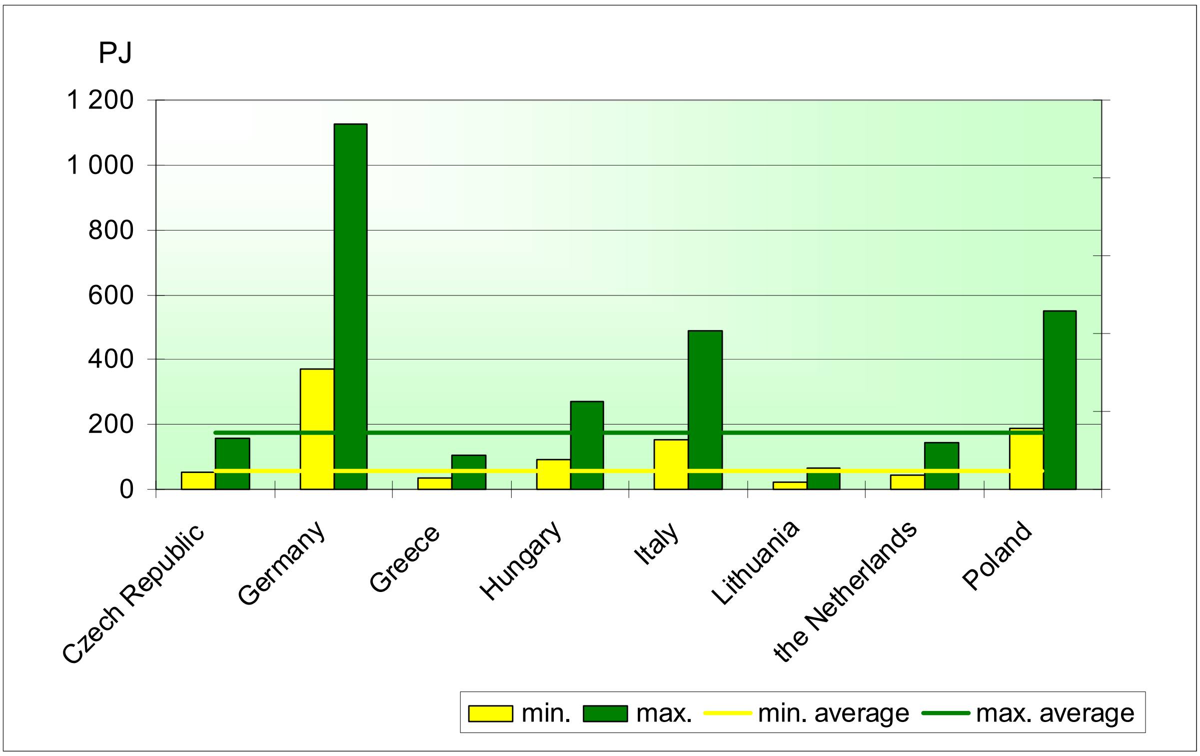

Figure 5 Biogas potential ratios in the Redubar countries

3.1. The Czech Republic

The summarised data for the Czech Republic are shown in Figure 6, and the detailed data are given in Figure 7.

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(II.1) Czech Republic		in 2008		
	Biogas from	min.	max.	
	(II.1.1) *Secondary products of plant cultivation:*	46.49	131.73	PJ in a year
	(II.1.2) *Secondary products of livestock production:*	2.98	7.31	PJ in a year
	(II.1.3) *Community waste water:*	2.35	8.47	PJ in a year
	(II.1.4) *Community solid wastes:*	2.23	11.15	PJ in a year
(II.1.5)	**Sum total of Czech Republic:**	**54.05**	**158.65**	**PJ in a year**
(II.1.6)	**Average of Czech Republic:**	**106.35**		**PJ in a year**
(II.1.7)	Sum total quantified in raw gas volume unit: ~	2 162	6 346	million m^3

Figure 6 Summary worksheet of the Czech Republic

The largest part of biomass suitable for biogas production in the Czech Republic is given by agricultural by-products and solid waste. The production of a much smaller amount of biogas is accounted for by the amount of biogas that can be theoretically produced from stock breeding, communal sewage sludge and organic industrial waste. In 2008 the biomass basic materials in the Czech Republic could have been used to produce an average of biogas-based energy of 106.35 PJ.

In 2007 the annual primary energy consumption of the Czech Republic was 1812.9 PJ, the energy content of the annual natural gas consumption calculated with an average calorific value being 334.9 PJ according to statistics by British Petrol and Eurostat.

Estimating the changes in theoretical biogas potential in the next 5-10 years can be performed only with the utmost uncertainty. The background is that the amounts of agrarian by-products representing the highest potential values vary from year to year, primarily due to the weather conditions of the year in question (drought, rain, number of sunshine hours, etc.). Let us look at the grain production data of the Czech Republic from 1998 to 2008 from the Eurostat database. Let us take as our starting point the year 1998, i.e. let us consider this to be 100 % as the basic data of the amounts of grain produced annually. In the following years the amount of grain produced was: 100% (1998), 103.89% (1999), 96.78% (2000), 110.03% (2001), 101.53% (2002), 86.41% (2003), 131.71% (2004), 114.86% (2005), 95.76%

(2006), 107.26% (2007) and 125.50% (2008), respectively. As the data show it clearly, a difference of up to several tens per cent is possible between the years on the same area of cultivated land depending on the weather conditions of the different years. Expressing it in numerical values, for Germany, representing the greatest potential, this may mean an amount of energy of up to ± 60-170 PJ. Since in each of the member countries of the consortium the biogas potential resulting from agricultural by-products accounts for 60-80% of the total amount, any conclusion or estimate would burden the numerical value of the potentials to be expected in the future with a high percentage of error.

The situation is different for the number of heads of standard animals, which does not show such differences through the years. On the basis of the Eurostat data it is possible to estimate the number of heads of the different species for the years to come, which has showed at most ± 7% for the individual countries in the past 5 years. Such a change in the number of heads has only an impact of the same size on the biogas amounts resulting from animal husbandry, which represents a change in the amount of energy of only some tenths of PJ expressed as a numerical value for the Czech, Greek, Hungarian and Lithuanian partners. It may be ± 2-5 PJ in the German value of potential, while in the Italian, Dutch, and Polish potentials it may be at most ± 1-2 PJ. For the countries of the EU 27 this represents a change in energy of ±14-34 PJ.

The amounts of theoretical biogas potentials from communal solid and liquid waste to be expected in the next 5-10 years can be primarily related to changes in the number of the population. Naturally, the economic situation, the impacts of programs encouraging economising on energy and an environmental-conscious behaviour exert further impacts on the amounts of waste produced. The number of the population has increased by 2.7% in the countries of the EU 27 in the past 5 years. Among the countries of the consortium, the number of the population increased in the Czech Republic (2.7%), Greece (2.3%), Italy (4.8%) and the Netherlands (1.8%), it decreased in Germany (-0.6%), Lithuania (-3.3%), Hungary (-1.1%) and Poland (-0.3%). The presumed further progress of these changes in the next 5 years may represent a change in the amount of energy of at most +1.5 PJ in Germany, having the largest number of population among the member countries of the consortium, and a change in the amount of energy of up to +8.4 PJ in Italy, producing the greatest increase in the number of the population. In the other member countries of the consortium a change of at most some tenths of PJ can be expected according to the above train of thought. Looking at the countries of the EU 27, and presuming a further 2.7 % increase in the number of population, a further theoretical amount of biogas of 8.0-36.1 PJ may be added to the values for 2008.

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Annual Theoretical Biogas Potentials in 2008

Czech Republic

(1) Main products of plant cultivation in 2008

(1A)	(1B)	(1C)	(1D)
(1.1)	**Cereals** (wheat (*Trititcum*), barley (*Hordeum*), maize (*Zea mays*), oat (*Avena*), rye (Secale)):	8 370	thousand tons in a year
(1.2)	**Sugar-beet** (*Beta vulgaris*):	2 885	thousand tons in a year
(1.3)	**Sunflower** (*Helianthus annuus*):	61	thousand tons in a year
(1.4)	**Rape** (*Brassica napus*):	1 049	thousand tons in a year
(1.5)	**Potatoes** (*Solanum tuberosum*):	770	thousand tons in a year
(1.6)	Sum total:	**13 134**	thousand tons in a year
(1.7)	Losses of main products:	8%	(*Transport, storage, etc.*)
(1.8)	Losses of main products:	**1 051**	thousand tons in a year (1.6)*(1.7)

(2) Seconrady products of plant cultivation in 2008

(2A)	(2B)	(2C) Thousand tons in a year (2D*1C)	(2D) Ratio compared with main crop (main crop=100%)	(2E) Organic-material content	(2F) Thousand tons organic mat. in a year (2C*2E)	(2G) Thousand m^3 raw biogas from 1 ton of org. material (*from technical literature) min.* 240 (2F*2G min.)	max.* 400 (2F*2G max.)	(2H) Unit
(2.1)	Cereal straw:	10 043	120%	80%	8 035	1 928 333	3 213 888	thousand m^3
(2.2)	Sugar-beet leaf:	577	20%	13%	75	18 000	30 000	thousand m^3
(2.3)	Sunflower stem:	49	80%	48%	24	5 649	9 416	thousand m^3
(2.4)	Peel of sunflower seed:	6	9%	48%	3	636	1 059	thousand m^3
(2.5)	Rape stem:	1 364	130%	80%	1 091	261 805	436 342	thousand m^3
(2.6)	Potato stem:	462	60%	45%	208	49 870	83 117	thousand m^3
(2.7)	Losses of main products:	1 051		80%	841	201 737	336 228	thousand m^3
(2.8)	Sum total:	**13 089**			Sum total:	**2 466 030**	**4 110 050**	thousand m^3 in a year
						min.	max.	
(2.9)	Methane contents of the raw biogas (DVGW G 262):					50	85	%
					(2.8)*GCV_{CH4}*(2.9)	46 492 062	131 727 508	GJ in a year
(2.10)	**Energy content of the biogas:**					**46.49**	**131.73**	**PJ in a year**

(3) Secondary products of livestock production in 2008

(3A)	(3B)	(3C) Thousand piece of animal species	(3D) Liquid dung: Litre/ day/ animal	(3E) Liquid dung: Thousand m^3 in a year (3C)*(3D)*365	(3F) Thousand m^3 raw biogas from 1 m^3 of liquid dung (*from technical literature) min.* 4.5 (3E*3F min.)	max.* 6.5 (3E*3F max.)	(3G) Unit	(3H) Comments
(3.1)	**Cattle and dairy cows**	1 758	46.00	29 508	132 788	191 805	thousand m^3	
(3.2)	**Pig**	2 135	7.00	5 455	24 547	35 457	thousand m^3	
(3.3)	**Sheep and lamb**	184	1.60	107	483	697	thousand m^3	estimated data
(3.4)	**Poultry**	10 661	0.07	272	1 226	1 771	thousand m^3	estimated data
(3.5)				Sum total:	**157 818**	**227 959**	thousand m^3 in a year	
					min.	max.		
(3.6)	Methane contents of the raw biogas (DVGW G262):				50	85	%	
				(3.5)*GCV_{CH4}*(3.6)	**2 975 335**	**7 306 100**	GJ in a year	
(3.7)	**Energy content of the biogas:**				**2.98**	**7.31**	**PJ in a year**	

(4) Communal wastes in 2008

(4.1) Community waste water

(4A)	(4B)	(4C)		(4D)	(4E)	
(4.1.1)	**Number of inhabitants of the country:**	10 475	thousand persons			at 01 Jan 2009
(4.1.2)	**Population connected to urban wastewater collecting systems:**	81	%			estimated data
(4.1.3)	Inhabitant eqivalent (IE):	8 484 432			(4.1.1)*(4.1.2)	
		min.	max.			
(4.1.4)	Specific solid contents (SC) of waste water:	0.10	0.14	kg/ day·IE		
(4.1.5)	Annual solid contents (SC) quantity:	309 682	433 554	tons in a year	(4.1.3)*(4.1.4)*365	
(4.1.6)	Specific biogas quantity:	310	740	m^3/ tons of SC	(from technical literature)	
(4.1.7)	Quantity of raw biogas:	**96 001**	**320 830**	thousand m^3 in a year	(4.1.5)*(4.1.6)	

		min.	max.	
(4.1.8)	Methane contents of the raw biogas (DVGW G 262):	65	70	%
	(4.1.7)*GCV_{CH4}*(4.1.8)	**2 352 887**	**8 468 059**	GJ in a year
(4.1.9)	**Energy content of the biogas:**	**2.35**	**8.47**	**PJ in a year**

(4.2) Community solid wastes (yearly accumulated biogas quantity)

(4.2.1)	**Number of inhabitants of the country:**	10 475	thousand persons		
(4.2.2)	**Municipal waste gerenarted:**	294	kg/person in a year		
(4.2.3)	Annual mass of the waste material:	3.080	million tons in a year		(4.2.1)*(4.2.2)
(4.2.4)	Average organic material content (OMC):	20	40	%	
		min.	max.		
(4.2.5)	Specific biogas yield from waste deposit:	240	400	m^3/ tons of OMC	(from technical literature)
(4.2.6)	Quantity of raw biogas:	**147.818**	**492.726**	million m^3 in a year	(4.2.3)*(4.2.4)*(4.2.5)

		min.	max.	
(4.2.7)	Methane contents of the raw biogas (DVGW G 262):	40	60	%
	(4.2.6)*GCV_{CH4}*(4.2.7)	**2 229 445**	**11 147 225**	GJ in a year
(4.2.8)	**Energy content of the biogas:**	**2.23**	**11.15**	**PJ in a year**

Input data source (red letters): EUROSTAT, 2009. (http://epp.ec.europa.eu)

Figure 7 Theoretical biogas potential estimates in the Czech Republic

3.2. Germany

The summarised data for Germany are shown in Figure 8, and the detailed data are given in Figure 9.

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(II.2) Germany		in 2008		
	Biogas from	min.	max.	
	(II.2.1) *Secondary products of plant cultivation:*	284.49	806.07	PJ in a year
	(II.2.2) *Secondary products of livestock production:*	30.41	74.68	PJ in a year
	(II.2.3) *Community waste water:*	22.07	79.45	PJ in a year
	(II.2.4) *Community solid wastes:*	33.51	167.53	PJ in a year
(II.2.5)	**Sum total of Germany:**	**370.49**	**1 127.72**	**PJ in a year**
(II.2.6)	**Average of Germany:**	**749.11**		**PJ in a year**
(II.2.7)	Sum total quantified in raw gas volume unit: ~	14 819	45 109	million m^3

Figure 8 Summary worksheet of Germany

The basic materials suitable for biogas production available in the largest quantities are agricultural by-products. In 2008 the basic materials suitable for biogas production in Germany could have been used to produce a total of 749.11 PJ of energy theoretically.

In 2007 the annual primary energy consumption of Germany was 13020.9 PJ, the energy content of the annual natural gas consumption calculated with an average calorific value being 3119.2 PJ according to statistics by British Petrol and Eurostat.

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Annual Theoretical Biogas Potentials in 2008 — Germany

(1) Main products of plant cultivation in 2008

(1A)	(1B)	(1C)	(1D)	
(1.1)	**Cereals** (wheat (*Trititcum*), barley (*Hordeum*), maize (*Zea mays*), oat (*Avena*), rye (Secale)):	50 105	thousand tons in a year	
(1.2)	**Sugar-beet** (*Beta vulgaris)*:	22 846	thousand tons in a year	
(1.3)	**Sunflower** (*Helianthus annuus)*:	49	thousand tons in a year	
(1.4)	**Rape** (*Brassica napus)*:	5 155	thousand tons in a year	
(1.5)	**Potatoes** (*Solanum tuberosum)*:	11 369	thousand tons in a year	
(1.6)	Sum total:	**89 523**	thousand tons in a year	
(1.7)	Losses of main products:	8%	*(Transport, storage, etc.)*	
(1.8)	Losses of main products:	**7 162**	thousand tons in a year	(1.6)*(1.7)

(2) Seconrady products of plant cultivation in 2008

(2A)	(2B)	(2C) Thousand tons in a year (2D*1C)	(2D) Ratio compared with main crop (main crop=100%)	(2E) Organic-material content	(2F) Thousand tons organic mat. in a year (2C*2E)	(2G) Thousand m^3 raw biogas from 1 ton of org. material (*from technical literature) min.* 240 (2F*2G min.)	max.* 400 (2F*2G max.)	(2H) Unit
(2.1)	Cereal straw:	60 126	120%	80%	48 101	11 544 169	19 240 282	thousand m^3
(2.2)	Sugar-beet leaf:	4 569	20%	13%	594	142 558	237 597	thousand m^3
(2.3)	Sunflower stem:	39	80%	48%	19	4 507	7 511	thousand m^3
(2.4)	Peel of sunflower seed:	4	9%	48%	2	507	845	thousand m^3
(2.5)	Rape stem:	6 701	130%	80%	5 361	1 286 613	2 144 355	thousand m^3
(2.6)	Potato stem:	6 821	60%	45%	3 070	736 711	1 227 852	thousand m^3
(2.7)	Losses of main products:	7 162		80%	5 729	1 375 079	2 291 799	thousand m^3
(2.8)	Sum total:	**78 602**			Sum total:	**15 090 145**	**25 150 241**	thousand m^3 in a year
						min.	max.	
(2.9)	Methane contents of the raw biogas (DVGW G 262):					50	85	%
					(2.8)*GCV$_{CH4}$*(2.9)	284 494 499	806 067 747	GJ in a year
(2.10)	**Energy content of the biogas:**					**284.49**	**806.07**	**PJ in a year**

(3) Secondary products of livestock production in 2008

(3A)	(3B)	(3C) Thousand piece of animal species	(3D) Liquid dung: Litre/ day/ animal	(3E) Liquid dung: Thousand m^3 in a year (3C)*(3D)*365	(3F) Thousand m^3 raw biogas from 1 m^3 of liquid dung (*from technical literature) min.* 4.5 (3E*3F min.)	max.* 6.5 (3E*3F max.)	(3G) Unit	(3H) Comments
(3.1)	**Cattle and dairy cows**	17 217	46.00	289 067	1 300 800	1 878 934	thousand m^3	
(3.2)	**Pig**	26 719	7.00	68 266	307 197	443 729	thousand m^3	
(3.3)	**Sheep and lamb**	1 920	1.60	1 121	5 045	7 288	thousand m^3	
(3.4)	**Poultry**	41 420	0.07	1 058	4 762	6 879	thousand m^3	estimated data
(3.5)				Sum total:	**1 613 043**	**2 329 951**	thousand m^3 in a year	
					min.	max.		
(3.6)	Methane contents of the raw biogas (DVGW G262):				50	85	%	
				(3.5)*GCV$_{CH4}$*(3.6)	**30 410 696**	**74 675 154**	GJ in a year	
(3.7)	**Energy content of the biogas:**				**30.41**	**74.68**	**PJ in a year**	

(4) Communal wastes in 2008

(4.1) Community waste water

(4A)	(4B)	(4C)		(4D)	(4E)	
(4.1.1)	**Number of inhabitants of the country:**	82 062		thousand persons		at 01 Jan 2009
(4.1.2)	**Population connected to urban wastewater collecting systems:**	97		%		estimated data
(4.1.3)	Inhabitant eqivalent (IE):	79 600 382			(4.1.1)*(4.1.2)	
		min.	max.			
(4.1.4)	Specific solid contents (SC) of waste water:	0.10	0.14	kg/ day·IE		
(4.1.5)	Annual solid contents (SC) quantity:	2 905 414	4 067 579	tons in a year	(4.1.3)*(4.1.4)*365	
(4.1.6)	Specific biogas quantity:	310	740	m^3/ tons of SC	(from technical literature)	
(4.1.7)	Quantity of raw biogas:	**900 678**	**3 010 009**	thousand m^3 in a year	(4.1.5)*(4.1.6)	

		min.	max.	
(4.1.8)	Methane contents of the raw biogas (DVGW G 262):	65	70	%
	(4.1.7)*GCV$_{CH4}$*(4.1.8)	**22 074 635**	**79 446 775**	GJ in a year
(4.1.9)	**Energy content of the biogas:**	**22.07**	**79.45**	**PJ in a year**

(4.2) Community solid wastes (yearly accumulated biogas quantity)

(4.2.1)	**Number of inhabitants of the country:**	82 062		thousand persons	
(4.2.2)	**Municipal waste gerenarted:**	564		kg/person in a year	
(4.2.3)	Annual mass of the waste material:	46.283		million tons in a year	(4.2.1)*(4.2.2)
(4.2.4)	Average organic material content (OMC):	20	40	%	
		min.	max.		
(4.2.5)	Specific biogas yield from waste deposit:	240	400	m^3/ tons of OMC	(from technical literature)
(4.2.6)	Quantity of raw biogas:	**2 221.589**	**7 405.297**	million m^3 in a year	(4.2.3)*(4.2.4)*(4.2.5)

		min.	max.	
(4.2.7)	Methane contents of the raw biogas (DVGW G 262):	40	60	%
	(4.2.6)*GCV$_{CH4}$*(4.2.7)	**33 506 897**	**167 534 485**	GJ in a year
(4.2.8)	**Energy content of the biogas:**	**33.51**	**167.53**	**PJ in a year**

Input data source (red letters): EUROSTAT, 2009. (http://epp.eurostat.ec.europa.eu)

Figure 9 Theoretical biogas potential estimates in Germany

3.3. Greece

The summarised data for Greece are shown in Figure 10, and the detailed data are given in Figure 11.

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REDUBAR D07

(II.3) Greece		in 2008		
	Biogas from	min.	max.	
	(II.3.1) *Secondary products of plant cultivation:*	25.05	70.97	PJ in a year
	(II.3.2) *Secondary products of livestock production:*	1.87	4.58	PJ in a year
	(II.3.3) *Community waste water:*	2.65	9.55	PJ in a year
	(II.3.4) *Community solid wastes:*	3.65	18.26	PJ in a year
(II.3.5)	**Sum total of Greece:**	**33.22**	**103.38**	**PJ in a year**
(II.3.6)	**Average of Greece:**	**68.30**		**PJ in a year**
(II.3.7)	Sum total quantified in raw gas volume unit: ~	1 329	4 135	million m^3

Figure 10 Summary worksheet of Greece

In Greece biogas could again be produced from agricultural by-products in the largest amount. The amounts of biogas that could be produced from the other basic materials show much lower values. At the annual level 68.3 PJ energy could have been theoretically produced in 2008.

In 2007 the annual primary energy consumption of Greece was 1427.7 PJ, the energy content of the annual natural gas consumption calculated with an average calorific value being 150.7 PJ according to statistics by British Petrol and Eurostat.

REDUBAR D07 EIE/06/221/SI2.442663

Annual Theoretical Biogas Potentials in 2008

Greece

(1) Main products of plant cultivation in 2008

(1A)	(1B)	(1C)	(1D)	
(1.1)	**Cereals** (wheat (*Trititcum*), barley (*Hordeum*), maize (*Zea mays*), oat (*Avena*), rye (Secale)):	5 043	thousand tons in a year	
(1.2)	**Sugar-beet** *(Beta vulgaris)*:	903	thousand tons in a year	
(1.3)	**Sunflower** *(Helianthus annuus)*:	16	thousand tons in a year	
(1.4)	**Rape** (*Brassica napus*):		thousand tons in a year	n.a.
(1.5)	**Potatoes** *(Solanum tuberosum)*:	848	thousand tons in a year	
(1.6)	Sum total:	**6 810**	thousand tons in a year	
(1.7)	Losses of main products:	8%	*(Transport, storage, etc.)*	
(1.8)	Losses of main products:	**545**	thousand tons in a year	(1.6)*(1.7)

(2) Seconrady products of plant cultivation in 2008

(2A)	(2B)	(2C)	(2D)	(2E)	(2F)	(2G)		(2H)
		Thousand tons in a year	Ratio compared with main crop (main crop=100%)	Organic-material content	Thousand tons organic mat. in a year	Thousand m³ raw biogas from 1 ton of org. material (*from technical literature) min.*	max.*	Unit
						240	400	
		(2D*1C)			(2C*2E)	(2F*2G min.)	(2F*2G max.)	
(2.1)	Cereal straw:	6 051	120%	80%	4 841	1 161 861	1 936 435	thousand m³
(2.2)	Sugar-beet leaf:	181	20%	13%	23	5 635	9 391	thousand m³
(2.3)	Sunflower stem:	12	80%	48%	6	1 438	2 396	thousand m³
(2.4)	Peel of sunflower seed:	1	9%	48%	1	162	270	thousand m³
(2.5)	Rape stem:	0	130%	80%	0	0	0	thousand m³
(2.6)	Potato stem:	509	60%	45%	229	54 976	91 627	thousand m³
(2.7)	Losses of main products:	545		80%	436	104 599	174 331	thousand m³
(2.8)	Sum total:	**6 791**			Sum total:	**1 328 670**	**2 214 450**	thousand m³ in a year
						min.	max.	
(2.9)	Methane contents of the raw biogas (DVGW G 262):					50	85	%
					(2.8)*GCV$_{CH4}$*(2.9)	25 049 418	70 973 351	GJ in a year
(2.10)	**Energy content of the biogas:**					**25.05**	**70.97**	**PJ in a year**

(3) Secondary products of livestock production in 2008

(3A)	(3B)	(3C)	(3D)	(3E)	(3F)		(3G)	(3H)
		Thousand piece of animal species	Liquid dung: Litre/ day/ animal	Liquid dung: Thousand m³ in a year	Thousand m³ raw biogas from 1 m³ of liquid dung (*from technical literature) min.*	max.*	Unit	Comments
					4.5	6.5		
				(3C)*(3D)*365	(3E*3F min.)	(3E*3F max.)		
(3.1)	**Cattle and dairy cows**	836	46.00	14 036	63 164	91 237	thousand m³	
(3.2)	**Pig**	1 061	7.00	2 711	12 199	17 621	thousand m³	
(3.3)	**Sheep and lamb**	8 994	1.60	5 252	23 636	34 141	thousand m³	
(3.4)	**Poultry**	13 021	0.07	333	1 497	2 162	thousand m³	estimated data
(3.5)				Sum total:	**98 999**	**142 999**	thousand m³ in a year	
					min.	max.		
(3.6)	Methane contents of the raw biogas (DVGW G262):				50	85	%	
				(3.5)*GCV$_{CH4}$*(3.6)	**1 866 429**	**4 583 121**	GJ in a year	
(3.7)	**Energy content of the biogas:**				**1.87**	**4.58**	**PJ in a year**	

(4) Communal wastes in 2008

(4.1) Community waste water

(4A)	(4B)	(4C)		(4D)	(4E)	
(4.1.1)	**Number of inhabitants of the country:**	11 263	thousand persons			at 01 Jan 2009
(4.1.2)	**Population connected to urban wastewater collecting systems:**	85	%			estimated data
(4.1.3)	Inhabitant eqivalent (IE):	9 573 158			(4.1.1)*(4.1.2)	
		min.	max.			
(4.1.4)	Specific solid contents (SC) of waste water:	0.10	0.14	kg/ day·IE		
(4.1.5)	Annual solid contents (SC) quantity:	349 420	489 188	tons in a year	(4.1.3)*(4.1.4)*365	
(4.1.6)	Specific biogas quantity:	310	740	m³/ tons of SC	(from technical literature)	
(4.1.7)	Quantity of raw biogas:	**108 320**	**361 999**	thousand m³ in a year	(4.1.5)*(4.1.6)	
					min.	max.
(4.1.8)	Methane contents of the raw biogas (DVGW G 262):				65	70	%
				(4.1.7)*GCV$_{CH4}$*(4.1.8)	**2 654 811**	**9 554 685**	GJ in a year
(4.1.9)	**Energy content of the biogas:**				**2.65**	**9.55**	**PJ in a year**

(4.2) Community solid wastes (yearly accumulated biogas quantity)

(4.2.1)	**Number of inhabitants of the country:**	11 263	thousand persons			
(4.2.2)	**Municipal waste gerenarted:**	448	kg/person in a year			
(4.2.3)	Annual mass of the waste material:	5.046	million tons in a year		(4.2.1)*(4.2.2)	
(4.2.4)	Average organic material content (OMC):	20	40	%		
		min.	max.			
(4.2.5)	Specific biogas yield from waste deposit:	240	400	m³/ tons of OMC	(from technical literature)	
(4.2.6)	Quantity of raw biogas:	**242.190**	**807.299**	million m³ in a year	(4.2.3)*(4.2.4)*(4.2.5)	
					min.	max.
(4.2.7)	Methane contents of the raw biogas (DVGW G 262):				40	60	%
				(4.2.6)*GCV$_{CH4}$*(4.2.7)	**3 652 801**	**18 264 005**	GJ in a year
(4.2.8)	**Energy content of the biogas:**				**3.65**	**18.26**	**PJ in a year**

Input data source (red letters): EUROSTAT, 2009. (http://epp.eurostat.ec.europa.eu)

Figure 11 Theoretical biogas potential estimates in Greece

3.4. Hungary

The summarised data for Hungary are shown in Figure 12, and the detailed data are given in Figure 13.

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(II.4) Hungary		in 2008		
	Biogas from	min.	max.	
	(II.4.1) *Secondary products of plant cultivation:*	86.26	244.41	PJ in a year
	(II.4.2) *Secondary products of livestock production:*	2.17	5.32	PJ in a year
	(II.4.3) *Community waste water:*	1.72	6.21	PJ in a year
	(II.4.4) *Community solid wastes:*	3.31	16.56	PJ in a year
(II.4.5)	**Sum total of Hungary:**	**93.47**	**272.50**	**PJ in a year**
(II.4.6)	**Average of Hungary:**	**182.98**		**PJ in a year**
(II.4.7)	Sum total quantified in raw gas volume unit: ~	3 739	10 900	million m^3

Figure 12 Summary worksheet of Hungary

At the annual level in Hungary 182.98 PJ energy could have been produced on a biogas basis in 2008. The largest part of that amount was accounted for by agricultural by-products, the amount of biogas developing in solid waste deposits also represents significant values.

In 2007 the annual primary energy consumption of Hungary was 1025.8 PJ, the energy content of the annual natural gas consumption calculated with an average calorific value being 443.8 PJ according to statistics by British Petrol and Eurostat.

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Hungary

Annual Theoretical Biogas Potentials in 2008

(1) Main products of plant cultivation in 2008

(1A)	(1B)	(1C)	(1D)	
(1.1)	**Cereals** (wheat (*Trititcum*), barley (*Hordeum*), maize (*Zea mays*), oat (*Avena*), rye (Secale)):	16 938	thousand tons in a year	
(1.2)	**Sugar-beet** *(Beta vulgaris)*:	532	thousand tons in a year	
(1.3)	**Sunflower** *(Helianthus annuus)*:	1 492	thousand tons in a year	
(1.4)	**Rape** (*Brassica napus)*:	656	thousand tons in a year	
(1.5)	**Potatoes** *(Solanum tuberosum)*:	646	thousand tons in a year	
(1.6)	Sum total:	20 263	thousand tons in a year	
(1.7)	Losses of main products:	8%	*(Transport, storage, etc.)*	
(1.8)	Losses of main products:	1 621	thousand tons in a year	(1.6)*(1.7)

(2) Seconrady products of plant cultivation in 2008

(2A)	(2B)	(2C)	(2D)	(2E)	(2F)	(2G)		(2H)
		Thousand tons in a year	Ratio compared with main crop (main crop=100%)	Organic-material content	Thousand tons organic mat. in a year	Thousand m^3 raw biogas from 1 ton of org. material (*from technical literature)		Unit
						min.*	max.*	
						240	400	
		(2D*1C)			(2C*2E)	(2F*2G min.)	(2F*2G max.)	
(2.1)	Cereal straw:	20 326	120%	80%	16 261	3 902 584	6 504 307	thousand m^3
(2.2)	Sugar-beet leaf:	106	20%	13%	14	3 318	5 530	thousand m^3
(2.3)	Sunflower stem:	1 193	80%	48%	573	137 475	229 125	thousand m^3
(2.4)	Peel of sunflower seed:	134	9%	48%	64	15 466	25 777	thousand m^3
(2.5)	Rape stem:	852	130%	80%	682	163 638	272 730	thousand m^3
(2.6)	Potato stem:	388	60%	45%	174	41 854	69 757	thousand m^3
(2.7)	Losses of main products:	1 621		80%	1 297	311 243	518 738	thousand m^3
(2.8)	Sum total:	24 233			Sum total:	4 575 578	7 625 963	thousand m^3 in a year
						min.	max.	
(2.9)	Methane contents of the raw biogas (DVGW G 262):					50	85	%
					$(2.8)*GCV_{CH4}*(2.9)$	86 263 372	244 412 886	GJ in a year
(2.10)	**Energy content of the biogas:**					**86.26**	**244.41**	**PJ in a year**

(3) Secondary products of livestock production in 2008

(3A)	(3B)	(3C)	(3D)	(3E)	(3F)		(3G)	(3H)
		Thousand piece of animal species	Liquid dung		Thousand m^3 raw biogas from 1 m^3 of liquid dung (*from technical literature)		Unit	Comments
			Litre/ day/ animal	Thousand m^3 in a year	min.*	max.*		
					4.5	6.5		
				(3C)*(3D)*365	(3E*3F min.)	(3E*3F max.)		
(3.1)	**Cattle and dairy cows**	964	46.00	16 186	72 835	105 206	thousand m^3	
(3.2)	**Pig**	3 383	7.00	8 644	38 896	56 183	thousand m^3	
(3.3)	**Sheep and lamb**	1 236	1.60	722	3 248	4 692	thousand m^3	
(3.4)	**Poultry**	13 838	0.07	354	1 591	2 298	thousand m^3	estimated data
(3.5)				Sum total:	114 979	166 081	thousand m^3 in a year	
					min.	max.		
(3.6)	Methane contents of the raw biogas (DVGW G262):				50	85	%	
					$(3.5)*GCV_{CH4}*(3.6)$	2 167 704	5 322 918	GJ in a year
(3.7)	**Energy content of the biogas:**					**2.17**	**5.32**	**PJ in a year**

(4) Communal wastes in 2008

(4A)	(4B)	(4C)	(4D)	(4E)		
(4.1)	**Community waste water**					
(4.1.1)	**Number of inhabitants of the country:**	10 030	thousand persons			at 01 Jan 2009
(4.1.2)	**Population connected to urban wastewater collecting systems:**	62	%			estimated data
(4.1.3)	Inhabitant eqivalent (IE):	6 218 521		(4.1.1)*(4.1.2)		
		min.	max.			
(4.1.4)	Specific solid contents (SC) of waste water:	0.10	0.14	kg/ day·IE		
(4.1.5)	Annual solid contents (SC) quantity:	226 976	317 766	tons in a year	(4.1.3)*(4.1.4)*365	
(4.1.6)	Specific biogas quantity:	310	740	m^3/ tons of SC	(from technical literature)	
(4.1.7)	Quantity of raw biogas:	**70 363**	**235 147**	thousand m^3 in a year	(4.1.5)*(4.1.6)	
					min.	max.
(4.1.8)	Methane contents of the raw biogas (DVGW G 262):				65	70	%
				$(4.1.7)*GCV_{CH4}*(4.1.8)$	1 724 509	6 206 521	GJ in a year
(4.1.9)	**Energy content of the biogas:**				**1.72**	**6.21**	**PJ in a year**
(4.2)	**Community solid wastes** (yearly accumulated biogas quantity)					
(4.2.1)	**Number of inhabitants of the country:**	10 030	thousand persons			
(4.2.2)	**Municipal waste gerenarted:**	456	kg/person in a year			
(4.2.3)	Annual mass of the waste material:	4.574	million tons in a year	(4.2.1)*(4.2.2)		
(4.2.4)	Average organic material content (OMC):	20	40	%		
		min.	max.			
(4.2.5)	Specific biogas yield from waste deposit:	240	400	m^3/ tons of OMC	(from technical literature)	
(4.2.6)	Quantity of raw biogas:	**219.534**	**731.780**	million m^3 in a year	(4.2.3)*(4.2.4)*(4.2.5)	
					min.	max.
(4.2.7)	Methane contents of the raw biogas (DVGW G 262):				40	60	%
				$(4.2.6)*GCV_{CH4}*(4.2.7)$	3 311 097	16 555 487	GJ in a year
(4.2.8)	**Energy content of the biogas:**				**3.31**	**16.56**	**PJ in a year**

Input data source (red letters): EUROSTAT, 2009. (http://epp.eurostat.ec.europa.eu)

Figure 13 Theoretical biogas potential estimates in Hungary

3.5. Italy

The summarised data for Italy are shown in Figure 14, and the detailed data are given in Figure 15.

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(II.5) Italy		in 2008		
	Biogas from	min.	max.	
	(II.5.1) *Secondary products of plant cultivation:*	98.76	279.82	PJ in a year
	(II.5.2) *Secondary products of livestock production:*	14.26	35.01	PJ in a year
	(II.5.3) *Community waste water:*	15.66	56.38	PJ in a year
	(II.5.4) *Community solid wastes:*	23.93	119.63	PJ in a year
(II.5.5)	**Sum total of Italy:**	**152.61**	**490.83**	**PJ in a year**
(II.5.6)	**Average of Italy:**	**321.72**		**PJ in a year**
(II.5.7)	Sum total quantified in raw gas volume unit: ~	6 104	19 633	million m^3

Figure 14 Summary worksheet of Italy

At the annual level in Italy 321.72 PJ energy could have been produced on a biogas basis in 2008. The largest part of that amount was accounted for by agricultural by-products.

In 2007 the annual primary energy consumption of Italy was 7519.5 PJ, the energy content of the annual natural gas consumption calculated with an average calorific value being 2930.8 PJ according to statistics by British Petrol and Eurostat.

REDUBAR D07 Intelligent Energy Europe REDUBAR EIE/06/221/SI2.442663

Annual Theoretical Biogas Potentials in 2008

Italy

(1) Main products of plant cultivation in 2008

(1A)	(1B)	(1C)	(1D)	
(1.1)	**Cereals** (wheat (*Trititcum*), barley (*Hordeum*), maize (*Zea mays*), oat (*Avena*), rye (Secale)):	20 201	thousand tons in a year	
(1.2)	**Sugar-beet** (*Beta vulgaris*) *:*	4 630	thousand tons in a year	estimated
(1.3)	**Sunflower** (*Helianthus annuus*) *:*	265	thousand tons in a year	
(1.4)	**Rape** (*Brassica napus*) *:*	25	thousand tons in a year	
(1.5)	**Potatoes** (*Solanum tuberosum*) *:*	1 694	thousand tons in a year	
(1.6)	Sum total:	**26 815**	thousand tons in a year	
(1.7)	Losses of main products:	8%	*(Transport, storage, etc.)*	
(1.8)	Losses of main products:	**2 145**	thousand tons in a year	(1.6)*(1.7)

(2) Seconrady products of plant cultivation in 2008

(2A)	(2B)	(2C) Thousand tons in a year	(2D) Ratio compared with main crop (main crop=100%)	(2E) Organic-material content	(2F) Thousand tons organic mat. in a year	(2G) Thousand m³ raw biogas from 1 ton of org. material (*from technical literature) min.* 240	max.* 400	(2H) Unit
		(2D*1C)			(2C*2E)	(2F*2G min.)	(2F*2G max.)	
(2.1)	Cereal straw:	24 242	120%	80%	19 393	4 654 403	7 757 338	thousand m³
(2.2)	Sugar-beet leaf:	926	20%	13%	120	28 891	48 151	thousand m³
(2.3)	Sunflower stem:	212	80%	48%	102	24 441	40 735	thousand m³
(2.4)	Peel of sunflower seed:	24	9%	48%	11	2 750	4 583	thousand m³
(2.5)	Rape stem:	32	130%	80%	26	6 215	10 358	thousand m³
(2.6)	Potato stem:	1 016	60%	45%	457	109 752	182 920	thousand m³
(2.7)	Losses of main products:	2 145		80%	1 716	411 880	686 467	thousand m³
(2.8)	Sum total:	**27 581**			Sum total:	**5 238 330**	**8 730 550**	thousand m³ in a year
						min.	max.	
(2.9)	Methane contents of the raw biogas (DVGW G 262):					50	85	%
					$(2.8)*GCV_{CH4}*(2.9)$	98 758 241	279 815 016	GJ in a year
(2.10)	**Energy content of the biogas:**					**98.76**	**279.82**	**PJ in a year**

(3) Secondary products of livestock production in 2008

(3A)	(3B)	(3C) Thousand piece of animal species	(3D) Liquid dung: Litre/ day/ animal	(3E) Liquid dung: Thousand m³ in a year	(3F) Thousand m³ raw biogas from 1 m³ of liquid dung (*from technical literature) min.* 4.5	max.* 6.5	(3G) Unit	(3H) Comments
				(3C)*(3D)*365	(3E*3F min.)	(3E*3F max.)		
(3.1)	**Cattle and dairy cows**	8 317	46.00	139 642	628 391	907 676	thousand m³	
(3.2)	**Pig**	9 252	7.00	23 640	106 379	153 659	thousand m³	
(3.3)	**Sheep and lamb**	8 175	1.60	4 774	21 484	31 033	thousand m³	
(3.4)	**Poultry**	55 460	0.07	1 417	6 377	9 211	thousand m³	estimated data
(3.5)				Sum total:	**756 255**	**1 092 368**	thousand m³ in a year	
					min.	max.		
(3.6)	Methane contents of the raw biogas (DVGW G262):				50	85	%	
				$(3.5)*GCV_{CH4}*(3.6)$	**14 257 672**	**35 010 506**	GJ in a year	
(3.7)	**Energy content of the biogas:**				**14.26**	**35.01**	**PJ in a year**	

(4) Communal wastes in 2008

(4.1) Community waste water

(4A)	(4B)	(4C)		(4D)	(4E)
(4.1.1)	**Number of inhabitants of the country:**	60 090		thousand persons	at 01 Jan 2009
(4.1.2)	**Population connected to urban wastewater collecting systems:**	94		%	estimated data
(4.1.3)	Inhabitant eqivalent (IE):	56 485 004			(4.1.1)*(4.1.2)
		min.	max.		
(4.1.4)	Specific solid contents (SC) of waste water:	0.10	0.14	kg/ day·IE	
(4.1.5)	Annual solid contents (SC) quantity:	2 061 703	2 886 384	tons in a year	(4.1.3)*(4.1.4)*365
(4.1.6)	Specific biogas quantity:	310	740	m³/ tons of SC	(from technical literature)
(4.1.7)	Quantity of raw biogas:	**639 128**	**2 135 924**	thousand m³ in a year	(4.1.5)*(4.1.6)
				min.	max.
(4.1.8)	Methane contents of the raw biogas (DVGW G 262):			65	70
	$(4.1.7)*GCV_{CH4}*(4.1.8)$			**15 664 320**	**56 376 004**
(4.1.9)	**Energy content of the biogas:**			**15.66**	**56.38**

(4.1.8) in %; (4.1.9) GJ in a year / **PJ in a year**

(4.2) Community solid wastes (yearly accumulated biogas quantity)

(4.2.1)	**Number of inhabitants of the country:**	60 090		thousand persons	
(4.2.2)	**Municipal waste gerenarted:**	550		kg/person in a year	
(4.2.3)	Annual mass of the waste material:	33.050		million tons in a year	(4.2.1)*(4.2.2)
(4.2.4)	Average organic material content (OMC):	20	40	%	
		min.	max.		
(4.2.5)	Specific biogas yield from waste deposit:	240	400	m³/ tons of OMC	(from technical literature)
(4.2.6)	Quantity of raw biogas:	**1 586.387**	**5 287.958**	million m³ in a year	(4.2.3)*(4.2.4)*(4.2.5)
				min.	max.
(4.2.7)	Methane contents of the raw biogas (DVGW G 262):			40	60
	$(4.2.6)*GCV_{CH4}*(4.2.7)$			**23 926 529**	**119 632 643**
(4.2.8)	**Energy content of the biogas:**			**23.93**	**119.63**

(4.2.7) in %; GJ in a year; (4.2.8) **PJ in a year**

Input data source (red letters): EUROSTAT, 2009. (http://epp.eurostat.ec.europa.eu)

Figure 15 Theoretical biogas potential estimates in Italy

3.6. Lithuania

The summarised data for Lithuania are shown in Figure 16, and the detailed data are given in Figure 17.

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REDUBAR D07

(II.6) Lithuania		in 2008		
	Biogas from	min.	max.	
	(II.6.1) *Secondary products of plant cultivation:*	18.71	53.03	PJ in a year
	(II.6.2) *Secondary products of livestock production:*	1.86	4.56	PJ in a year
	(II.6.3) *Community waste water:*	0.58	2.07	PJ in a year
	(II.6.4) *Community solid wastes:*	0.97	4.85	PJ in a year
(II.6.5)	**Sum total of Lithuania:**	**22.12**	**64.51**	**PJ in a year**
(II.6.6)	**Average of Lithuania:**	**43.31**		**PJ in a year**
(II.6.7)	Sum total quantified in raw gas volume unit: ~	885	2 580	million m^3

Figure 16 Summary worksheet of Lithuania

In Lithuania the potential that could be produced is substantially smaller than those in the countries described above. Annually an average 43.31 PJ of energy could be theoretically produced from the biomass basic materials available. In Lithuania again the plant cultivation by-products account for the main basis of the theoretical potential.

In 2007 the annual primary energy consumption of Lithuania was 376.8 PJ, the energy content of the annual natural gas consumption calculated with an average calorific value being 142.4 PJ according to statistics by British Petrol and Eurostat.

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Annual Theoretical Biogas Potentials in 2008

Lithuania

(1) Main products of plant cultivation in 2008

(1A)	(1B)	(1C)	(1D)	
(1.1)	**Cereals** (wheat (*Trititcum*), barley (*Hordeum*), maize (*Zea mays*), oat (*Avena*), rye (Secale)):	3 422	thousand tons in a year	
(1.2)	**Sugar-beet** *(Beta vulgaris)*:	339	thousand tons in a year	
(1.3)	**Sunflower** *(Helianthus annuus)*:		thousand tons in a year	n.a.
(1.4)	**Rape** (*Brassica napus)*:	330	thousand tons in a year	
(1.5)	**Potatoes** *(Solanum tuberosum)*:	710	thousand tons in a year	
(1.6)	Sum total:	4 801	thousand tons in a year	
(1.7)	Losses of main products:	8%	*(Transport, storage, etc.)*	
(1.8)	Losses of main products:	384	thousand tons in a year	(1.6)*(1.7)

(2) Seconrady products of plant cultivation in 2008

(2A)	(2B)	(2C)	(2D)	(2E)	(2F)	(2G)		(2H)
		Thousand tons in a year	Ratio compared with main crop (main crop=100%)	Organic-material content	Thousand tons organic mat. in a year	Thousand m³ raw biogas from 1 ton of org. material (*from technical literature) min.*	max.*	Unit
						240	400	
		(2D*1C)			(2C*2E)	(2F*2G min.)	(2F*2G max.)	
(2.1)	Cereal straw:	4 106	120%	80%	3 285	788 406	1 314 010	thousand m³
(2.2)	Sugar-beet leaf:	68	20%	13%	9	2 116	3 527	thousand m³
(2.3)	Sunflower stem:	0	80%	48%	0	0	0	thousand m³
(2.4)	Peel of sunflower seed:	0	9%	48%	0	0	0	thousand m³
(2.5)	Rape stem:	429	130%	80%	343	82 418	137 363	thousand m³
(2.6)	Potato stem:	426	60%	45%	192	45 995	76 658	thousand m³
(2.7)	Losses of main products:	384		80%	307	73 743	122 906	thousand m³
(2.8)	Sum total:	4 987			Sum total:	992 678	1 654 463	thousand m³ in a year
						min.	max.	
(2.9)	Methane contents of the raw biogas (DVGW G 262):					50	85	%
					(2.8)*GCV$_{CH4}$*(2.9)	18 714 960	53 025 719	GJ in a year
(2.10)	**Energy content of the biogas:**					**18.71**	**53.03**	**PJ in a year**

(3) Secondary products of livestock production in 2008

(3A)	(3B)	(3C)	(3D)	(3E)	(3F)		(3G)	(3H)
		Thousand piece of animal species	Liquid dung: Litre/ day/ animal	Liquid dung: Thousand m³ in a year	Thousand m³ raw biogas from 1 m³ of liquid dung (*from technical literature) min.*	max.*	Unit	Comments
					4.5	6.5		
				(3C)*(3D)*365	(3E*3F min.)	(3E*3F max.)		
(3.1)	**Cattle and dairy cows**	1 166	46.00	19 570	88 067	127 208	thousand m³	
(3.2)	**Pig**	897	7.00	2 292	10 314	14 899	thousand m³	
(3.3)	**Sheep and lamb**	48	1.60	28	125	180	thousand m³	
(3.4)	**Poultry**	4 386	0.07	112	504	728	thousand m³	estimated data
(3.5)				Sum total:	98 506	142 287	thousand m³ in a year	
					min.	max.		
(3.6)	Methane contents of the raw biogas (DVGW G262):				50	85	%	
				(3.5)*GCV$_{CH4}$*(3.6)	1 857 136	4 560 301	GJ in a year	
(3.7)	**Energy content of the biogas:**				**1.86**	**4.56**	**PJ in a year**	

(4) Communal wastes in 2008

(4A)	(4B)	(4C)	(4D)	(4E)			
(4.1)	**Community waste water**						
(4.1.1)	**Number of inhabitants of the country:**	3 350	thousand persons				at 01 Jan 2009
(4.1.2)	**Population connected to urban wastewater collecting systems:**	62	%				estimated data
(4.1.3)	Inhabitant eqivalent (IE):	2 077 239			(4.1.1)*(4.1.2)		
		min.	max.				
(4.1.4)	Specific solid contents (SC) of waste water:	0.10	0.14	kg/ day·IE			
(4.1.5)	Annual solid contents (SC) quantity:	75 819	106 147	tons in a year	(4.1.3)*(4.1.4)*365		
(4.1.6)	Specific biogas quantity:	310	740	m³/ tons of SC	(from technical literature)		
(4.1.7)	Quantity of raw biogas:	23 504	78 549	thousand m³ in a year	(4.1.5)*(4.1.6)		
					min.	max.	
(4.1.8)	Methane contents of the raw biogas (DVGW G 262):				65	70	%
				(4.1.7)*GCV$_{CH4}$*(4.1.8)	576 056	2 073 230	GJ in a year
(4.1.9)	**Energy content of the biogas:**				**0.58**	**2.07**	**PJ in a year**
(4.2)	**Community solid wastes** (yearly accumulated biogas quantity)						
(4.2.1)	**Number of inhabitants of the country:**	3 350	thousand persons				
(4.2.2)	**Municipal waste gerenarted:**	400	kg/person in a year				
(4.2.3)	Annual mass of the waste material:	1.340	million tons in a year		(4.2.1)*(4.2.2)		
(4.2.4)	Average organic material content (OMC):	20	40	%			
		min.	max.				
(4.2.5)	Specific biogas yield from waste deposit:	240	400	m³/ tons of OMC	(from technical literature)		
(4.2.6)	Quantity of raw biogas:	64.327	214.425	million m³ in a year	(4.2.3)*(4.2.4)*(4.2.5)		
					min.	max.	
(4.2.7)	Methane contents of the raw biogas (DVGW G 262):				40	60	%
				(4.2.6)*GCV$_{CH4}$*(4.2.7)	970 211	4 851 057	GJ in a year
(4.2.8)	**Energy content of the biogas:**				**0.97**	**4.85**	**PJ in a year**

Input data source (red letters): EUROSTAT, 2009. (http://epp.eurostat.ec.europa.eu)

Figure 17 Theoretical biogas potential estimates in Lithuania

3.7. The Netherlands

The summarised data for the Netherlands are shown in Figure 18, and the detailed data are given in Figure 19.

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(II.7) the Netherlands		in 2008		
	Biogas from	min.	max.	
(II.7.1)	*Secondary products of plant cultivation:*	22.30	63.17	PJ in a year
(II.7.2)	*Secondary products of livestock production:*	10.57	25.96	PJ in a year
(II.7.3)	*Community waste water:*	4.52	16.28	PJ in a year
(II.7.4)	*Community solid wastes:*	7.52	37.58	PJ in a year
(II.7.5)	**Sum total of the Netherlands:**	**44.91**	**143.01**	**PJ in a year**
(II.7.6)	**Average of the Netherlands:**	**93.96**		**PJ in a year**
(II.7.7)	Sum total quantified in raw gas volume unit: ~	1 796	5 720	million m^3

Figure 18 Summary worksheet of the Netherlands

At the annual level in the Netherlands 93.96 PJ energy could have been produced on a biogas basis in 2008. The largest part of that amount was accounted for by agricultural by-products, however, the theoretical amount of biogas from developing in solid waste deposits and in organic industrial wastes also represent significant values.

In 2007 the annual primary energy consumption of the Netherlands was 3843.5 PJ, the energy content of the annual natural gas consumption calculated with an average calorific value being 1398.4 PJ according to statistics by British Petrol and Eurostat.

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Annual Theoretical Biogas Potentials in 2008 — the Netherlands

(1) Main products of plant cultivation in 2008

(1A)	(1B)	(1C)	(1D)
(1.1)	**Cereals** (wheat (*Trititcum*), barley (*Hordeum*), maize (*Zea mays*), oat (*Avena*), rye (Secale)):	2 063	thousand tons in a year
(1.2)	**Sugar-beet** *(Beta vulgaris)*:	5 219	thousand tons in a year
(1.3)	**Sunflower** *(Helianthus annuus)*:	0	thousand tons in a year
(1.4)	**Rape** (*Brassica napus)*:	10	thousand tons in a year
(1.5)	**Potatoes** *(Solanum tuberosum)*:	6 993	thousand tons in a year
(1.6)	Sum total:	**14 283**	thousand tons in a year
(1.7)	Losses of main products:	8%	*(Transport, storage, etc.)*
(1.8)	Losses of main products:	**1 143**	thousand tons in a year (1.6)*(1.7)

(2) Seconrady products of plant cultivation in 2008

(2A)	(2B)	(2C)	(2D)	(2E)	(2F)	(2G)		(2H)
		Thousand tons in a year	Ratio compared with main crop (main crop=100%)	Organic-material content	Thousand tons organic mat. in a year	Thousand m^3 raw biogas from 1 ton of org. material (*from technical literature) min.*	max.*	Unit
						240	400	
		(2D*1C)			(2C*2E)	(2F*2G min.)	(2F*2G max.)	
(2.1)	Cereal straw:	2 475	120%	80%	1 980	475 223	792 038	thousand m^3
(2.2)	Sugar-beet leaf:	1 044	20%	13%	136	32 563	54 272	thousand m^3
(2.3)	Sunflower stem:	0	80%	48%	0	0	0	thousand m^3
(2.4)	Peel of sunflower seed:	0	9%	48%	0	0	0	thousand m^3
(2.5)	Rape stem:	12	130%	80%	10	2 371	3 952	thousand m^3
(2.6)	Potato stem:	4 196	60%	45%	1 888	453 127	755 212	thousand m^3
(2.7)	Losses of main products:	1 143		80%	914	219 391	365 652	thousand m^3
(2.8)	Sum total:	**4 674**			Sum total:	**1 182 676**	**1 971 127**	thousand m^3 in a year
						min.	max.	
(2.9)	Methane contents of the raw biogas (DVGW G 262):					50	85	%
					(2.8)*GCV_{CH4}*(2.9)	22 296 993	63 174 814	GJ in a year
(2.10)	**Energy content of the biogas:**					**22.30**	**63.17**	**PJ in a year**

(3) Secondary products of livestock production in 2008

(3A)	(3B)	(3C)	(3D)	(3E)	(3F)		(3G)	(3H)
		Thousand piece of animal species	Liquid dung: Litre/ day/ animal	Liquid dung: Thousand m^3 in a year	Thousand m^3 raw biogas from 1 m^3 of liquid dung (*from technical literature) min.*	max.*	Unit	Comments
					4.5	6.5		
				(3C)*(3D)*365	(3E*3F min.)	(3E*3F max.)		
(3.1)	**Cattle and dairy cows**	5 583	46.00	93 739	421 824	609 301	thousand m^3	
(3.2)	**Pig**	11 735	7.00	29 983	134 923	194 889	thousand m^3	
(3.3)	**Sheep and lamb**	1 545	1.60	902	4 060	5 865	thousand m^3	
(3.4)	**Poultry**	42 726	0.07	1 092	4 912	7 096	thousand m^3	estimated data
(3.5)				Sum total:	**560 807**	**810 055**	thousand m^3 in a year	
					min.	max.		
(3.6)	Methane contents of the raw biogas (DVGW G262):				50	85	%	
				(3.5)*GCV_{CH4}*(3.6)	**10 572 894**	**25 962 329**	GJ in a year	
(3.7)	**Energy content of the biogas:**				**10.57**	**25.96**	**PJ in a year**	

(4) Communal wastes in 2008

(4.1) Community waste water

(4A)	(4B)	(4C)		(4D)	(4E)		
(4.1.1)	**Number of inhabitants of the country:**	16 481	thousand persons				at 01 Jan 2009
(4.1.2)	**Population connected to urban wastewater collecting systems:**	99	%				estimated data
(4.1.3)	Inhabitant eqivalent (IE):	16 316 328			(4.1.1)*(4.1.2)		
		min.	max.				
(4.1.4)	Specific solid contents (SC) of waste water:	0.10	0.14	kg/ day·IE			
(4.1.5)	Annual solid contents (SC) quantity:	595 546	833 764	tons in a year	(4.1.3)*(4.1.4)*365		
(4.1.6)	Specific biogas quantity:	310	740	m^3/ tons of SC	(from technical literature)		
(4.1.7)	Quantity of raw biogas:	**184 619**	**616 986**	thousand m^3 in a year	(4.1.5)*(4.1.6)		
					min.	max.	
(4.1.8)	Methane contents of the raw biogas (DVGW G 262):				65	70	%
				(4.1.7)*GCV_{CH4}*(4.1.8)	**4 524 815**	**16 284 842**	GJ in a year
(4.1.9)	**Energy content of the biogas:**				**4.52**	**16.28**	**PJ in a year**

(4.2) Community solid wastes (yearly accumulated biogas quantity)

(4.2.1)	**Number of inhabitants of the country:**	16 481	thousand persons				
(4.2.2)	**Municipal waste gerenarted:**	630	kg/person in a year				
(4.2.3)	Annual mass of the waste material:	10.383	million tons in a year		(4.2.1)*(4.2.2)		
(4.2.4)	Average organic material content (OMC):	20	40	%			
		min.	max.				
(4.2.5)	Specific biogas yield from waste deposit:	240	400	m^3/ tons of OMC	(from technical literature)		
(4.2.6)	Quantity of raw biogas:	**498.390**	**1 661.299**	million m^3 in a year	(4.2.3)*(4.2.4)*(4.2.5)		
					min.	max.	
(4.2.7)	Methane contents of the raw biogas (DVGW G 262):				40	60	%
				(4.2.6)*GCV_{CH4}*(4.2.7)	**7 516 912**	**37 584 560**	GJ in a year
(4.2.8)	**Energy content of the biogas:**				**7.52**	**37.58**	**PJ in a year**

Input data source (red letters): EUROSTAT, 2009. (http://epp.eurostat.ec.europa.eu)

Figure 19 Theoretical biogas potential estimates in the Netherlands

3.8. Poland

The summarised data for Poland are shown in Figure 20, and the detailed data are given in Figure 21.

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(II.8) Poland		in 2008		
	Biogas from	min.	max.	
(II.8.1)	*Secondary products of plant cultivation:*	158.07	447.86	PJ in a year
(II.8.3)	*Secondary products of livestock production:*	14.87	36.51	PJ in a year
(II.8.4)	*Community waste water:*	6.34	22.83	PJ in a year
(II.8.6)	*Community solid wastes:*	8.89	44.44	PJ in a year
(II.8.7)	**Sum total of Poland:**	**188.17**	**551.64**	**PJ in a year**
(II.8.8)	**Average of Poland:**	**369.90**		**PJ in a year**
(II.8.9)	Sum total quantified in raw gas volume unit: ~	7 527	22 066	million m^3

Figure 20 Summary worksheet of Poland

Poland is the country with the second largest theoretical biogas potential among those studied. Its theoretical potential average for 2008 is 369.90 PJ. The largest share is given again by agricultural by-products and communal solid waste.

In 2007 the annual primary energy consumption of Poland was 3952.3 PJ, the energy content of the annual natural gas consumption calculated with an average calorific value being 515.0 PJ according to statistics by British Petrol and Eurostat.

REDUBAR D07 — EIE/06/221/SI2.442663 — **Poland**

Annual Theoretical Biogas Potentials in 2008

(1) Main products of plant cultivation in 2008

(1A)	(1B)	(1C)	(1D)
(1.1)	**Cereals** (wheat (*Trititcum*), barley (*Hordeum*), maize (*Zea mays*), oat (*Avena*), rye (Secale)):	27 664	thousand tons in a year
(1.2)	**Sugar-beet** *(Beta vulgaris)*:	8 715	thousand tons in a year
(1.3)	**Sunflower** *(Helianthus annuus)*:	5	thousand tons in a year
(1.4)	**Rape** (*Brassica napus)*:	2 106	thousand tons in a year
(1.5)	**Potatoes** *(Solanum tuberosum)*:	10 462	thousand tons in a year
(1.6)	Sum total:	**48 952**	thousand tons in a year
(1.7)	Losses of main products:	8%	*(Transport, storage, etc.)*
(1.8)	Losses of main products:	**3 916**	thousand tons in a year (1.6)*(1.7)

(2) Seconrady products of plant cultivation in 2008

(2A)	(2B)	(2C)	(2D)	(2E)	(2F)	(2G)		(2H)
		Thousand tons in a year	Ratio compared with main crop (main crop=100%)	Organic-material content	Thousand tons organic mat. in a year	Thousand m³ raw biogas from 1 ton of org. material (*from technical literature)		Unit
						min.*	max.*	
						240	400	
		(2D*1C)			(2C*2E)	(2F*2G min.)	(2F*2G max.)	
(2.1)	Cereal straw:	33 197	120%	80%	26 558	6 373 855	10 623 091	thousand m³
(2.2)	Sugar-beet leaf:	1 743	20%	13%	227	54 382	90 637	thousand m³
(2.3)	Sunflower stem:	4	80%	48%	2	433	722	thousand m³
(2.4)	Peel of sunflower seed:	0	9%	48%	0	49	81	thousand m³
(2.5)	Rape stem:	2 738	130%	80%	2 190	525 608	876 013	thousand m³
(2.6)	Potato stem:	6 277	60%	45%	2 825	677 944	1 129 907	thousand m³
(2.7)	Losses of main products:	3 916		80%	3 133	751 903	1 253 171	thousand m³
(2.8)	Sum total:	**41 598**			Sum total:	**8 384 173**	**13 973 622**	thousand m³ in a year
						min.	max.	
(2.9)	Methane contents of the raw biogas (DVGW G 262):					50	85	%
					(2.8)*GCV$_{CH_4}$*(2.9)	158 066 819	447 855 988	GJ in a year
(2.10)	**Energy content of the biogas:**					**158.07**	**447.86**	**PJ in a year**

(3) Secondary products of livestock production in 2008

(3A)	(3B)	(3C)	(3D)	(3E)	(3F)		(3G)	(3H)
		Thousand piece of animal species	Liquid dung: Litre/ day/ animal	Liquid dung: Thousand m³ in a year	Thousand m³ raw biogas from 1 m³ of liquid dung (*from technical literature)		Unit	Comments
					min.*	max.*		
					4.5	6.5		
				(3C)*(3D)*365	(3E*3F min.)	(3E*3F max.)		
(3.1)	**Cattle and dairy cows**	8 261	46.00	138 694	624 122	901 510	thousand m³	
(3.2)	**Pig**	14 242	7.00	36 389	163 751	236 529	thousand m³	
(3.3)	**Sheep and lamb**	270	1.60	157	709	1 023	thousand m³	
(3.4)	**Poultry**	45 502	0.07	1 163	5 232	7 557	thousand m³	estimated data
(3.5)				Sum total:	**788 581**	**1 139 062**	thousand m³ in a year	
					min.	max.		
(3.6)	Methane contents of the raw biogas (DVGW G262):				50	85	%	
				(3.5)*GCV$_{CH_4}$*(3.6)	**14 867 126**	**36 507 053**	GJ in a year	
(3.7)	**Energy content of the biogas:**				**14.87**	**36.51**	**PJ in a year**	

(4) Communal wastes in 2008

(4A) (4B) (4C) (4D) (4E)

(4.1) Community waste water

(4.1.1)	**Number of inhabitants of the country:**	38 130	thousand persons			at 01 Jan 2009
(4.1.2)	**Population connected to urban wastewater collecting systems:**	60	%			estimated data
(4.1.3)	Inhabitant eqivalent (IE):	22 878 181			(4.1.1)*(4.1.2)	
		min.	max.			
(4.1.4)	Specific solid contents (SC) of waste water:	0.10	0.14	kg/ day·IE		
(4.1.5)	Annual solid contents (SC) quantity:	835 054	1 169 075	tons in a year	(4.1.3)*(4.1.4)*365	
(4.1.6)	Specific biogas quantity:	310	740	m³/ tons of SC	(from technical literature)	
(4.1.7)	Quantity of raw biogas:	**258 867**	**865 116**	thousand m³ in a year	(4.1.5)*(4.1.6)	

		min.	max.	
(4.1.8)	Methane contents of the raw biogas (DVGW G 262):	65	70	%
	(4.1.7)*GCV$_{CH_4}$*(4.1.8)	**6 344 536**	**22 834 033**	GJ in a year
(4.1.9)	**Energy content of the biogas:**	**6.34**	**22.83**	**PJ in a year**

(4.2) Community solid wastes (yearly accumulated biogas quantity)

(4.2.1)	**Number of inhabitants of the country:**	38 130	thousand persons		
(4.2.2)	**Municipal waste gerenarted:**	322	kg/person in a year		
(4.2.3)	Annual mass of the waste material:	12.278	million tons in a year		(4.2.1)*(4.2.2)
(4.2.4)	Average organic material content (OMC):	20	40	%	
		min.	max.		
(4.2.5)	Specific biogas yield from waste deposit:	240	400	m³/ tons of OMC	(from technical literature)
(4.2.6)	Quantity of raw biogas:	**589.342**	**1 964.473**	million m³ in a year	(4.2.3)*(4.2.4)*(4.2.5)

		min.	max.	
(4.2.7)	Methane contents of the raw biogas (DVGW G 262):	40	60	%
	(4.2.6)*GCV$_{CH_4}$*(4.2.7)	**8 888 691**	**44 443 455**	GJ in a year
(4.2.8)	**Energy content of the biogas:**	**8.89**	**44.44**	**PJ in a year**

Input data source (red letters): EUROSTAT, 2009. (http://epp.eurostat.ec.europa.eu)

Figure 21 Theoretical biogas potential estimates in Poland

4. Information for competitors and financial investors

The contents of the individual rows in the D07 worksheets gives a clear indication of the area within the target groups (TG2, TG3, TG4, TG6) where experts are interested in the utilisation of the given biogas potentials irrespective of the fact whether they are experts, decision makers, biogas producers or staff of various institutions:

- blocks number 1 and 2 of the worksheets (plant main and by-products) are the competence of agricultural experts involved in plant cultivation;
- block number 3 of the worksheets (organic waste of stock breeding plants) is the competence of agricultural experts involved in stock breeding;
- block number 4 of the worksheets (communal sewage and solid waste) is the competence of experts involved in the protection of man-made environment.

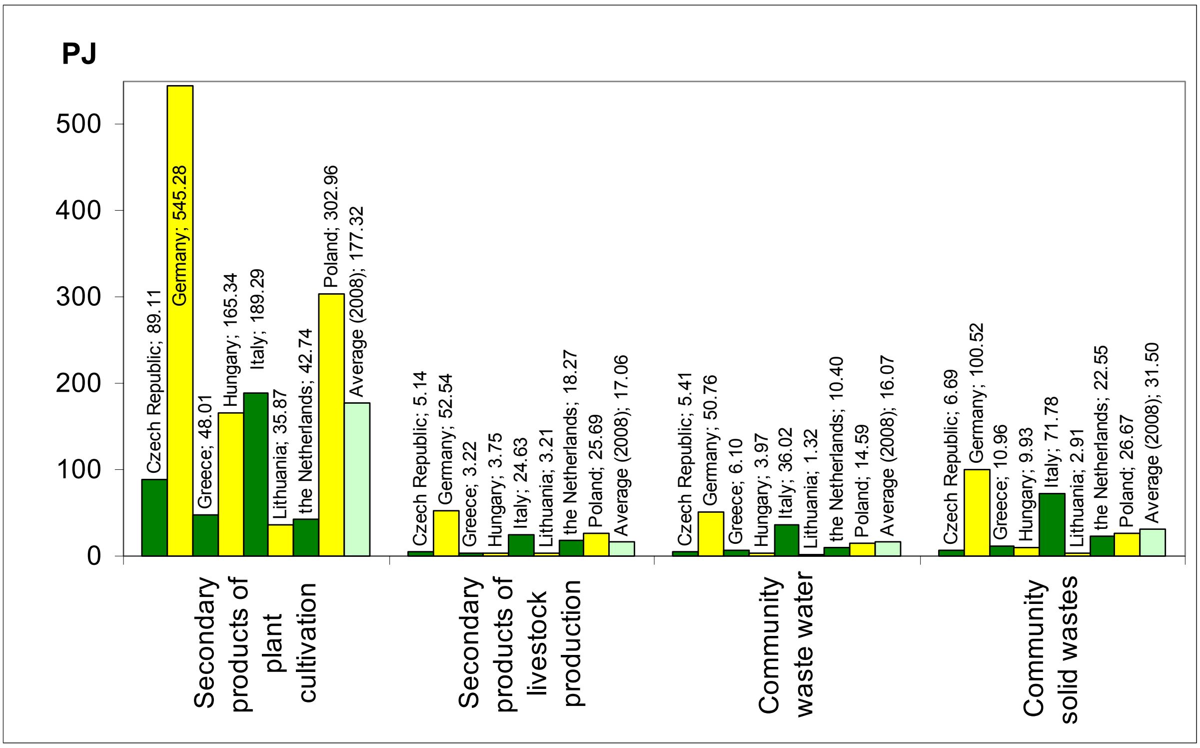

Figure 22 Average biogas potential ratios for eight countries of the consortium according to biomass raw materials

Figure 22 shows the average theoretical biogas potentials of the consortium countries in a diagram format. In the Figure it can be seen that the largest theoretical potential is accounted for by plant by-products and solid communal waste. For each basic material the last columns show the average values for the eight countries. Germany ranks in every case far higher than the average values. The average values are best approximated by Poland. These ratios result primarily from the size of the territories of the countries.

Figure 23 the summarised theoretical potentials of the individual countries grouped into biogas basic material groups in 2008.

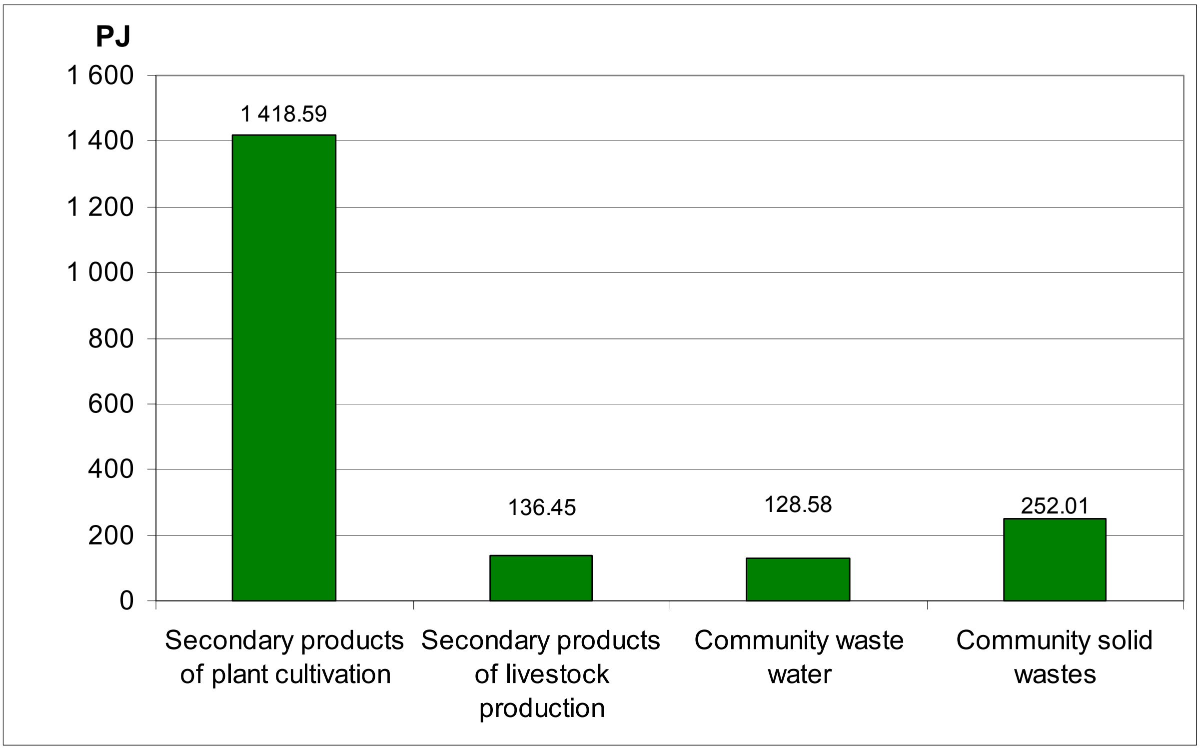

Figure 23 Summarized average biogas potential ratios in eight countries of the consortium according to biomass raw materials in 2008

Finally it was examined what amounts of energy are represented by the average theoretical biogas potentials of the countries for 2008 as compared to the primary energy use of the given country in 2007 and to their natural gas consumption in 2007 (these were the accessible data at first quarter of 2009).

The primary energy and natural gas data of the eight countries for 2007 were taken from the British Petrol statistics (http://www.bp.com), and Eurostat statistics (http://epp.eurostat.ec.europa.eu). The BP energy statistics data referred to were given in measurement units of Mtoe, as conversion factor the relation 1 Mtoe = 41,868 PJ applied equally by IEA, OECD and BP was used.

The amounts of primary energy for 2007 and the average theoretical biogas potentials are summarised in Table 1.

2007	**Primary energy**		**Biogas potential (average)**	
Country	[Mtoe]	[PJ]	[PJ]	[%]
Czech Republic	43.3	1 812.9	106.3	5.9%
Germany	311.0	13 020.9	749.1	5.8%
Greece	34.1	1 427.7	68.3	4.8%
Hungary	24.5	1 025.8	183.0	17.8%
Italy	179.6	7 519.5	321.7	4.3%
Lithuania	9.0	376.8	43.3	11.5%
Netherlands	91.8	3 843.5	94.0	2.4%
Poland	94.4	3 952.3	369.9	9.4%
The Consortium	**787.7**	**32 979.4**	**1 935.6**	**5.9%**
EU 27	**1 744.5**	**73 038.7**	**6 772.7**	**9.3%**

Table 1 Amounts of primary energy consumption

In Hungary 17.8 % of the annual primary energy consumption could be covered by biogas if the total mass of biomass available were used to produce biogas from fermentation processes. The ratio is also high at 11.5 % in Lithuania, and again in the rest of the countries the values around 5-10 % can be qualified as of considerable amount. The ratio of the average theoretical biogas potential in the consortium is 5.9 %, and in the EU 27 countries 9.3 %.

Table 2 shows the energy content of the natural gas consumption in the year 2007 and data of the average theoretical biogas potentials.

2007	**Natural gas**		**Biogas potential (average)**	
Country	[Mtoe]	[PJ]	[PJ]	[%]
Czech Republic	8.0	334.9	106.3	31.8%
Germany	74.5	3 119.2	749.1	24.0%
Greece	3.6	150.7	68.3	45.3%
Hungary	10.6	443.8	183.0	41.2%
Italy	70.0	2 930.8	321.7	11.0%
Lithuania	3.4	142.4	43.3	30.4%
Netherlands	33.4	1 398.4	94.0	6.7%
Poland	12.3	515.0	369.9	71.8%
The Consortium	**215.8**	**9 035.1**	**1 935.6**	**21.4%**
EU 27	**433.7**	**18 158.2**	**6 772.7**	**37.3%**

Table 2 Energy content of the natural gas consumption

The average theoretical biogas potentials for 2007 represent energy contents in the countries examined almost equal to half the natural gas consumption in Greece and Hungary, and over 70 % in Poland. In EU 27 countries this ratio is 37.3% and in the Redubar consortium is 21.4%.

The following is an evaluation of the data previously presented in Figure 24 for each country from the point of view of investors. The theoretical biogas potentials determined in the task provide fundamental information for those competing in the market and for financial investors where the information shows which raw material produces the biogas that is worth dealing with in a given country.

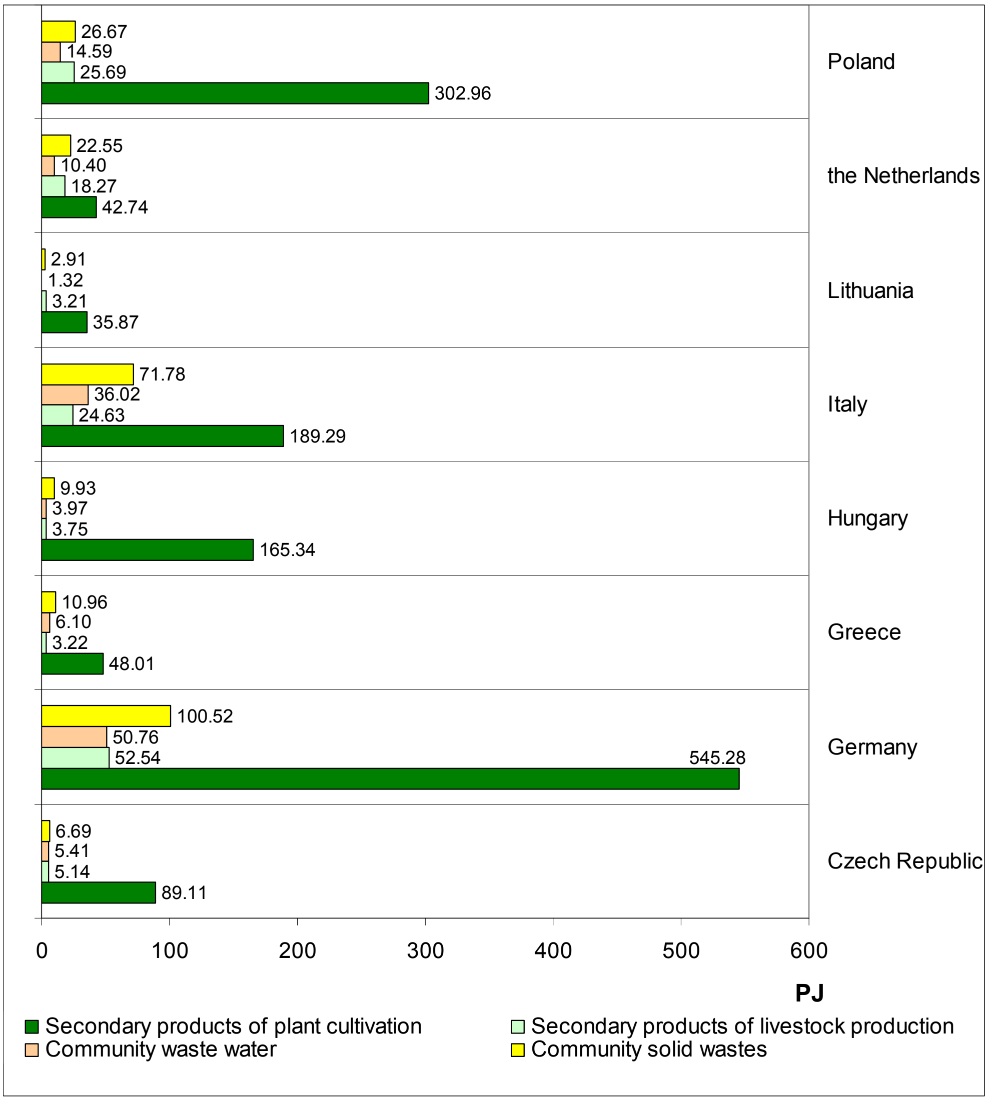

Figure 24 Average biogas potential ratios in eight countries of the consortium according to biomass raw material types in 2008 for competitors and investors

The next step which goes beyond the task D07 is to survey the financial support and the economic and legislative environment that are relevant for the biogases resulting from the various sources. For the market players only the set of information produced in this complex way can provide decision alternatives. We wish to stress that an analysis of this issue goes beyond the task D07, however, the further results of the REDUBAR project together with the survey of the biomass potential may provide a significant contribution to making a business decision.

By way of summary it can be stated that the above grouping provides for the financial investors and market players clear and quantifiable information to facilitate easier decision making, or for orienting in the right direction. The analysis performed enables the following conclusions to be drawn:

- The value of the theoretical biogas potential is the most promising in Germany, followed by Poland, among the countries studied.
- The highest biogas potentials were found in terms of the plant cultivation by-products (agriculture), which are closely related to the sizes of the agricultural cultivation areas of the individual countries.
- Therefore it can be established that a considerable biogas potential can be exploited by choosing the right production structure in agriculture and the planned collection of the by-products produced.
- The amount of biogas that can be extracted from communal solid waste also shows a potential for exploitation in nearly every country.
- The amount of energy that can be extracted from communal sewage also offers a potential opportunity for biogas investors, although to a much lower extent than the previous ones.
- Having examined the data for us of primary energy of the 8 countries in the consortium and in EU27, it can be established that not even the theoretical biogas potentials (maximum values) make it possible to replace an amount of primary energy higher than approximately 20 %.
- Looking at the data for the use of natural gas, a significant amount could be replaced if the biomass were used to produce bio-methane.
- In this way for financial investors, a combination of the biomass potentials for the given country (D07) and the political-economic-legislative environment of the given country determine the future profitability of the investment.

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Notes