Assessment of actual framework conditions and potentials for Biogas investments in Turkey

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Abbreviations

BP	Biogas Plant
COD	Chemical Oxygen Demand
da	Decare
DM	Dry Matter
DSI	Directorate General of State Hydraulic Works
EBK	The Meat and Fish Institute
ELD	European Landfill Directive
EMRA	Energy Market Regulatory Authority
EPDK	Energy Markets and the Regulatory Board
FM	Fresh Matter
kWh	Kilowatt Hour
MARA	Ministry of Agriculture and Rural Affairs
meq	Milliequivalents
MFAL	Ministry of Food, Agriculture and Livestock
MMT	Million Metric Tons
MSW	Municipal Solid Waste
MT	Million Tons
Mtoe	Million Ton Oil Equivalent
OECD	Organization of Economic Cooperation and
OME	Olive Mill Effluent
OMRS	Olive Mill Residual Solids
OMWW	Olive-Oil Mill Waste Water
PJ	Peta Joule
RES	Renewable Energy Sources
t	Ton
TJ	Tera Joule
TL	Turkish Lira
TSWL	Turkish Solid Waste Law
TUBITAK	The Scientific and Technologic Research Council
TUIK	Turkish Statistical Centre
TURKVET	Veterinary Information System
TUSEDAD	All Milk, Meat and Cattle Breeders´Association
VS	Volatile Solid Content

1. Introduction

1.1. Background

The Turkish-German Biogas-Project is an assistance project signed between the Turkish Republic and Federal Republic of Germany, enforced by the GIZ within the scope of a Cooperation Agreement. The partner and beneficiary of the Project is the Ministry of Environment and Urbanisation (MoEU).

The overall objective of the Turkish-German Biogas-Project of the GIZ namely “Resource-efficient and climate-friendly use of animal waste for biogas production in Turkey” is to develop a sustainable biogas production concept from agricultural residues (e.g. cattle breeding) and organic waste (e.g. from the agro industry), introduce organic/natural fertilizer and as a result reduce carbon emissions. The project (2010-2014) is commissioned by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), in the context of the International Climate Initiative (ICI).

Moreover, the aim is to identify biogas production capacity for a selected pilot site and establish a practical operating environment for the investors in the country, in which such enterprises can operate competitively with German high quality and holistic biogas concept and technology.

Therefore, it is necessary to get a clear overview about the current situation, existing knowledge, legal framework and potentials for biogas implementation in Turkey.

1.2. Objective

By the request of the GIZ, the DBFZ worked out the biogas potential analyses of Turkey. The objectives of the assessment are the gross estimation of biogas potentials of different sectors (agricultural residues, animal residues, agro-industrial residues) on a national and regional level as well as the gross calculation of the total national biogas potential and the distribution on the energy mix in Turkey. The availability of surplus agricultural land currently not in use, should be included within the potential for the cultivation of energy crops for biogas production. Finally, the regions with the highest biogas potentials are determined. Within these regions attractive locations for pilot biogas plants in Turkey could be identified in the future.

Following topics are part of this assessment:

1) Overview on biogas plants in Turkey (current situation)
2) Current legal framework
3) Biogas potential analysis (data, calculation, results)
4) Overview of other biogas studies (comparison of results, biogas potentials studies)
5) Actors screening (Actors in the field of biogas,)
6) GAP Analysis
7) Conclusions

2. Overview on biogas plants in Turkey

Turkey has 2.000 biogas plant potential only with animal manure (IEA Bioenergy Task 37, 2011). However, only 85 biogas facilities with 36 plants are currently in operation (Figure 2).

Most plants are within the municipal or industrial sector (Table 1) (landfill gas or waste water treatment plants) and are located in the western part of Turkey (esp. Istanbul, Kocaeli) (Figure 3). The amount of biogas plants within the agricultural sector could not be defined exactly.

An overview of the identified number of biogas plants according to the agricultural, municipal and industrial sector are represented in

*Figure 1: Features of biogas plants based on sectors.*Table 1 and

Figure *1*.

Table 1: Biogas plants based on sectors and status and their total installed capacity.

	Biogas Plants in operation	Capacity in operation [MW]	Biogas Plants in planning	Capacity in planning [MW]	Biogas Plants total	Total Capacity [MW]
Agriculture (animal waste, crops)	2	0,68	12	11,99	14	12,58
Food Industry (wastewater, organic waste)	17	13,68	2	3,88	19	17,56
Municipality (landfill gas, wastewater)	17	96,98	12	34,72	29	131,70
Municipality (landfill gas)	13	93,04	9	32,03	22	125,08
Municipality (wastewater)	4	3,94	3	2,69	7	6,62
Undefined	0	0	23	61,16	23	61,16
Total	**36**	**111,23**	**49**	**111,76**	**85**	**222,99**

The distribution of biogas plants in Turkey are illustrated in Figure 2 (plants in operation) and Figure 3 (plants in planning and operation).

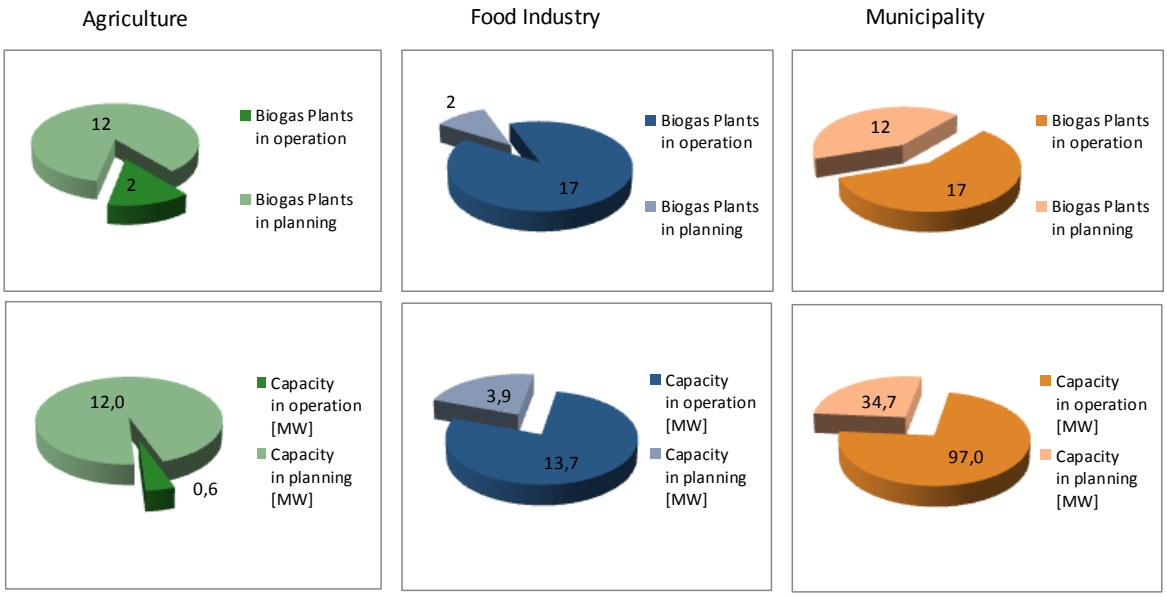

Figure 1: Features of biogas plants based on sectors.

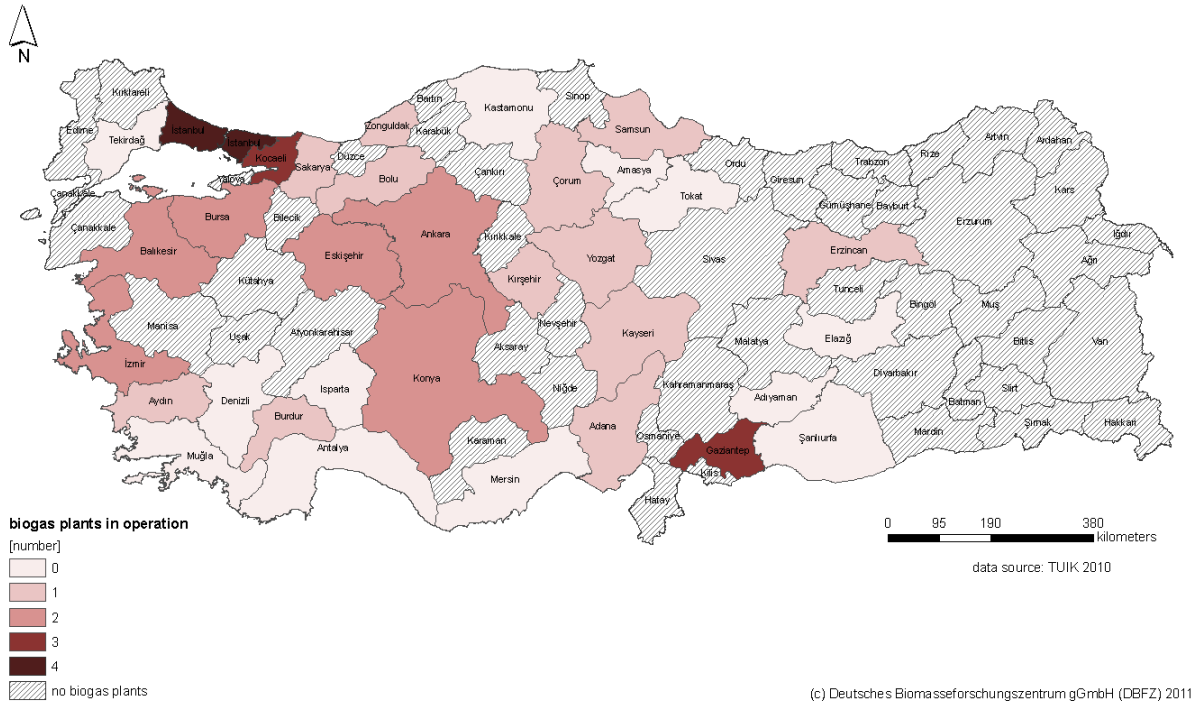

Figure 2: Distribution of biogas plants in Turkey (number of plants in operation)

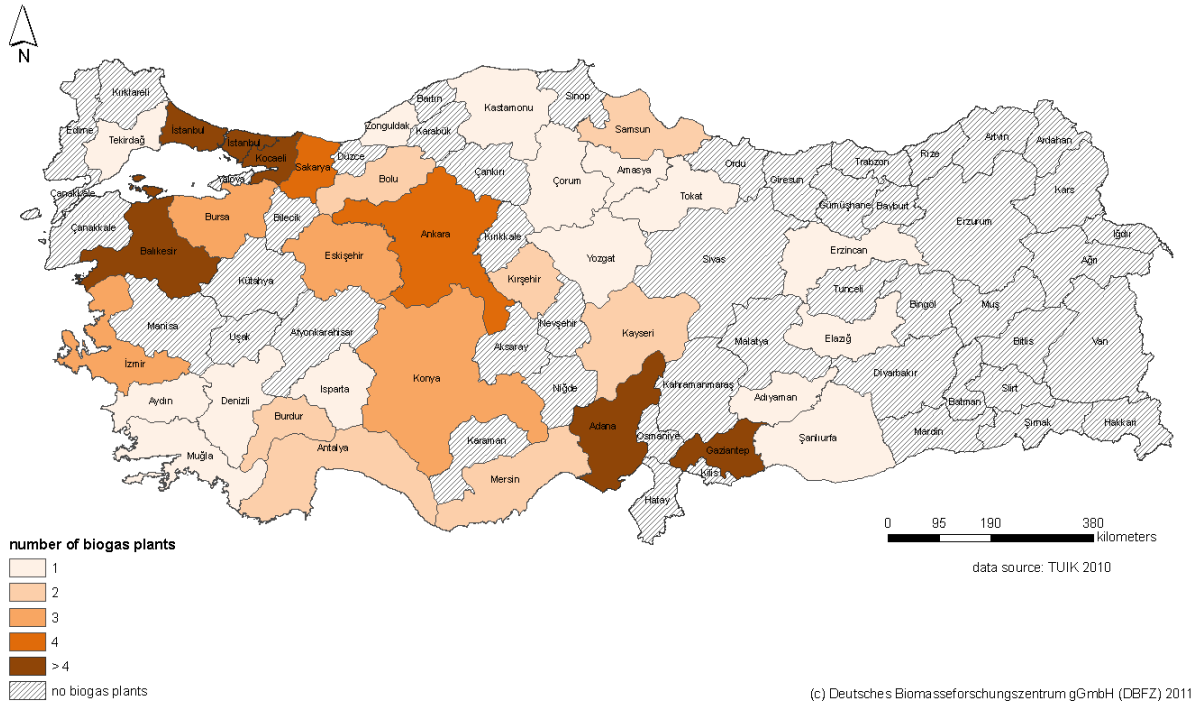

Figure 3: Number of biogas plants in Turkey (status: in operation and in planning)

In Turkey, there is still no biogas upgrading plant. The produced biogas is only seperated from condensate and hydrogen sulphide to be utilised in gas engines. Furthermore, many biogas plants are waiting for certificates from EPDK and only few of them is in operation. Because, anaerobic digestion plant permitting which includes steps such as application, examination and evaluation, approval, granted a license takes around 150-180 days.

Gaziantep, Istanbul and Kocaeli have higher numbers of biogas plant which is in operation (Figure 2). Municipalities are more interested in the planning of new biogas plants with high capacity (

Figure *1*). The situation of application regarding to grid connections (electricity, gas, pipeline) is still not clear. No legislation on digestate characteristics and utilization ways creates other barrier (IEA Bioenergy Task 37, 2011).

3. Energy policy in Turkey

Energy demand of Turkey is increasing rapidly [58, 59, 60] due to the demographic and economic growth. Turkey constitues a major energy market [60] and heavily depends on imported expensive energy sources [58]. Therefore, the main discussion about renewable energy resources is; RES can both meet Turkey´s energy demand with positive aspects for the economy and it can provide solutions for environmental problems which come from the intensive use of fossil fuels (e.g. air pollution). In this regard, the implementation of renewable energies sources (RES) is an efficient option for clean and sustainable energy development in Turkey [58]. The air pollution and energy consumption are main topics that are in dicussion among the industries and regulatory agencies

(EPDK and ministries) [58]. Moreover, the international political pressure, especially from the European Union, forces Turkey to improve its environmental and energy policies [58].

The main body responsible for energy policy in Turkey is the Ministry of Energy and Natural Resources. However, there are many state organizations working under the responsibility of the Ministry of Energy and Natural Resources (Table 2). Besides, there are non-ministerial organizations with responsibilities for various aspects of energy policy (Table 3).

Table 2: Main state organizations having responsibility for planning Turkish energy policy. Data source: [57].

Organization Name	Under the Responsibility of:
DPT, State Planning Organization	Prime Minister
TUBITAK, Scientific and Technical Research Council of Turkey	Prime Minister
Research, Planning and Co-ordination Board	Ministry of Energy and Natural Resources
Directorate General for Energy Affairs	Ministry of Energy and Natural Resources
Directorate General of Mining Affairs	Ministry of Energy and Natural Resources
Directorate General of Petroleum Affairs	Ministry of Energy and Natural Resources
TEUAS, Turkish Electricity Generation Company	Ministry of Energy and Natural Resources
TEIAS, Turkish Electricity Transmission Company	Ministry of Energy and Natural Resources
TEDAS, Turkish Electricity Distribution Company	Ministry of Energy and Natural Resources
TETTAS, Turkish Electricity Trading and Contractor Company	Ministry of Energy and Natural Resources
DSI, Directorate General of State Hydraulic Works	Ministry of Energy and Natural Resources
TPAO, Turkish Petroleum Company	Ministry of Energy and Natural Resources
The Directorate of renewable Energy	Ministry of Energy and Natural Resources
BOTAS, Turkish Pipeline Corporation	Ministry of Energy and Natural Resources
TKI, Turkish Coal Enterprises	Ministry of Energy and Natural Resources
Turkish Hard Coal Enterprises (TTK)	Ministry of Energy and Natural Resources

Table 3: Non-Ministerial agencies with responsibilities for various aspects of energy policy. Data source: [57].

Regulation or Policy Category	Involved Organization(s)
Energy policy and/or regulation	Energy Market Regulatory Authority
Nuclear power	Turkish Atomic Energy Authority (state organization)
Energy efficiency	TUBITAK MRC Energy Institute (state organization)
	Various universities (presenting reports, organizing meetings and courses)
Energy standards	TSE, Turkish Standardization Institute, IEC, International Electro technical Commission
R&D	Energy Systems & Environmental, Research Institute / TUBITAK Marmara Research Center
Renewable energy	Clean Energy Foundation, Turkish Wind Energy Association, International Solar Energy Society Turkish Section, Geo-thermal Energy Association

However, up to now there is no special agency which is responsible of only biomass respectively biogas in order to enforce the policy regarding this kind of energy source. Moreover, the biogas association – a public association – in Turkey has currently no power on the energy policy. Therefore, a long term strategy for implementation of biogas policy and technology is missing.

3.1. Current energy situation

The country currently has considerable potential for RES. [58]. Although the use of RES in Turkey increased considerably it is still on a low level. Different studies indicate that the most significant sources of RE in Turkey are wind, solar and geothermal energy. Although there are considerable biomass respectively biogas potentials in Turkey, currently, it is not in use.

Turkey's energy consumption had been growing faster than its own energy production, which makes Turkey a rapidly growing energy importer. Figure 4 shows Turkey´s increasing energy consumption between 2000 - 2009 (Figure 4). Energy is important for economic and social development and an improved quality of life in Turkey [30].

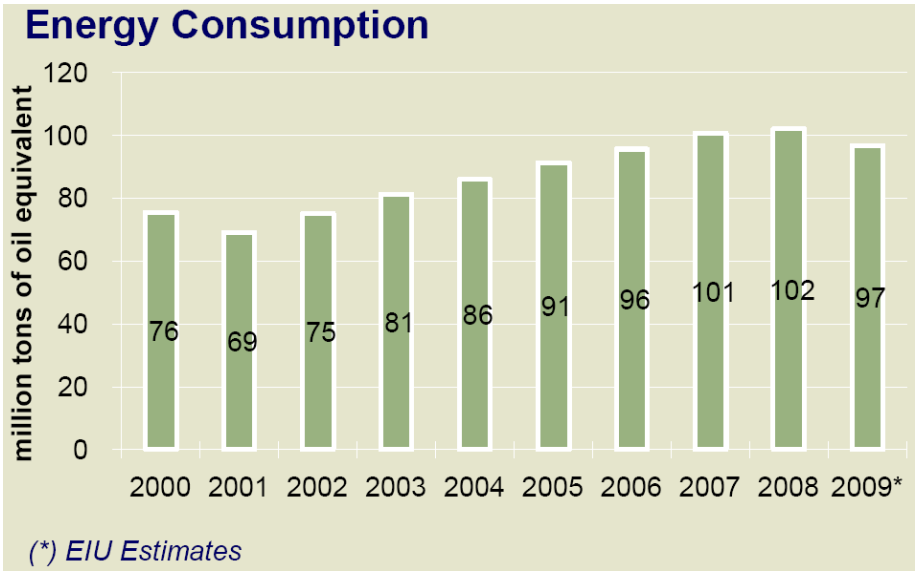

Figure 4: Total Energy Consumption of Turkey between 2000 - 2009. Data source: [22].

According to the Ministry of Energy, Industry and Technology, Turkey consumes three times more energy than the amount it could produce. Dependency on energy imports are over 70 % [8]. The main energy resources of Turkey are lignite, hydropower and biomass. Electricity is mostly produced by thermal power plants which consume coal, lignite, natural gas or fuel oil. Geothermal energy and hydropower plants are other important sources in Turkey [47].

Use of home-grown resources could significantly reduce Turkey's need of fossil fuels and it could provide sustainable energy [25].

According to data from the Ministry of Energy, Industry and Technology, the total primary energy demand in Turkey for 2010 is 1,271 TWh/year, total energy consumption is 969.6 TWh/year. The share of RES is 10.7 % in the primary energy demand (135.75 TWh/year) and 8.9 % related to the total energy consumption (87.15 TWh/year). Natural gas contributes 16.8 % of energy consumption [41]. The share of RES contains mainly hydropower and geothermal heat (Table 4). Petroleum, natural gas and coal are the main energy sources of Turkey. Turkey meets its own energy demand by the more than 80 % import of petroleum and natural gas.

Table 4: Primary energy demand and total energy consumption of Turkey, Data source: [41].

TWh/year	Import	Export	Primary Energy Demand	Total Energy Consumption
Fossil Fuels				
Coal	159.7	0	180	94
Lignite	0	0	178.9	70.7
Wood	0	0	39.4	39.3
Animal and plant waste	0	0	13.6	12.3
Petroleum	425.3	84.3	339.8	321.8
Natural gas	405	6.9	406	163.05
Renewables				
Hydropower	0	0	51.8	0
Geothermal	0	0	6.7	0
Biofuel	0	0	0.13	0.13
Wind	0	0	2.9	0
Geothermal heat, Other heat	0	0	16.2	30.4
Sun	0	0	5.02	5.02
Others	26.6	1.94	30.55	232.9
TOTAL	1,016.6	93.1	1,271.0	969.6

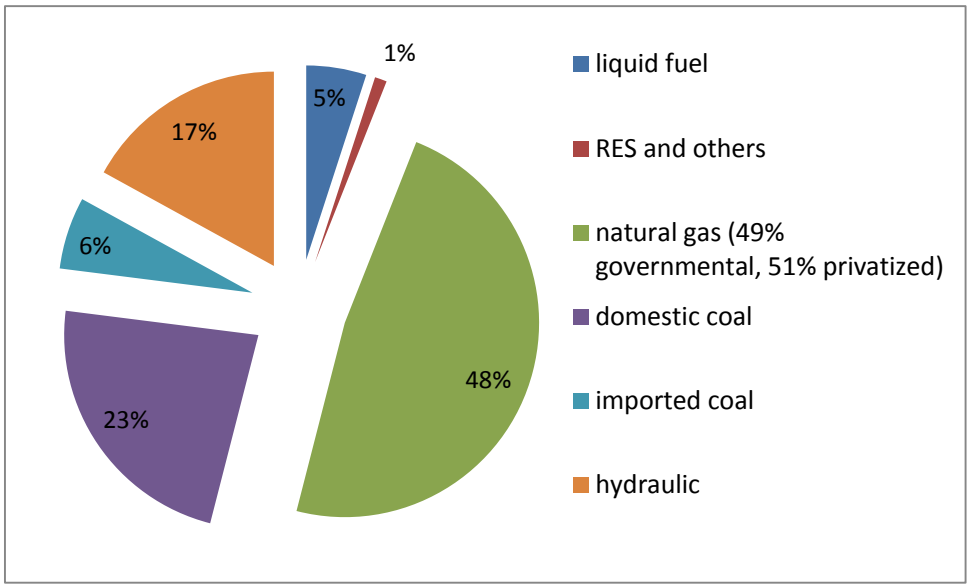

Figure 5: Electricity production of Turkey based on sources. Data source: [41].

Electricity production today in Turkey is 211.2 TWh/year mainly based on convertion of more than 70 % of imported natural gas into electricity energy and gained from hydropower (Figure 5). Electricity is mainly being consumed in the metropolitan areas of Istanbul, Izmit, Izmir, Ankara and Bursa (Figure 6).

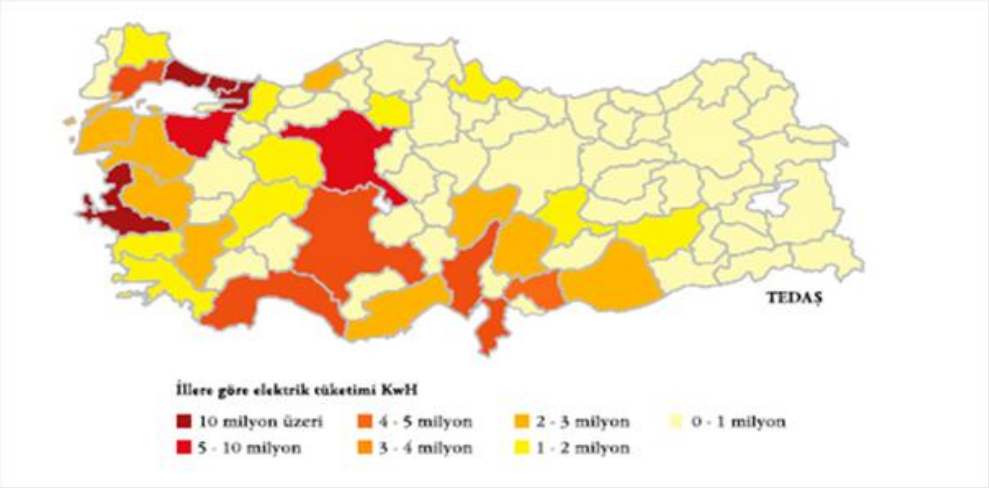

Figure 6: Electricity consumption of Turkey on province level (KWh). Data source: [33].

Electricity is mostly being consumed in housing and services and industry sectors [41, 38] (

Figure *7*).

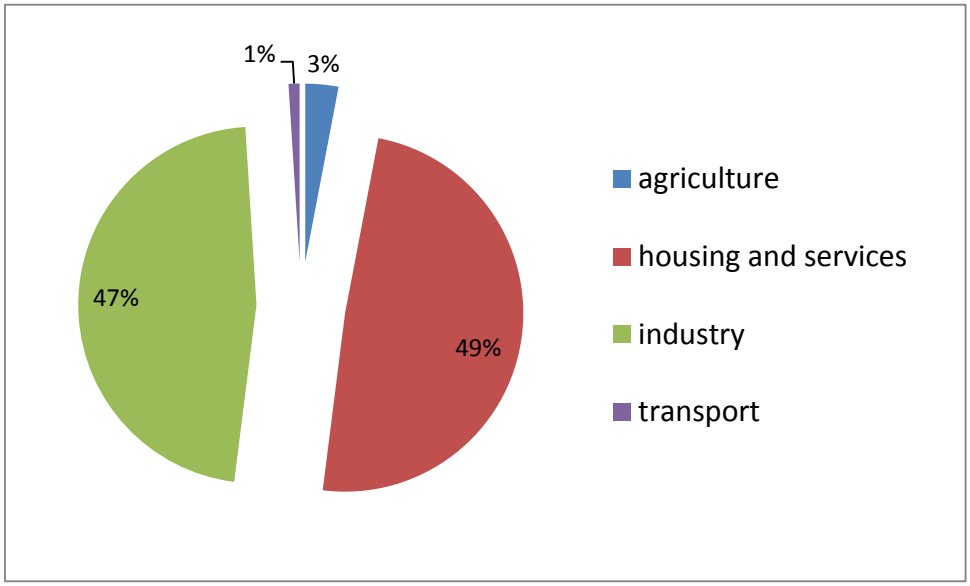

Figure 7: Electricity consumption of Turkey based on different sectors. Data source: [41, 38].

According to an scenarios regarding the future energy production/consumption of Turkey increasing energy consumption and production are being expected until 2020. [43] (Table 5).

Table 5: Energy production/consumption scenario of Turkey in the near future. Data source: [43].

Source	Energy Production PJ/year			Energy Consumption PJ/year		
	2010	2015	2020	2010	2015	2020
Fossil Fuels						
Bituminous Coal	213.2	213.9	199.1	723.6	112.5	2016.2
Lignite	753.7	1012.8	1341.6	753.7	1012.8	1341.6
Asphaltite	12.6	12.6	12.6	12.6	12.6	12.6
Petroleum	65.8	44.8	29	1724.3	2111	2550.5
Natural Gas	9.8	8.9	9.6	1557.2	1873.5	2157.7
Renewables						
Hydro electric	205.3	295.6	394.4	205.3	295.6	394.4
Geothermal (heat + electricity)	87.1	132.6	205.7	87.1	132.6	205.7
Wind	17.6	23.9	30.2	17.6	23.9	30.2
Sun	20.7	25.3	36.1	20.7	25.3	36.1
Wood	141.6	128.7	128.7	141.6	128.7	128.7
Animal and plant waste	43.3	38.8	35.6	43.3	38.8	35.6
Nuclear	0	344.5	344.5	0	344.5	344.5
TOTAL	1570.7	2282.4	2767.2	5286.8	7124	9312.4

Regarding energy production in near future renewable energy sources are expected to increase in contribution. According to the scenario in which Turkey does not change the legal framework, at the end of 2020 Turkey still will be energy importing country.

3.2. Political Strategy

While national policy on renewable energies is being formulated, nonbiomass (wind, solar, hydropower) renewable energy sources are being promoted more than biomass [57.] Policy studies and programmes on Turkey´s renewable energy potentials and technologies often focus on hydropower and geothermical heat. The implementation of biomass utilization facilities which might contribute to the energy demand is often not part of political strategies.

Basic principles guiding national policy on renewable energies given in Table 6 demonstrate the fact that biogas respectively biomass is less focused than nonbiomass such as wind, solar and hydropower. This situation could be seen also in Turkey´s 2023 energy targets which are defined under the name of “Vision 2023” (the year 2023 is important due to 100th year of founding of Turkish Republic).

Table 6: Basic principles guiding national policy on renewable energies. Data source: [57].

Guiding principles	Ranking 0=non relevant 5=highly relevant
Need for a substitution of traditional fossil fuels	4
Development of a national concept promoting renewable energies	4
Financial support in promoting renewable energies	3
National focus more on promoting of renewable energies based on biomass (biogas, biodiesel, bioethanol)	3
National focus more on promoting renewable energies based on nonbiomass (wind, solar, hydropower)	4
Stimulation/support of the private sector	3
Competitiveness of renewable energies with fossil energy	3
National independence of fossil energy supplies	3

According to Energy vision 2023 of Turkey (TUBITAK), some priorities regarding to energy were given. These priorities could be summarized as below [13]:

- Giving priority to national resources, search for the desired quality, safe and economical development of advanced technologies in production;
- Produce efficient and environmentally-friendly technologies
- Compete in the international energy market,
- Develop international energy technologies,
- Take an active role in investments
- A 25 % increase in 80 Mtep level of 2001 total energy demand, energy efficiency and provide 3.5 tep energy consumption per capita.
- Increase 2001 electricity demand from 127 TWh level of to 480 TWh by the end of 2023, increase the energy supply from 28 GW to 100 GW.
- Search biomass energy technologies:
- Seed development and improvement of energy crops,
- Biogas systems in rural and urban applications,
- Biomass gasification and gas cleaning
- Obtain energy from waste and waste management,

The Ministry of Energy and Natural Resources (2010 – 2014) declared strategic targets regarding especially to energy demand security [12]:

- Within the Plan period, domestic oil, natural gas and coal exploration activities will be increased.
- The construction of the 3,500 MW coal-fired thermal power plants will be completed by the end of 2013.

- The construction of the hydroelectric power plants of 5,000 MW will be completed by the end of 2013.
- Wind energy for 2009 will be increased from 802.8 MW to 10,000 MW by the end of 2015.
- Geothermal energy for 2009 will be increased from 77.2 MW to 300 MW by the end of 2015.
- Until 2014, the completion of the privatizations in the electricity sector will be done.
- Until 2015, domestic natural gas and petroleum production will be increased 2 times than the production in 2008.
- 2.1 million m³ natural gas storage capacity of 2009 will be doubled by the end of 2015 [32].
- The main target regarding to renewable energy is to provide 30 % share of renewable energy level concerning the electricity production.

Nevertheless there is a high biomass potential in Turkey. It is necessary to have long term policy strategies on national level with focusing more on promoting of renewable energies based on biomass (biogas, biodiesel, bioethanol) and not only on renewable energy.

According to Kacira et al. 2006 [26] the most important barriers in the institutional, legal and administrative framework for the exploitation of biomass in Turkey can be described as follows:

- Establishment of structural and organizational responsibilities at the institutional level, which requires a higher level of coordination and cooperation within and between institutions, agencies, institutes and other stakeholders,
- Lack of information about existing and possible future costs of biomass utilization,
- Lack of detailed biomass energy resource assessments and data banks pertaining to Turkey,
- Lack of credit facilities, particularly for small-scale projects,
- Administrative and time-consuming obstacles for foreign investors,
- Lack of participation of the private sector,
- Lack of technically experienced staff,
- Difficulties encountered during planning, project feasibility and project control activities,
- insufficient policy and market instruments (including available subsidies) regarding the environmental, agricultural and energy sectors,
- The need of public acceptance and willingness

3.3. Legal Framework

The following regulations give an overview about existing Turkish legal frameworks regarding to implementation of biogas in Turkey. At last, aspects regarding to missing regulations and framework are summarized in chapter 3.3.6.

Table 7: The list of current regulations related to biogas.

Name of regulation	Accept Date	Last Amendment Date
The Renewable Energy Law	10 May 2005	08 January 2011
Animal Side Products Unused for Human Consumption Regulation	24 December 2011	
The Protection of Waters Against Pollution Caused by Nitrates from Agrıcultural Sources	18 February 2004	
The Solid Waste Control Regulation	14 March 1991	05 April 2010
General Rules For The Regulatıon of Waste Management	05 July 2008	
Environmental Law	09 August 1983	26 April 2004
The Production, Importation and Placing on the Market of Agricultural Organic, Organomineral Fertilizers, Soil Regulators and Other Microbial Product with Enzyme Content Regulation	04 June 2010	

3.3.1. Renewable Energy Law

The *Renewable Energy Law No.5346 on Utilization of Renewable Energy Resources for the Purpose of Generating Electrical Energy* was accepted at 10 May, 2005. The main objectives of the law are to increase the use of renewable energy sources for generation of electrical energy (not for heat), as well as to diversify energy resources, reduce greenhouse gas emissions, assess waste products, protect the environment, and develop the necessary manufacturing sector for realizing these objectives [26]. This law has been revised by Law No. 6094. The amendments were officially announced in official Gazette on 8 January 2011.

The revised Law is the wide complex statute, accepted for the advancement of the use of renewable energy sources in Turkey. The main aim is to:

- Expand the deployment of renewable energy sources for electric power production sector,
- Introduce these implementations by secure, cost-beneficial and qualitative way,
- enhance source variety,
- reduce greenhouse gas emissions,
- recalculate waste values,
- Work out with the manufacture sector which should meet the requirements concerning protection of environment.

There are some resolutions introduced by the amendments

- There is not one tariff for all RES as before (5,5 €cent), but different tariffs for wind, solar, biomass, geothermal energy

- With the latest amendments landfill gases are considered as a part of RES as one of the subsidized non-fossil sources.
- Feed-in Tariffs values are now defined in "Dollar cents" instead of "Euro cents" [27].

The new derived incentives are shown in Table 8.

Table 8: Feed-in Tariffs of Renewable Energy Law in Turkey in Dollar cents based on facilities.

Facilities	feed-in Tariffs values in "Dollar cents"
Hydroelectric generation facility	7.3
Wind power generation facility	7.3
Geothermal energy generation facility	10.5
Generation facility based on biomass	13.3
Generation facility based on solar power	13.3

The rates will be the same for a period of 10 years for generation license holders who have begun/will begin operations between 18 May 2005 and 31 December 2015. For the facilities that will start operations after 31 December 2015, new rates will be specified by the Council of Ministers under the stipulation that they will not exceed the above-mentioned rates.

- In law, regarding to purchase amounts for the renewable energies, the size of plants is not taken into account [7].
- Energy producers holding a renewable energy generation license and wishing to benefit from the RES Support Mechanism must apply to the Energy Market Regulatory Authority by 31 October of the year.
- The Amendment provides that electricity suppliers (as defined by Electricity Market Law No. 4628) must pay into a pool that is managed by the Market Financial Settlement Centre. This mechanism will better facilitate the collection of revenues by the producers. The pool will guarantee the purchase of that generator's electricity by the suppliers.
- The Amendments additionally incentivize the use of mechanical and/or electromechanical components manufactured in Turkey.

Incentives (US dollar cents per kWh) which will be applied for the use of mechanical and/or electromechanical components manufactured in Turkey are listed in Table 9.

Table 9: Incentives (US dollar cents per kWh) which will be applied for the use of mechanical and/or electromechanical components manufactured in Turkey.

Components	İncentives (US dollar cents per kWh)
Fluidized bed steam boilers	0.8
Liquid or gas bed steam boilers	0.4
Gasification and gas cleaning group	0.6
Steam or gas turbines	2.0
Internal combustion engines or sterling motors	0.9
Generator and power electronics	0.5
Cogeneration systems	0.4

- Generation facilities which become operative till 31 December 2015 will continue to benefit from 85 % discount for power transmission line permits, leases, rights of easement and usage permit costs during the first 10 years of their investment and operation.
- The establishment of electricity generation facilities based on RES may be permitted in environmentally sensitive areas; subject to the affirmation of the relevant Ministry or regional conservation committee.
- Legal persons who are licensed to generate electricity energy based on RES can set up additional capacity provided that
    - They remain within the scope (e.g. area) set out in their license; and
    - The powers released to the system at the time of operations do not exceed the installed capacity specified in their license.
- Generators based on RES whose installed capacity do not exceed 500 kWh as stated under Electricity Market Law No. 4628 can benefit from the aforesaid price incentives for portions of energy that exceed their personal use and are released into the energy distribution system.
- Electricity Market Independent Consumer Regulation was amended on 8 February 2011, stipulating that until all consumers become independent consumers, the list of all consumers whose electricity consumption exceeds the independent consumer limit shall be published on the web sites of distribution companies.
- The independent consumer limit has been decreased to 30,000 kWh by EMRA's decision dated 26 January 2011. The limit applied in 2010 was 100,000 kWh.

3.3.2. Waste Management Regulations

In Turkey, most of the landfills are uncontrolled sites where urban and industrial waste are being dumped together. Uncontrolled land dumping of waste without any form of pre-treatment in order to reduce their harmfulness is the dominant form of disposal for all types of waste in Turkey. Waste is generally dumped close to where it is produced, irrespective of the environmental consequences. Most sites are largely unsupervised without a filling plan, and waste is dumped in a disorganized manner with no compaction or capping after dumping and no restoration or aftercare of the site after tipping operations are completed. The sites are seldom fenced giving access to domestic animals. Major problems have been found regarding the contamination of aquifers with toxic leachate, with odor and with harmful smoke from burning waste. Fires and subsidence at dumpsites are also common. Only a few dumpsites meet the basic requirements of modern landfilling in Turkey [45].

General rules on *Waste Management Regulation* were announced in official gazette dated on 05/07/2008. The aim of the regulation is to prevent harmful effects of the waste from their production till their disposal. Regulations related to biowaste are not included. According to this law:

- All the ministries and civil organizations should work together in order to decrease, dispose, recycle and recover the waste.
- Polluting the environment is forbidden.

- If there is a waste production possibility for one facility, that facility should prepare a report about environmental impact assessment. If the facility cannot get approval, it cannot start to operate.
- All the facilities must recover their waste according to the laws. If recovery is not possible, disposal should be done based on relevant laws.
- Facility that causes pollution is responsible for recleaning.
- Ministry could decide to apply electricity discount to the facility which decides to operate its own waste water treatment system.
- Combustion of the manure is forbidden.
- Facilities are responsible to keep their odor emissions at the allowed concentrations.

According to *Environmental Law*, violation of relevant regulations, standards and methods determined directly and indirectly, receiving to environment, store, move, remove, and similar activities related to all kinds of waste and residues which could result in the detriment of the environment are prohibited.

According to the legal definition, municipal solid waste includes all the waste arising from human activities that are normally solid and discarded as useless or unwanted. Municipal solid waste generally consists of waste generated from residential to commercial areas, industries, parks, and streets [44].

In the *Environmental law*, there was no consensus on the best option for municipal solid waste management. Therefore in 1991, the *Solid Waste Control Regulation (TSWL: Turkish solid waste law)* was published in order to organize the collection, storage, transport, and disposal of the solid waste [44]. According to this legislation, municipalities are responsible for the collection, transportation, recycling and disposal of the solid waste. There is no specific target set for the reduction in biodegradable municipal waste going to landfills [45]. However, there was a law that included bio waste which was called Principles and Implementation of Organic Agriculture.

Last amendment of solid waste control regulation was accepted on 05/04/2010. Aim of the regulation is to prevent the direct or indirect expose of the waste to environment, management of the waste. This regulation suggest compost or combustion of the waste for the disposal way.

Odor emissions from the bovine and poultry animals manure are regulated under the *Industrial Air Pollution Control Regulation* which was announced in the official gazette dated on 3/7/2009. The waste come from farming process is needed to be regulated if it is intended to use as fuel, since in Turkey waste and residues from farming process (animal manure and crop residues) are mostly being directly burnt, which causes high air pollution.

The manifesto regarding the recovery of unhazardous waste was announced in 27967 numbered official gazette dated on 17th of June 2011. The aim of the regulation is to decrease the negative effect of the unhazardous waste that is being produced from production process. However, in this regulation waste comeing from anaerobic treatment is not included. This means there exists no regulation concerning management of digestate and digestate cannot be used as fertilizer.

In general, it can be said that lack of national, regional and local waste management plans had led to decline in the amounts of municipal waste recycled in Turkey. The waste management in Turkey has

suffered from negligence of waste management issues resulting in a weak legislative base, administrative structures and inefficient implementation, control and enforcement mechanisms.

According to the sighted EU membership of Turkey, the Europen Landfill Directive (ELD) could be a guideline for the improvement of Turkish waste management. Therefore a national waste management strategy is important. Article 5 (waste and treatment not acceptable in landfills) of the Europen Landfill Directive implies that a national strategy for the implementation of the reduction of biodegradable waste going to landfills should be set-up and there should be a reduction in the amount of biodegradable MSW disposed at landfills. Regarding ELD, reduction targets for the biodegradable waste amount going to landfills should be launched also in the *Turkish solid waste law.* Therefore the responsibilities must be defined and strategy of minimizing the amount of biodegradable waste going to landfills must be declared and measures to achieve targets should be included. Unfortunately, potential for anaerobic digestion was not investigated up to now [45].

3.3.3. Fertilizer Regulations

In Turkey, liquid manure is often discharged into water environment – currently, there is no mentality to use the liquid manure as a fertilizer in the agriculture. In some cases the solid manure is used as fertilizer, however it is mostly dumped on empty areas or burnt for heating in especially small villages.

In general, it can be said that there is a lack of animal waste management in the legal framework. Animal waste management is somehow excluded from any type of regulation. However, there was a law including management of animal waste which was called *Principles and Implementation of Organic Agriculture*. Unfortunately, this regulation only defines, whether or how animal waste could be used in organic agriculture and it does not establish any control ways for animal waste in general.

Up to now there are no regulations for handling or storage liquid fertilizer. Therefore, liquid manure is not being used as fertilizer and the current utilization/storage of liquid manure causes significant environmental problems. Therefore, it is necessary to have a sustainable manure management in order to be able to close the nutrient cycle. Moreover, the current regulation is not suitable for the digestate that comes from biogas plants.

Regarding the solid manure management the organic agriculture regulation (2004) could be applied to until it was revoked in 2004. It was indicated that total organic fertilizer amount must not exceed 170 kg/N/ha/year for organic herbal production. Storage area of animal manure must have some parameters preventing the soil and water contamination through flow and leakage. Furthermore, the storage of digestate is not included in this regulation either.

Regulation regarding the *Production, Importation and Placing on the Market of Agricultural Organic, Organomineral Fertilizers, Soil Regulators and Other Microbial Product with Enzyme Content* was officially announced in official Gazette with the number of 27601 on 4 June 2010. This law has an effect on the direct use of chicken manure and any other type of potential manure that could be used as fertilizer. Within this regulation some limitations are put regarding heavy metals and microorganisms as shown in Appendix 2. If the manure fullfills the limitations it can be used as fertilizer directly.

3.3.4. Animal Side Products Unused For Human Consumption Regulation

The regulation was officially announced in official Gazette with the number of 28152 on 24 December 2011. The provision of this regulation is being executed by the Ministry of Food, Agriculture and Livestock. The purpose of this regulation is to derivative and determine the procedures and principles of animal side products which are not offered for human consumption in order to prevent or minimize the risks of food and feed safety, public and animal health.

The regulation covers:

- The identification, classification, collection, transportation, storage, processing, market placement, destruction, use, import, export and transit of animal side products unused for human consumption and the institutions, organizations and businesses, individuals which are engaged with these jobs,
- The raw materials used in the manufacture of animal origin products which is produced for human consumption, but decide not to use for human consumption by the operator,
- Food waste.

When;

- Their arrival is from transports engaged in international transportation,
- They are intended to be used in animal nutrition,
- They are intended to be used in biogas and composting businesses, pressure sterilization, or any of the methods specified in Article 10.

Regarding the supply and use of animal side products and their derivatives as organic fertilizer and soil enhancer on the market;

- They should be obtained from the category two and three materials,
- They should come from approved or registered business and facilities,
- Digestive residues that arise during the conversion of biogas and compost may be offered to the market as organic fertilizer and soil enhancer,
- When it is required, the Ministry sets limits on the use of organic fertilizers and soil enhancer,
- in order to prevent the use of organic fertilizers and soil enhancers for nutritional purposes, required marking should be done.

Export of animal side products and their derived products for biogas or compost purposes to countries which are not the member of the Organization of Economic Cooperation and Development (OECD) is prohibited. This regulation will be implemented on 13/06/2013. Facilities should adapt their conditions till 13/12/2014.

3.3.5. The Protection of Waters Against Pollution Caused by Nitrates

There are many central or local institutions and organizations authorized in water resources utilization and preservation such as the Ministries of Environment, Forestry, Culture, Public Works, Energy and

Natural Resources (General Directorate of State Hydraulic Works, Electrical Works Research Administration), and Agriculture. There is not a single wide-scoped water law in Turkey. As a result of a high number of related bodies and relevant laws and regulations, water resource utilization rights are significantly complex in Turkey.

Last amendment of water pollution control regulation was announced in the official gazette on 13/12/2008. The aim of the regulation is to protect water from contamination with sustainable development targets. All the waste should get permission paper. Over fertilizing is forbidden and controls are realized regularly.

Later, on 08/06/2010 *Soil Pollution Control and Point Source Contaminated Fields Regulation* was announced in the official gazette. This regulation aims to prevent soil from contamination and find out the potential contaminants. Any type of waste that could contaminate the soil is forbidden to be given directly to the soil or cannot be stored within the methods that are not described in the environmental law.

The regulation on *The Protection of Waters Against Pollution Caused by Nitrates from Agricultural Sources* was officially announced in official Gazette with the number of 25377 on 18 February 2004. It covers the related technical and administrative bases to determine, control and protect ground waters, surface waters and soil caused by nitrogen and nitrogen compounds.

Regarding the pollution determination, considering physical and environmental features of water and soil and the quantities of nitrogen compounds in water and soil, Ministry of Agriculture and Rural Affairs, Ministry of Environment and Forest, Ministry of Health and Ministry of Energy and Natural Resources determine following:

- All surface and ground waters used or could be used in the future as drinking water which contain nitrate over 50 mg/l,
- Whether natural fresh water lakes, other fresh water resources, bays, coastal waters and sea waters are eutrophic, and also whether these waters could be eutrophic.

Vulnerable zones were determined in two years after the publication of this regulation and in subsequent periods, all the areas which cause pollution, either by filtering or carrying, in the waters specified in the article 5 of this regulation will be determined as vulnerable zones. Vulnerable zones are reviewed at least every four years.

In two years after the publication of this regulation, to ensure general protection level in all the waters against pollution, good agricultural practices fundamentals shall be developed by related institutions under the coordination of Ministry of Agriculture and Rural Affairs.

The fundamentals of good agricultural practices shall include following:

- Periods when the land application of fertiliser is inappropriate,
- The land application of fertiliser to steeply sloping ground,
- The land application of fertiliser to water-saturated, flooded, frozen or snow covered ground,
- The conditions for land application of fertilizer near water courses,

- The capacity and construction of storage vessels for livestock manures, including measures to prevent water pollution by run-off and seepage into the ground water and surface water of liquids containing livestock manures and effluents from stored plant materials such as silage,
- procedures for the land application, including rate and uniformity of spreading, of both chemical fertilizer and livestock manure, that will maintain nutrient losses to water at an acceptable level,
- Land use management, including the use of crop rotation systems and the proportion of the land area devoted to permanent crops relative to annual tillage crops,
- The maintenance of a minimum quantity of vegetation cover during rainy periods that will take up the nitrogen from the soil that could otherwise cause nitrate pollution of water,
- The establishment of fertilizer plans on a farm-by-farm basis and the keeping of regular records on fertilizer use,
- The prevention of water pollution from run-off and the downward water movement beyond the reach of crop roots in irrigation systems.

Biogas can be an option to solve the problem by using the manure in combination with a good ferzilizer management. Programs shall be developed in required areas to train and inform farmers and to promote the implementation of good agricultural practices. Action programmes shall be implemented within four years of their establishment and shall consist of the following measures:

- Fertilizer and periods when the land application of fertilizer shall be designated.
- The capacity of storage vessels for livestock manure shall be determined.
- The capacity must exceed that required for storage throughout the longest period during which land application in the vulnerable zone is prohibited, except where it can be demonstrated to the competent authority that any quantity of manure in excess of the storage capacity will be disposed of in a way that will not cause harm to the environment.
- The land application of fertilizers shall be limited as to consistent with the definition of good agricultural practice, soil conditions, rainfall, irrigation, land use, available agricultural practices, crop rotation systems, and to be based on a balance between the foreseeable nitrogen supply to the crops from the soil and from fertilization.
- The amount of nitrogen supply from soil to the crops shall be designated corresponding to:
    - the amount of nitrogen present in the soil at the moment when the crop starts to use it,
    - the level of the supply of nitrogen through the mineralization of the reserves of organic nitrogen in the soil,
    - the supply of nitrogen compounds from fertilizers.

The amount of livestock manure for vulnerable zones shall be determined by the Ministry of Agriculture and Rural Affairs, with respect to region, soil, climatic conditions and specific agricultural activities to be implemented.

3.3.6. Missing Regulations for Implementing Biogas

Regarding the implementation of biogas in Turkey, following framework is necessary:

- manure management regulation
- energy targets regarding the biogas within an energy action plan
- favourable feed in tariffs (FiT) for biogas
- biowaste management with targets and/or with given utilization pathways

According to Taseli (2007), the strategic action plan which focuses on identifying measures to strengthen waste management institutions in order to develop human resources and to improve management and planning aspects should be created. The plan should emphasize the need to close and remediate the most highly polluting disposal sites and improve the standard of management and operation of the better existing sites. In order to reduce dependence on landfill, Turkish Waste Strategy should set out the following recommendations for action [45]:

- efforts to reduce waste,
- increase in re-use, recycling and composting,
- where waste cannot be recycled, recovery of energy from waste, through incineration (Taseli, 2007).

Closure and post-closure conditions should be added in to the TSWL (*Turkish solid waste law*). New fund for the use of financial assurance of closure and post-closure mechanism should be set up. There should be general guidelines for the municipalities on how to collect data on household and municipal waste (average quantities per capita and average composition of waste from households) and on municipal waste from sources other than household, i.e. from commercial activities, offices, small businesses, etc. It is not possible to set realistic targets or monitor progress without these data. The lack of periodicity in TURKSTAT studies is the biggest problem in obtaining reliable solid waste data in Turkey. Following issues should also be considered in the TSWL in addition to improvements suggested for a pre-requisite to the implementation of the ELD and establishment of the necessary framework within which waste are managed [45]:

- Define the basic concepts such as waste and the list of waste,
- Determine the hierarchy of waste management measures,
- Creation of national, regional and local waste management plans,
- establishment of a permitting or registration system for establishments that carry out waste
- disposal or recovery operations,
- registeration of businesses which collect or transport waste,
- introduction of periodic inspections of waste management installations,
- obligation of waste management installations and undertaking to keep records of relevant
- information on waste

Finally a biogas roadmap and creation of policy are needed for a national biogas programme and a long term national strategy.

4. Biogas Potential Analysis

4.1. Methodology

There are different definitions of biogas potentials: theoretical, technical, economic and realisable potentials which are described below:

- *Theoretical potential:* The theoretical potential refers to a theoretical limit of the available energy supply from biomass meaning all phytomass and zoomass in a defined area.
- *Technical potential:* The technical potential means the part of the present biomass (theoretical potential) that can be used given current technical possibilities as well as structural and ecological restrictions.
- *Economic potential* :The economic potential refers to the fraction of the technical potential that can be used economically in the context of the economic framework (development of conventional energy systems, prices of energy sources).
- *Realisable potential*: The realisable potential depicts the expected current use of bioenergy.

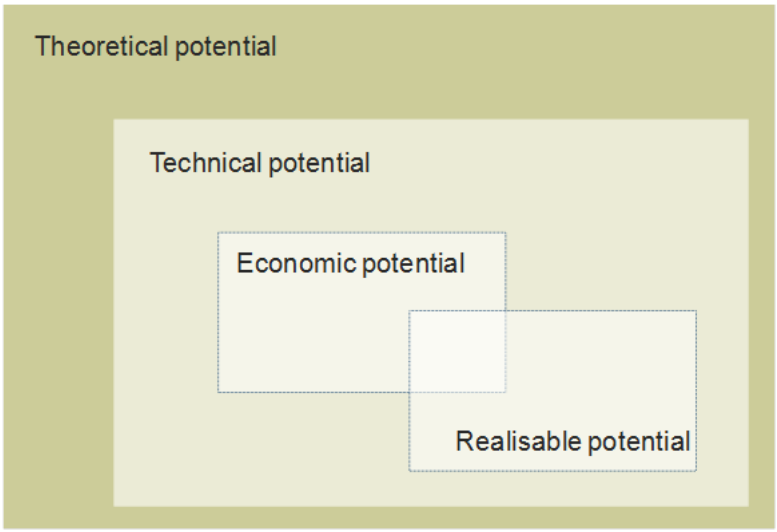

Figure 8: Kind of biomass potential

Within the study the theoretical and technical biogas potentials were determined. Regions with high biogas potential were identified by summarizing the most important substrates for biogas production in Turkey. Nevertheless, further analysis of current utilization pathways with prices of organic residues as well as the current local situation (e.g. demand of energy, actors, financial situation) are necessary in order to get detailled information for realizing local biogas facilities.

According to the availability of statistical data the biogas potential of Turkey was determined on national, province and district level. The biogas calculation on province and district level based on different statistical data (kind and number of animals, number of facilities, crops cultivation) focus on:

- Livestock (manure from cattle, manure from poultry differed to broiler and laying chicken) and
- Agricultural byproducts (straw of cultivation of cereals, tomato waste, sugar beet leaf).

On national level suitable agro-industrial residues from food industry, slaughterhouses, fruits and vegetables production (e.g. meat residues, cheese waste water, press cake of sugar beet and olive production, pomace of juice production, draff of bioethanol production) as well as the biogas potentials of municipal solid waste were analyzed and calculated.

Moreover the availability of surplus agricultural land currently not in use, were analyzed for the biogas production (energy crops). Therefore a gross calculation of energy crops on fallow land were calculated.

For the calculation of biogas potential of each kind of substrates following data are of great importance:

- Kind of substrates
- Amount per year
- Dry matter (DM) and organic dry Matter (oDM) content of substrates
- Biogas yield and methane content to calculate the amount of biogas resp. methane
- Seasonal availability of biomass
- Actual use, handling of substrate/ residues

Based on the amount of substrates combined with the biogas parameter (biogas yield, methane content) the amount of methane was calculated and transfered to kWh (heating value of methane ~ 9.97 kWh/m^3). The unit of biogas potential is given in TJ or PJ (1 TWh = 3.6 PJ).

4.2. Data collection / Data base

In order to analyse biogas potential of Turkey, data were obtained from statistical data base of the ministries, municipalities reports as well as associations.

Data on district level were used from TUIK (Turkish Statistical Centre), TURKVET (Veterinary Information System) and associations such as cattle breeders association and egg producer association. The date base for the analysis is described below.

4.2.1. Livestock

The Turkish Statistical Institute (TUIK) is the government agency responsible for publishing livestock data. The Ministry of Agriculture and Rural Affairs collects data from their provincial and county level organizations and sends it to TUIK for evaluation and publication. The reliability of livestock statistics is doubtful. Cattle population tagging was done in Turkey, however due to a support system which is based on payments per head, some farmers fail to notify slaughter of cattle to the system. Consequently, at the moment official cattle population numbers are overstated.

Regarding the livestock data, mainly TUIK, 2010 data was used. In some cases municipalities yearly reports and TURKVET 2011 data were used especially for comparing with TUIK 2010 data.

Another data for compilation was provided by cattle breeders and egg producer associations regarding to the kind and number of animals. For broiler and laying hen information, data 2011 on district level was collected from egg producers association. Data regarding broiler on province level was taken from broiler breeders association.

İnformation regarding to kind of animal husbandry systems in Turkey and options for collection of manure were collected by interviewing agricultural actors and experts.

4.2.2. Agricultural land

Agricultural data regarding the agricultural land uitlization, kind and amount of crops, hectare yields, size of the facilities, number of parcels was taken from TUIK, 2010. Specific data regarding to some cities was obtained from municipalities.

Tomato, olive, sugarbeets, cereals were considered as high biogas potential due to their high biomass yields in Turkey.

4.2.3. Agro-Industry

For the distribution of agro-industrial residues a survey for the food industry was implemented, however, no answers were obtained. The prepaired questionnary (in English and Turkish) for food industry can be found in (Appendix 20 and Appendix 19).

For the survey especially sectors of organic residues of food industry for biogas production which are written below were considered:

- Meat production: e.g. slaughterhouse residues, meat and bone meal, blood, grease separator/ fat separator
- Sugar industry: e.g. press cake of sugar beet, molasses,
- Brewery, distillery: e.g. brewer grains, draff, yeast
- Starch industry: e.g. waste water,
- Fruit production and processing: e.g. pomace of oranges, apples, bananas,
- Vegetable production and processing: e.g. olive press cake, potato peels, peas, tomatoes, pulses, maize
- Creamery: Grease separator/ fat separator, waste water
- Cheese Dairy
- Bakery: e.g. old bread
- Beverage industry
- Fish processing
- Canning / frozen foods production: food condemned to be unfit for consumption

For the calculation of national biogas potential especially dairy, meat, slaughter house, sugar, olive and wine sectors were considered, since they are major industries in Turkey. Agro industry facilities, address of the facilities, their products and capacities were taken from ministry of industry and technology. According to this kind of data, all sectors were examined in detail.

4.2.4. Municipalities

Data regarding the municipal solid waste such as disposal ways, number of municipalities and amount of waste is based on TUIK, 2008 [38].

4.3. Calculation of Biogas potential and results

4.3.1. Livestock residues

There are many small-scale farms in the livestock sector. Low-yielding domestic breeds are grazed on pastures and meadows. The small-scale livestock sector is characterized by high production costs and low yields. There is great interest in investing in the livestock sector, especially from outside the traditional livestock business [18].

In Turkey, problems regarding the animal residues start with the collection of the same. In the eastern part, long grazing days of the animals difficult o the use of manure due to unpossible collection. Regarding this problem the western part of Turkey is more valuable, since animals are already placed in a barn system without grazing days. Western part of Turkey is characterised by mostly bigger farms than eastern part. In the eastern part of Turkey livestock is the main source of livelihood. Small farms with few amount of animals which is called backyard farming are the typical characteristic of the eastern part.

Regarding the collection of manure, it is mostly collected in the manure pits in the barn, then flushed outside of the barn together with the water. This diluted waste needs to be stored temporarily in an outside manure storage trench. Mostly these trenches are permeable which causes ground water pollution. Another way for disposal of waste is directly discharging into the closest water environment.

Poultry breeding waste is characterized by high total solids and organic content, NH4-N concentration and pathogens. Because of insufficient or uncontrolled handling and disposal, they present a danger to public health and the environment. According to the data obtained from the Broiler Breeders Association, due to pebble containing structure of the broiler bedding system, collected manure could possibly cause problems in the biogas plant equipments.

There has been a rapid increase in the number of integrated animal farms and farm sizes for the last two decades due to the development in agriculture in Turkey. The most common utilization of manure in Turkey is land spreading. Manure is usually considered as waste material and farmers seek empty areas for dumping. Most of the farms do not have properly designed structures or units to store and process manures from animal barns or existing structures are not sufficient. They cause environmental problems including odors, appearance of pollution, water pollution, and environmental health problems [4].

In Turkey, large ruminants represent 60 % and poultry 33 % of total livestock. The number of bovine animal is 11,518,827 in 2010 according to TUIK data base (Table 10). Cattle populations are mostly spreaded within Turkey. However, poultry breeding (broiler and laying hen) is mostly developed in western part of Turkey. Whilst broiler breeding is mostly developed especially in the western part and north eastern part of Anatolia, laying hen breeding is spreaded within whole Turkey.

Table 10: Distribution of the number of animals depending on large animal races. Data source: [36].

Kind of animals	Number of animals	Distribution of number of animals in total (%)
Bovine	**11,518,827**	**27,88**
Cattle Culture	4,224,267	10,22
Cattle cross breed	4,730,922	11,45
Cattle domestic	2,477,939	6,00
Buffalo	85,699	0,21
Ruminants	**29,382 924**	**71,11**
Sheep	23,089,691	55,88
Goat	6,293,233	15,23
Others	417,119	1,01
Camel	1,254	0,00
Pig	1,558	0,00
Horse	154,702	0,37
Donkey	211,529	0,51
Mule	48,076	0,12
TOTAL	**41,3180,870**	**100,00**

Table 11: Changes in the number of animals depending on races between 2005-2010. Data source: [36].

Years	2005	2006	2007	2008	2009	2010
buffalo	104.965	100.516	84.705	86.297	87.207	85.699
cattle culture	2.354.957	2.771.818	3.295.678	3.554.585	3.723.583	4.224.267
cattle cross breed	4.537.998	4.694.197	4.465.350	4.454.647	4.406.041	4.730.922
cattle domestic	3.633.485	3.405.349	3.275.725	2.850.710	2.594.334	2.477.939
broiler	257.221.440	286.121.360	205.082.159	180.915.558	163.468.942	163.984.725
laying hen	60.275.674	58.698.485	64.286.383	63.364.818	66.500.461	70.933.660
turkey	3.697.103	3.226.941	2.675.407	3.230.318	2.755.349	2.942.170
geese	1.066.581	830.081	1.022.711	1.062.887	944.731	715.555
duck	656.409	525.250	481.829	470.158	412.723	396.851

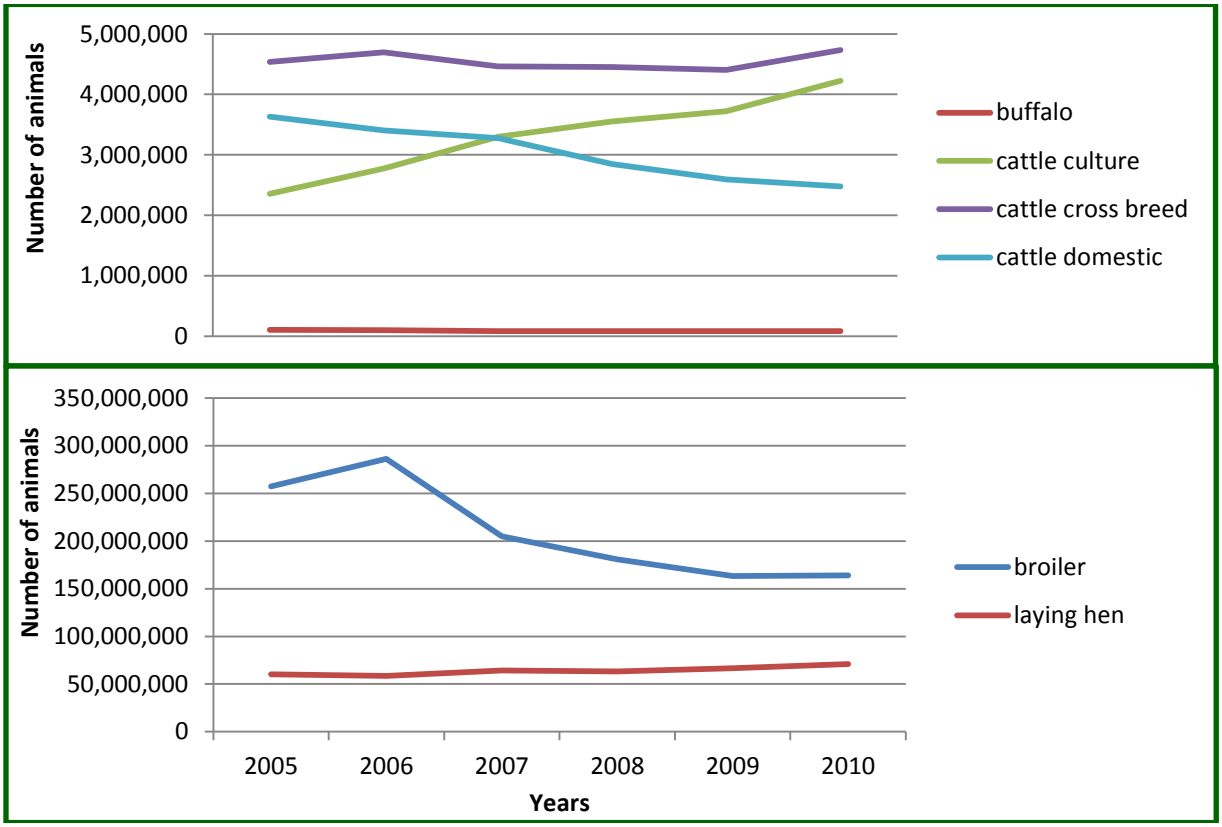

Figure 9: Development – Number of Cattles and Poultry in Turkey (2005 - 2010). Data source: [36].

During the last five years almost a 15 % decrease in buffalo population was observed (Table 11). Whilst cattle culture population increased, cattle domestic population decreased. There was a big amount of decrease in broiler population, however laying hen population increased (Figure 9).

Different amounts of manure could be obtained from different kind of animals mainly based on size and diet of animals which creates the need to use “animal units” in calculations. When the animal potential of a district is being calculated, use of animal unit is important due to existence of different kind and age of animals. For the calculation of manure for biogas facilities just the cattles (without buffalo) and the poultry (broiler chicken and laying hen) were taken into account. The amount of manure from other animals is with less importance or impossible to collect.

Table 12: Calculation of animal unit from number of animals. Data source: [63]

Kind of animal	animal unit (GVE) per animal
young Cattle < 0,5-1 years	0.3
Cattle 1-2 years	0.7
Cattle >2 years	1
Poultry	0.004

When the animal unit is considered for cattle races, north eastern part of Turkey has high potential (Figure 10). However, the cattle potential is spreaded among the country. Poultry (broiler chicken and laying hen) mostly has higher potential in the western part (Figure 11). Especially when broiler potential is considered alone, it could be seen that, the potential in the Balikesir, Izmir, Manisa, Sakarya, Corum is higher than in the other provinces (Figure 12 and Figure 13).

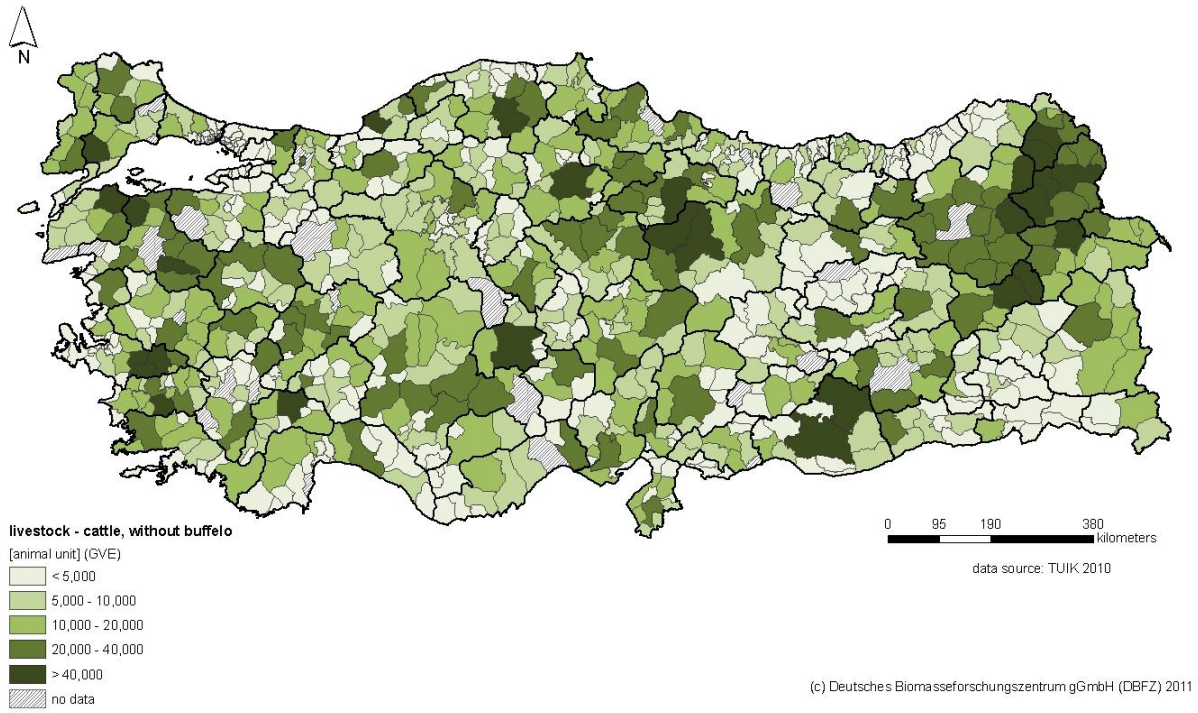

Figure 10: Livestock: cattle without buffalo potential of Turkey on district level by animal unit (Data source: [35].

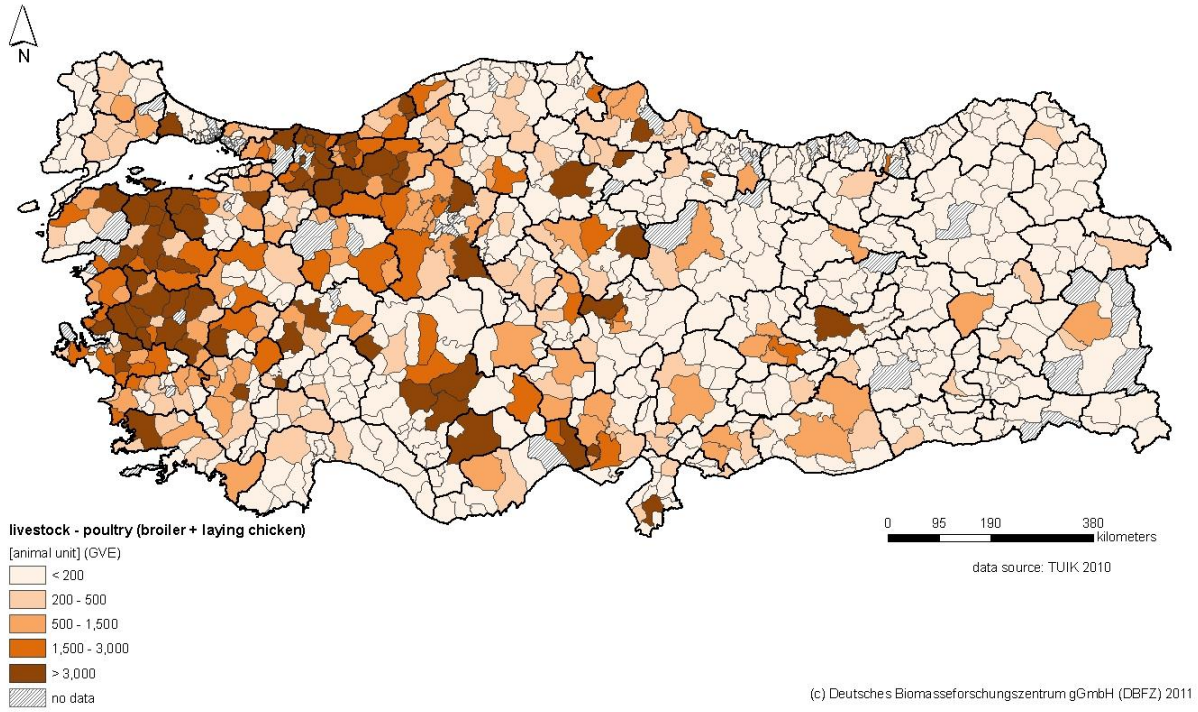

Figure 11: Livestock: poultry (broiler chicken and laying hen) potential of Turkey on district level by animal unit. Data source: [36].

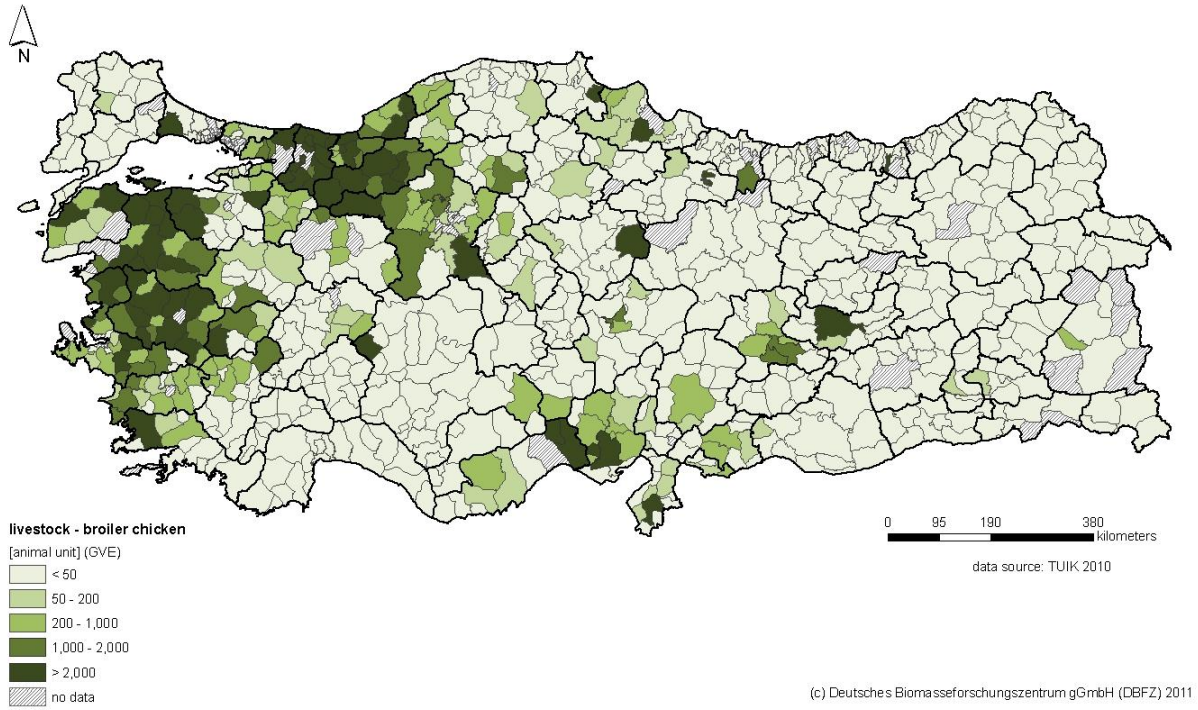

Figure 12: Livestock: broiler potential of Turkey on district level by animal unit. Data source: [36].

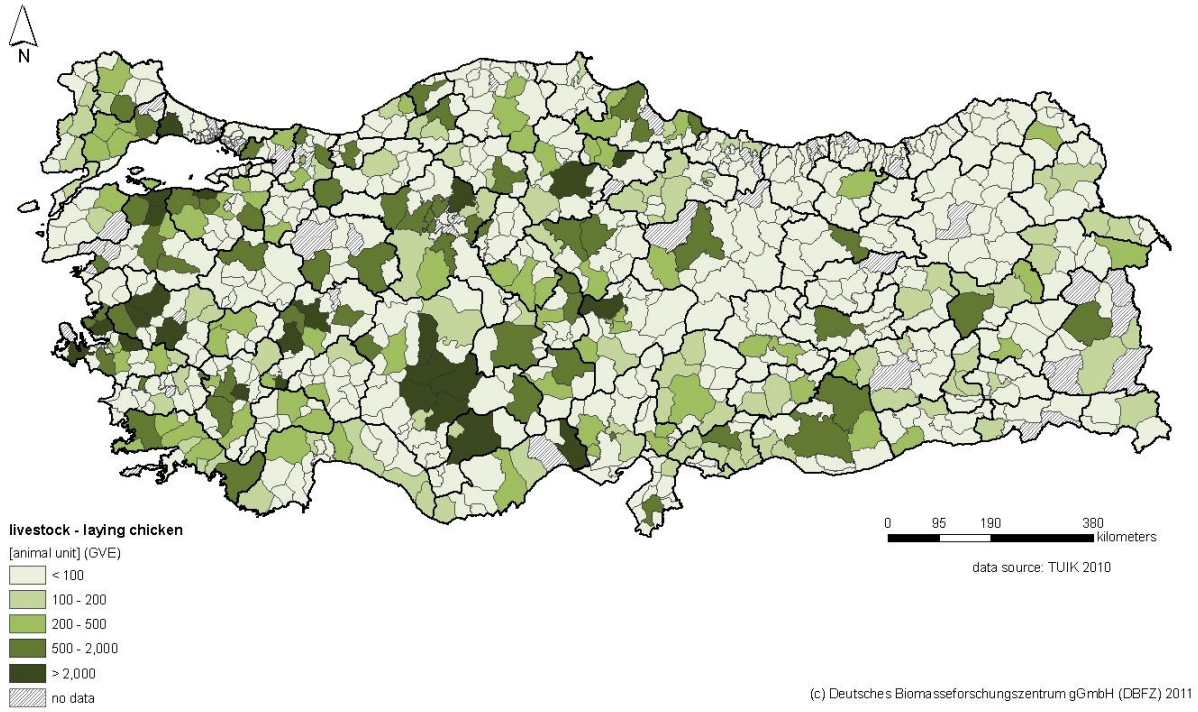

Figure 13: Livestock: laying hen potential of Turkey on district level by animal unit. Data source: [36].

Assumptions for biogas potential calculation of animal manure from bovine and poultry were done according to the information from Yaldiz 2011, Ekinci et al. 2010 and Tubitak. Theoretical biogas potential is calculated without grazing days and other utilization pathways.

Table 13: Regions of western part of Turkey. Data source: [14].

Western part of Turkey					
Marmara Region	Aegean	West Anatolia	Mediterranean	Mid Anatolia	West Black Sea
Istanbul	Izmir	Ankara	Antalya	Kirikkale	Zonguldak
Tekirdag	Aydin	Konya	Isparta	Aksaray	Karabük
Edirne	Denizli	Karaman	Burdur	Nigde	Bartin
Kirklareli	Mugla		Adana	Nevsehir	Kastamonu
Balikesir	Manisa		Mersin	Kirsehir	Cankiri
Canakkale	Afyon		Hatay	Kayseri	Sinop
Bursa	Kütahya		Kahramanmaras	Sivas	Samsun
Eskisehir	Usak		Osmaniye	Yozgat	Tokat
Bilecik					Corum
Kocaeli					Amasya
Sakarya					
Düzce					
Bolu					
Yalova					

Table 14: Regions of eastern part of Turkey. Data source: [14].

Eastern part of Turkey			
East Black Sea	North East Anatolia	Middle East Anatolia	South East Anatolia
Trabzon	Erzurum	Malatya	Gaziantep
Ordu	Erzincan	Elazig	Adiyaman
Giresun	Bayburt	Bingöl	Kilis
Rize	Agri	Tunceli	Sanliurfa
Artvin	Kars	Van	Diyarbakir
Gümüshane	Igdir	Mus	Mardin
	Ardahan	Bitlis	Batman
		Hakkari	Sirnak
			Siirt

Regarding the calculation of the technical biogas potential western and eastern part of Turkey considered differently (Table 13 and Table 14). Western part of Turkey is characterized by mostly bigger farms than in the eastern part. Animals are already placed in a barn system without grazing days. In comparison to the western part of Turkey, cattles in the eastern part is grazing outside; therefore the manure could not be collected for biogas production during the whole year. Following assumption were used for the calculation of the theoretical biogas potential:

- Bovine in the western part: manure is 100 % available
- Bovine in the eastern part: manure is 30 % available
- Poultry: 100 % is available

According to the technical biogas potential it is assumed that just 50 % of the available manure of bovine are collectable but 99 % of poultry manure according to data from Ekinci et al. 2010, Kulcu 2007, Ekinci 2011 (Table 15).

That means 50 % of cattle manure is estimated as usable in the western part; 15 % in the eastern part of Turkey (conservative approach).

Table 15: Ratios of collectable animal manure based on kind of animal. Data Source: [1, 4].

Type of animal	ratio of collectable animal manure
Dairy cattle	0.5
Beef cattle	0.5
Broiler chicken	0.99
Laying chicken	0.99

Moreover, 89 % of total cattles were assumed as adult and 11 % as calves (according to the analysis of TUIK data base of whole Turkey). Amount of manure from calves per day is accepted as a quarter of the manure amount of adult cattles per day. Different manure features were accepted for bovine pupil and bovine adult (Table 16) as well as for poultry manure based on broiler chicken and laying hen (Table 17).

Table 16: The features of bovine manure based on adult or pupil.

kind of animal	Bovine (adult)	Bovine (pupil)
kg manure/ animal *day	37.5	9.4
tons manure/ animal *year	13.7	3.4
Dry matter content %	14.5	14.5
organic Dry matter content %	77.5	77.5
Volatile solid content (VS) % related to fresh matter content	11.2	11.2
m3 CH_4/kg VS manure	0.2	0.2
m3 CH_4/kg FM manure	0.024	0.024
m3 CH_4/animal *day	0.9	0.2
m3 CH_4/animal *year	323	80.8
TJ/animal *year	0.0116	0.0029

Table 17: The features of chicken manure based on broiler chicken and laying hen.

Features	Broiler	Laying hen
kg manure/ animal *day	0.19	0.13
Volatile solid content (VS) % related to fresh matter content	20	18.75
m3 CH_4/kg VS	0.35	0.35
m3 CH_4/kg FM manure	0.07	0.066
m3 CH_4/animal* day	0.013	0.009
m3 CH_4/animal* year	4.9	3.1
Biogas potential TJ/animal* year	0.00017	0.00011

Assumptions for the amount of manure per animal/day as well as methane yields were used according to data from Ekinci et al. (2010) [14].

In Figure 14 and Figure 15 the distribution of technical biogas potential on district level that can be expected from broiler chicken manure and laying chicken manure is presented.

The total biogas potential that could be obtained from cattle and poultry manure together is illustrated in Figure 16 (theoretical biogas potential) and Figure 17 (technical biogas potential) on district level.

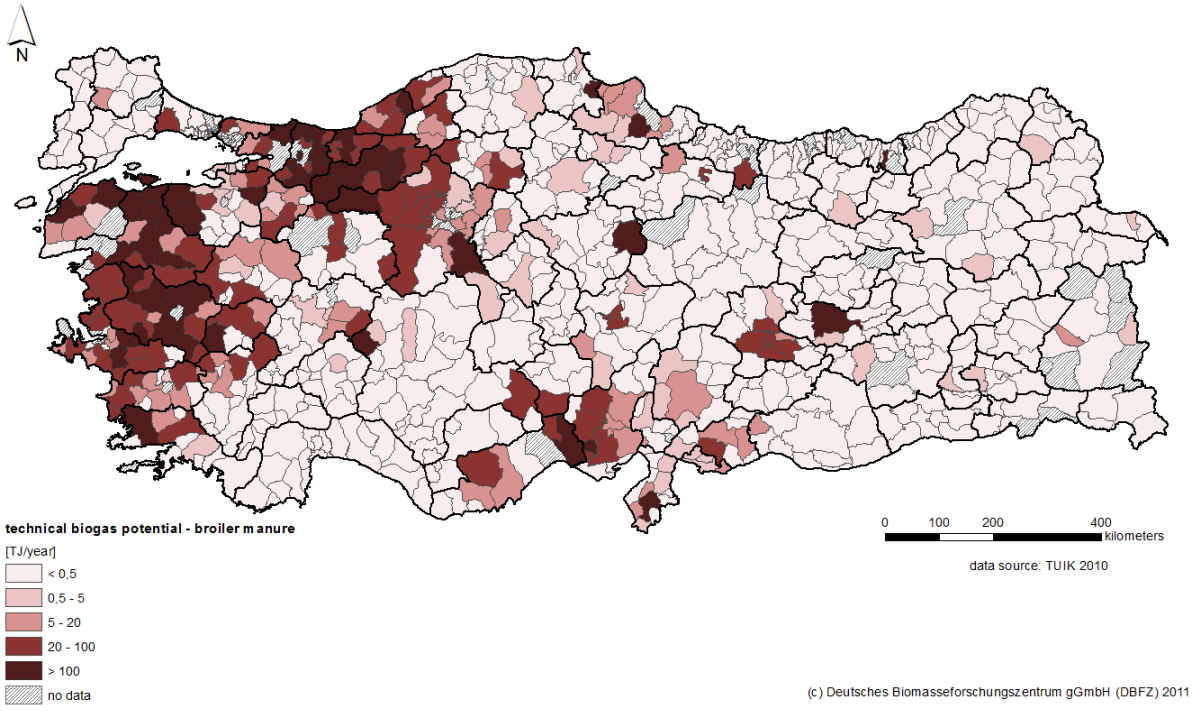

Figure 14: Technical biogas potential from broiler chicken on district level. Data source; [36]

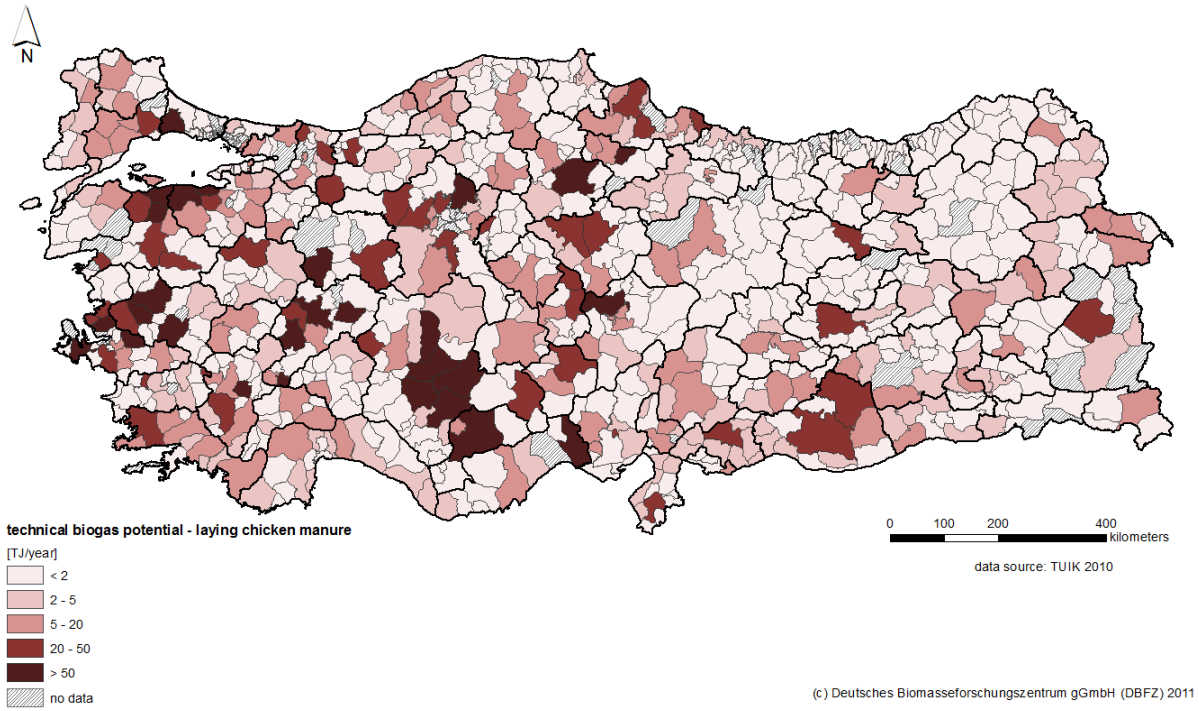

Figure 15: Technical biogas potential from laying hen on district level. Data source; [36]

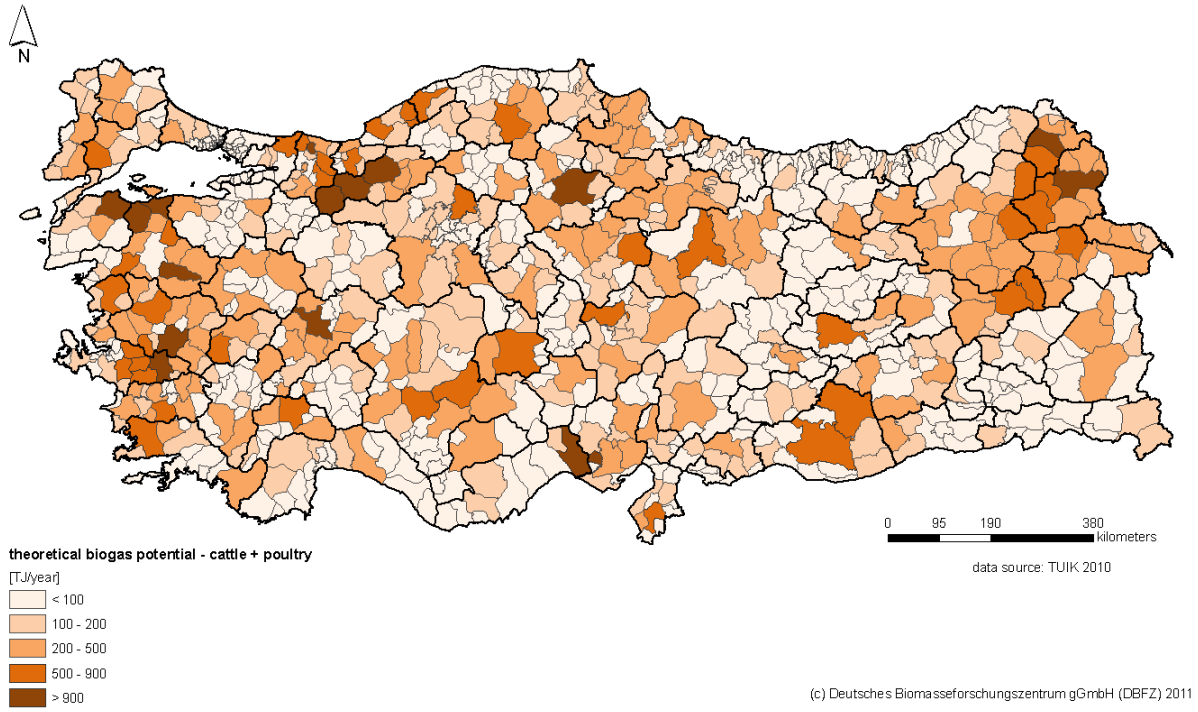

Figure 16: Theoretical biogas potential from cattle and poultry. Data source; [36].

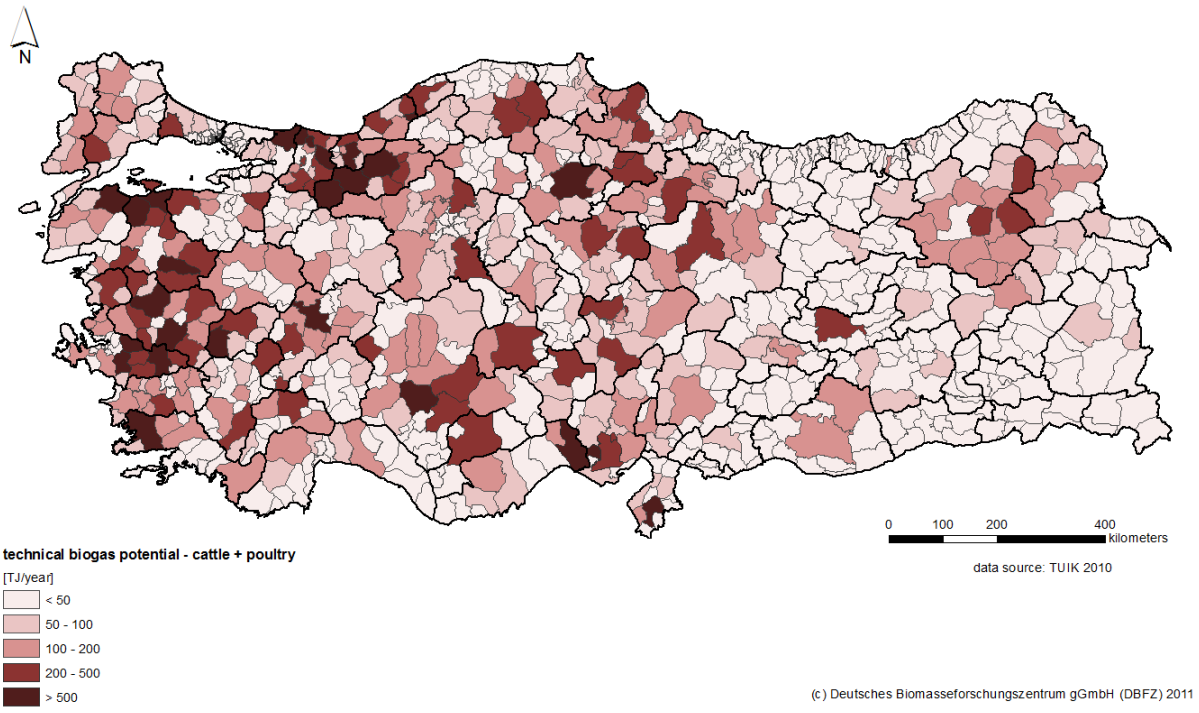

Figure 17: Technical biogas potential from cattle and poultry. Data source; [36].

In conclusion, the theoretical biogas potential that could be obtained from cattle manure was calculated as 107.8 PJ/year, and 36.6 PJ/year for poultry manure. In total, Turkey has 144.4 PJ theoretical biogas potential from poultry and cattle per year (Figure 18).

When large ruminants, small ruminants and poultry are considered together, large animals create the highest biogas potential. Moreover, the western part of Turkey has the most technical biogas potential from poultry. Poultry breeding is not developed in eastern parts.

Whilst, cattles create 76 % of theoretical biogas potential, this ratio decreases to 54 % in technical biogas potential due to differences between eastern and western part of Turkey regarding the available and collectable manure. Higher biogas potential could be obtained from broiler chicken in comparison to laying hen (Figure 19).

In total, technical biogas potential from cattle and poultry manure amounts to 78.4 PJ/year (cattle manure: 42.1 PJ/year; poultry manure: 36.2 PJ/year).

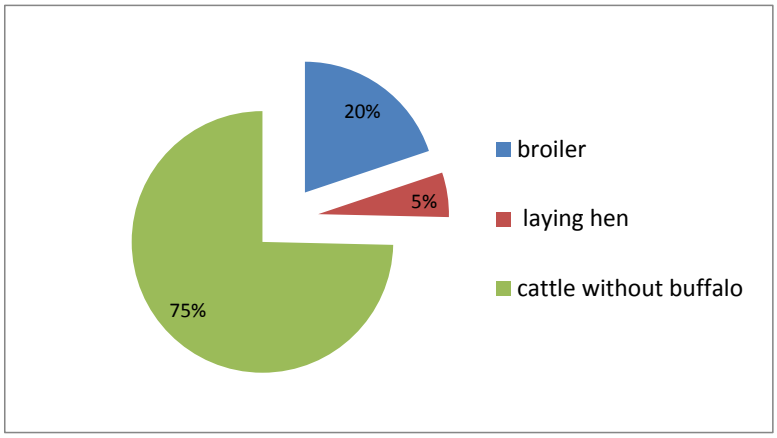

Figure 18: Theoretical biogas potential of manure based on kind of animal

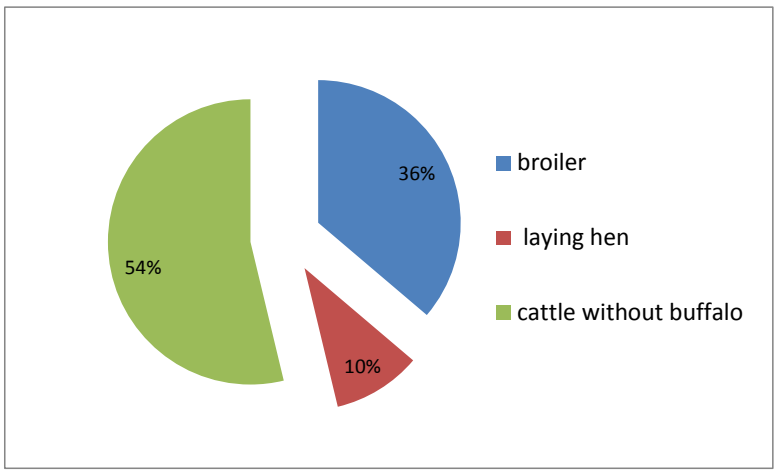

Figure 19: Technical biogas potential of manure based on kind of animal

4.3.2. Agricultural residues

Turkey's total land surface is about 78 million hectares [15]. The total agricultural area amounts to 24.4 million hectares, of which 4.25 million lay fallow [35]. The distribution of agricultural area utilization in Turkey (2010) is shown in Figure 20 and on district level in Figure 21. According to TUIK 2010 [35] 16.3 million hectares are used for cereals and other crops, 8 million hectares for vegetable production and 30.5 million hectares for fruits, beverage and spices.

During the 20th century, population pressure resulted in the expansion of farmland which resulted in deforestation and loose of good quality soil due to erosion. The cultivated area increased from about 8 million hectares in the 1920s to nearly 19 million hectares in 1952 and to almost 28 million hectares by 1991. Turkey's unusually high proportion of fallow land limits the production since 1981. At that time, the government began encouraging double cropping and the planting of feed crops on fallow fields. The government also was considering a broad land-use policy. However, reform faced with obstacles due to government inefficiency and the lack of alternative crops in areas cut off from markets, where farmers had little option but to use their land to grow grain to feed their families. Expansion of the road network, irrigation facilities, and extension services continued to offer hope for eventual improvements in land use [15].

However, getting enough water to crops is a major problem for many Turkish farmers. Rainfall tends to be relatively abundant and regular in the coastal areas because of the mountains behind them. However, the bulk of the agricultural land is on the Anatolian Plateau, which receives less rainfall because it is surrounded by mountains. Although rainfall on the plateau varies considerably among regions, it is barely adequate over large areas. Furthermore, the amount and time of rains vary sharply from year to year, causing sharp fluctuations in harvests. Deficiencies in irrigation causes a serious lag between the construction of the main parts of an irrigation system and the completion of land leveling and drainage on farms. Moreover, crop research and farmer training are inadequate to assure the planting of suitable crops to obtain maximum yields from irrigated land [15].

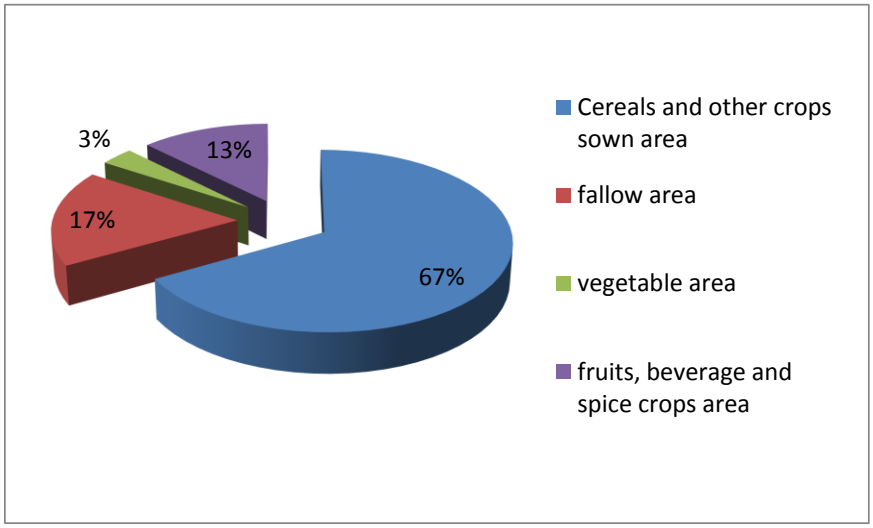

Figure 20: Distribution of agricultural area utilization in Turkey. Data source: [35].

In Turkey, agricultural land which is mostly larger in Centre anatolia are being used for cereals, fruits and vegetable productions. Distribution of the products differs from region to region due to different climatic and soil conditions (Figure 21).

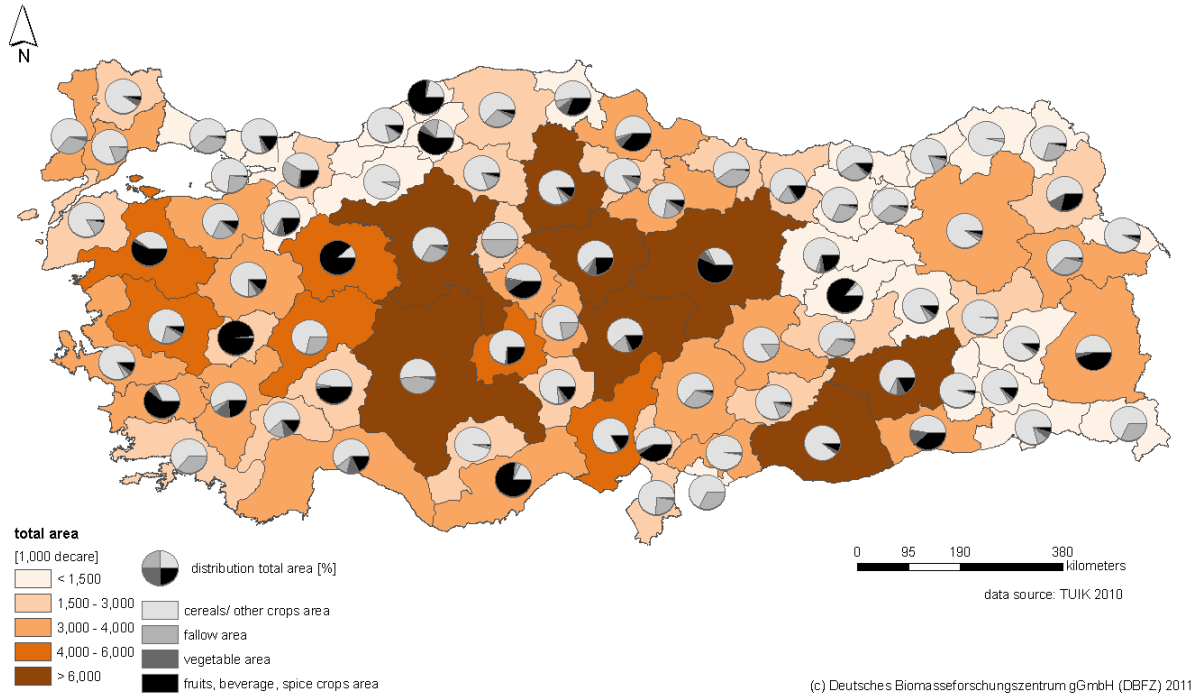

Figure 21: Distribution of total agricultural area in Turkey. Data source: [35].

Small farm size is a characteristic of Turkish agriculture (Figure 22). Unfortunately, this distribution causes the farm output to be low in comparison to the country's enormous potential. Small farms are mainly caused due to heritage issues which makes the farmers have small agricultural areas with big number of parcels (

Figure *23*). Mostly distances between these parcels are also far. Another reason of small farms is differences in elevation due to highlands characteristic of Turkish surface area.

Other problem which affects the farming is soil quality in Turkey. The soil is mostly characterised as low organic matter and high pH (acidity) which makes crops hard to benefit from trace elements [11]. Therefore there are lots of fallow land especially in the Centre Anatolia regions.

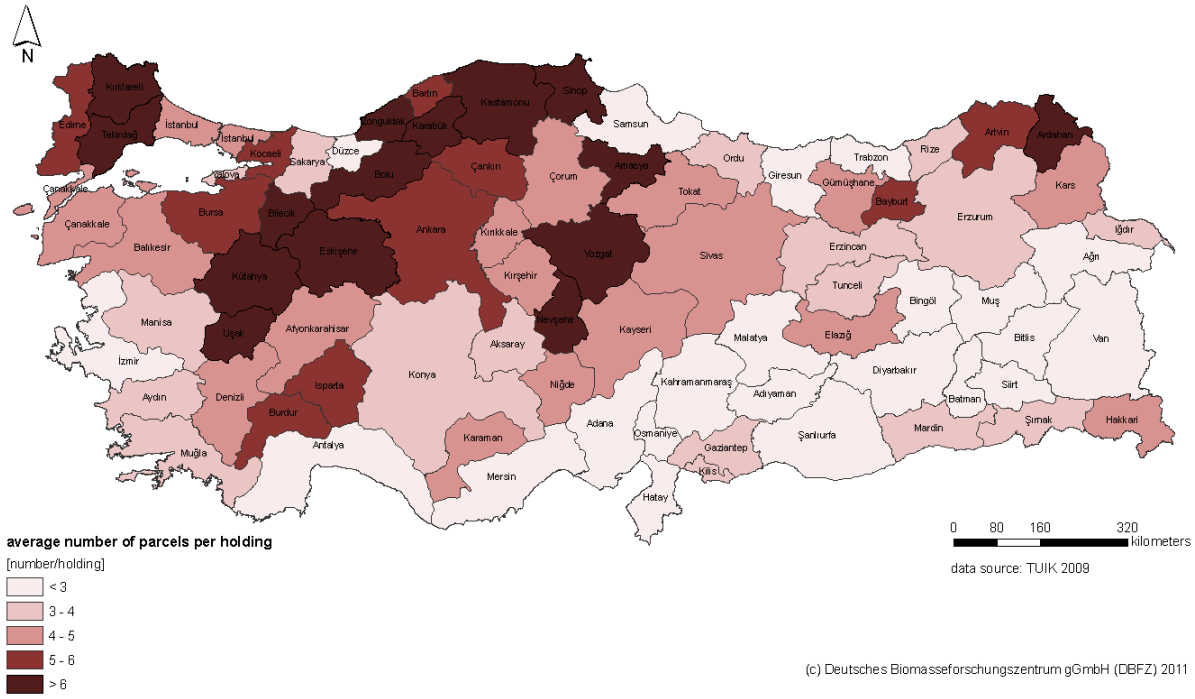

Figure 22: Distribution of average numbers of parcels per holding. Data source: [35].

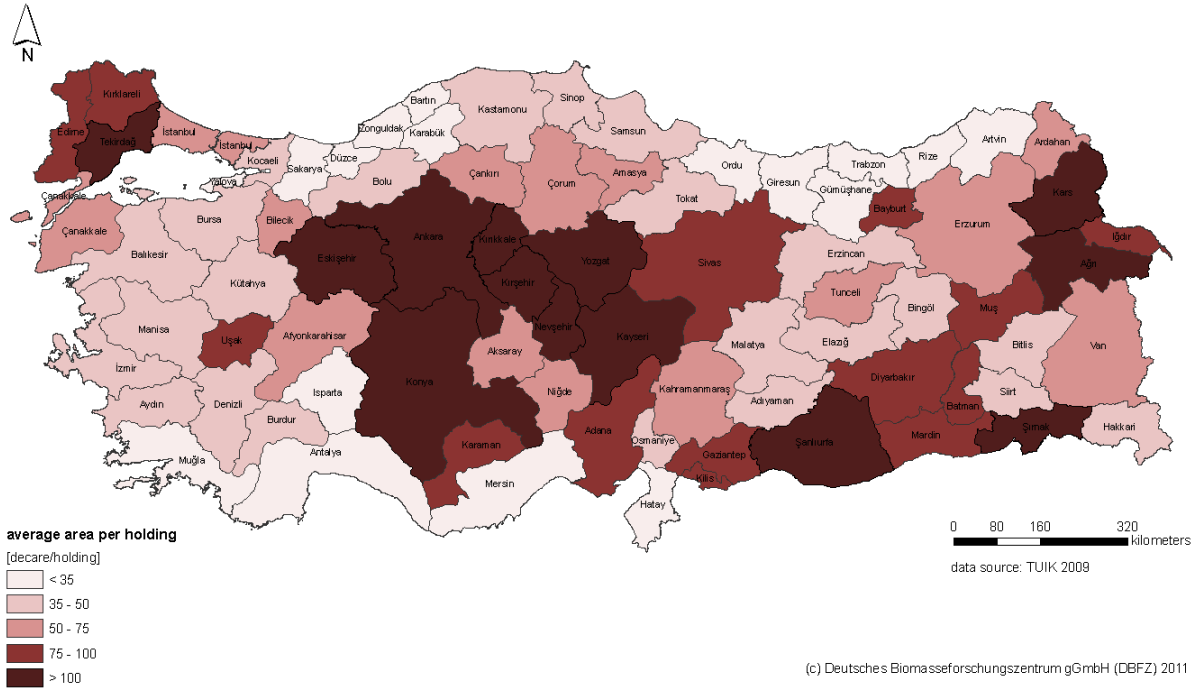

Figure 23: Distribution of average area per holding. Data source: [35].

In Figure 24 the distribution of cereals, fruits and vegetables productions in Turkey on province level is shown.

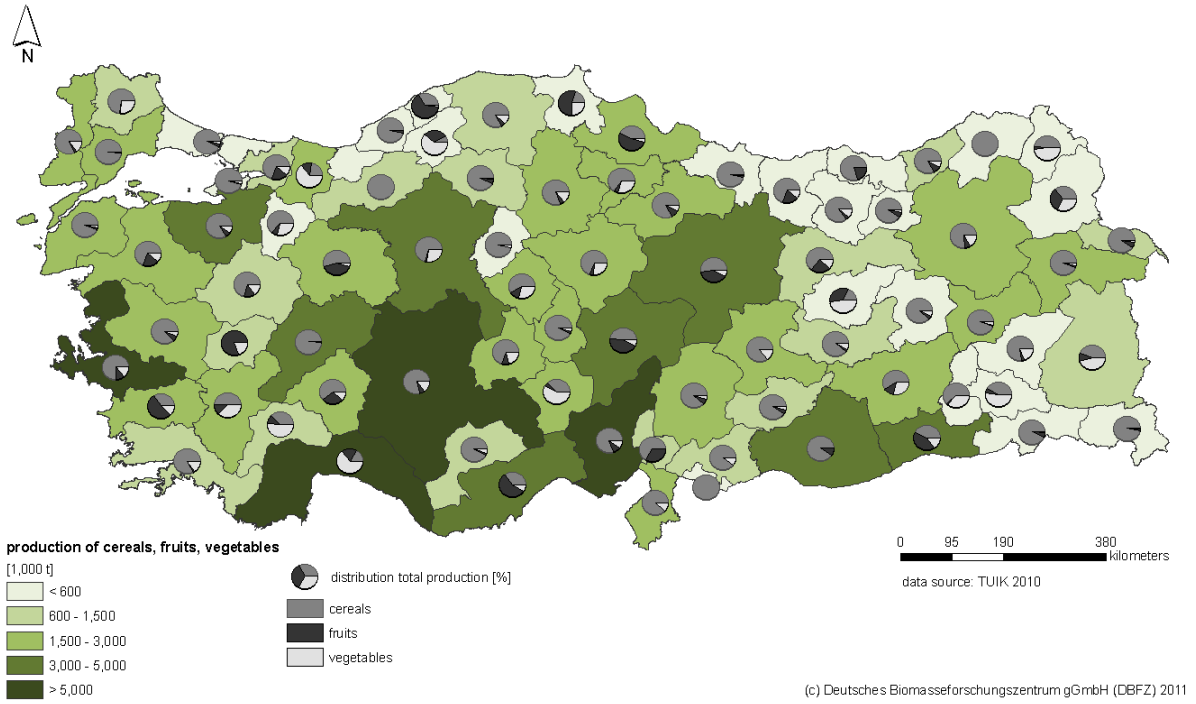

Figure 24: Distribution of cereals, fruits and vegetables productions in Turkey on province level. Data source: [35].

Agricultural residues could be divided in three categories [25]:

1. Annual crop residues that remain in the field after the crops are harvested. The main annual crops in Turkey are cereals, maize, cotton, rice, tobacco, sunflower, groundnuts, soybeans,
2. Perennial residues in Turkey that remain in the field after pruning of trees, shells, kernels etc.
3. Agro-industrial residues such as; cotton-ginning, seed oil industries, olive oil industries, rice industries, corn industries, wine and kernel factories.

Regarding the biogas potential analysis of agricultural residues, straw of cereals, tomato residues, sugar beet leaves and energy crops on fallow land were mainly focused on.

According to Mr. Yaldiz, 2011 [6] current situation regarding the agricultural residues could be summarized as below:

“After harvesting period of agricultural crops, their residues are in general stubed and stored. These waste are dried during the storage period. They are burned after 3-4 months. Mainly their fresh material must be used for biogas production. Otherwise it is necessary to produce a silage from residues of plants. After that, this silage can be used for a for biogas production the whole year. However, this method is expensive and needs large free areas, but agricultural areas are very expensive in this regions”. [6]

Moreover the availability and collectability of agricultural residues depend on several parameters (e.g. technical equipment, current utilization).

Cereal straw

In Turkey, 67 % of total agricultural area is being used for cereal production. Wheat production creates 54 % of total cereal production (Figure 20). Especially Ankara, Konya, SanliUrfa and Diyarbakir have high cereal potentials (Figure 25). Cereals provide different amount of residues. The highest residues (kg/da) could be obtained from sorghum. Cereal straw could provide a high biogas potential if suitable technology for straw (higher pre-treatment) or a combination with easy degradable substrates (e.g. sugar beet residues) were available. Moreover, a share of straw has to be left on the field because of the humus reproduction potential. This share depends on the current situation of the soil conditions in Turkey and needs further detailed information and analysis to define the realistic share of usable straw for biogas facilities. Furthermore it is necessary to know more about the current utilization pathways of straw. Currently straw in Turkey is used as fodder for animal breeding. Burning of straw is a common practice in Turkey. The practice results in loss of nutrients, atmospheric pollution and emission of greenhouse gases. Digested materials of the biogas process should be used as fertilizer. Due to this utilization the hectare yields of cereals and soil fertility could be improved and atmospheric pollution could be reduced in comparison to the current utilization where straw is used completely without return.

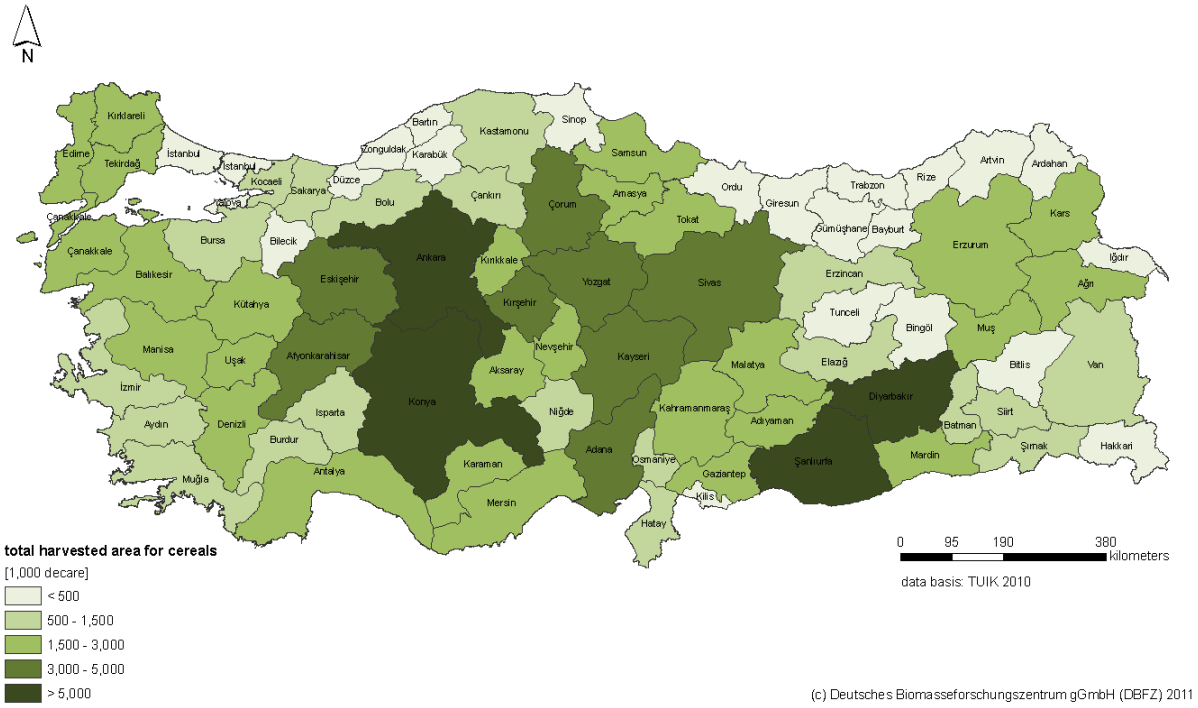

Figure 25: Distribution of total harvested area for cereals. Data source: [35].

For the calculation of biogas potential of cereal straw TUIK, 2010 data base were considered for harvested area for cereals (da) and Teknodan study (Table 18) for the residues yield (kg/da) for

different cereals in Turkey were used. The statistical data base differs between maize corn and maize silage. The calculation for cereal straw were investigated except of maize silage, because it is often used as fodder. Most of maize production is maize silage, that means the whole plant is used. Therefore just a straw potential from maize resulting from maize corn production is considered. The total amount of cereal straw in Turkey is calculated as 51.452.330 tons/year.

Table 18: Amount of residues that could be obtained from different kind of cereals. Data source: [23].

kind of cereal	residue kg/da
barley	200
wheat	325
rye	450
rice	600
maize	1480
sorghum	1975
triticale	738
oat	434

According to the harvested area of cereals in Turkey highest amount of area for cereal production could be obtained especially for wheat (>53 %) and barley (Figure 26).

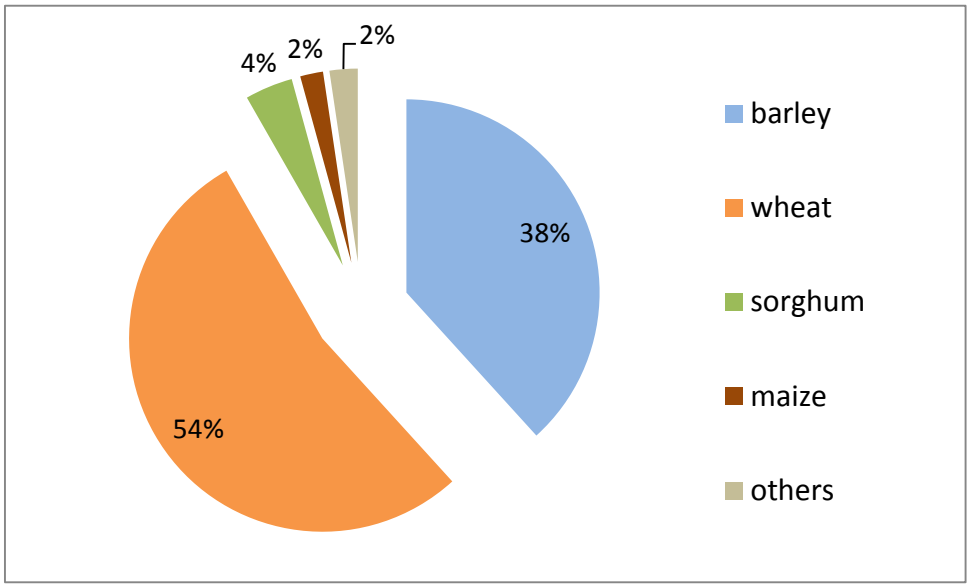

Figure 26: Distribution of harvested area of cereals in Turkey based on kind of cereals. Data source: [35].

In conclusion, the total theoretical biogas potential of cereal straw could be calculated as 276.74 PJ/year. Technical Biogas Potential of straw depends on the utilization pathways and soil

fertility in Turkey (humus reproduction). If it could be assumed that 10 % of the theoretical potential can be used for biogas according to (Kaltschmitt/Hartmann 2001) (range of 10 - 30 % for energetic use in Germany) the technical biogas potential is 27.67 PJ/year. The highest straw potential results esp. from wheat (>53%) and barley. According to Figure 22 the highest biogas potential of cereal straw is located in Ankara, Adana, Konya, Diyarbakir and Sanliurfa.

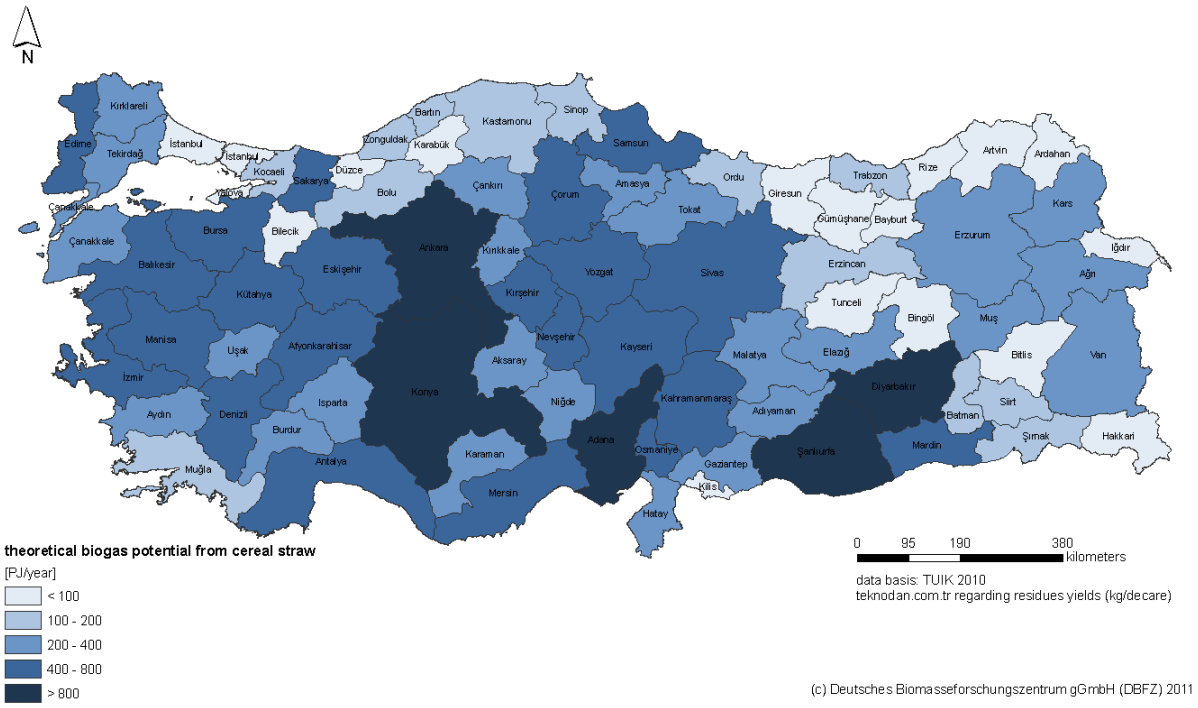

Figure 27: Theoretical biogas potential of cereal straw. Data source: [35].

To compare the results a second calculation for straw based on German ratio for corn – straw was investigated. (Appendix 14). In this case it could be stated that the amount of straw in reality is higher with respect to Turkish conditions (corn : straw- ratio). According to Yaldiz, 2011 [2] corn straw ratio for wheat in Turkey is for example 1 : 1. Based on the German ratio corn - straw 210 PJ/year (without maize for fodder just maize corn) as theoretical biogas potential of straw and 21 PJ/year as technical biogas potential (10 % of theoretical assumed) could be found.

Residues of vegetable production

In Figure 28 is shown the production of most common vegetables in Turkey. According to the produced vegetables in ton/year tomato production is of great importance (share of 40 % of total vegetable production).

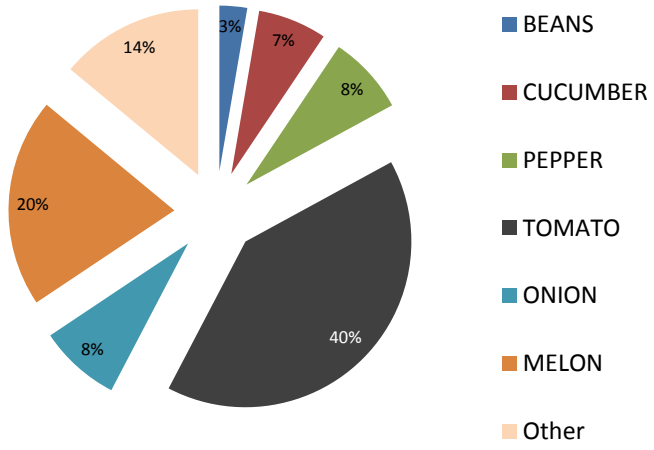

Figure 28: Production of most common vegetables of Turkey (tons/year). Data source: [35].

There is a high amount of tomato production in Turkey. Especially coastal part of Turkey has high amounts of production. Residues from tomatoes, as well as the peppers and egg plants are suitable for biogas production, however it is necessary to production of a silage from residues of these plants is necessary. Therefore a high demand of area for storage which makes it expensive should be expected [6].

Total production of tomato in Turkey is 12.9 million tons/year [35]. Tomato production differed between field and greenhouses. Mostly tomato is being produced on fields and smaller amount is in greenhouses (Figure 29). The most of tomato production are located near the coast.

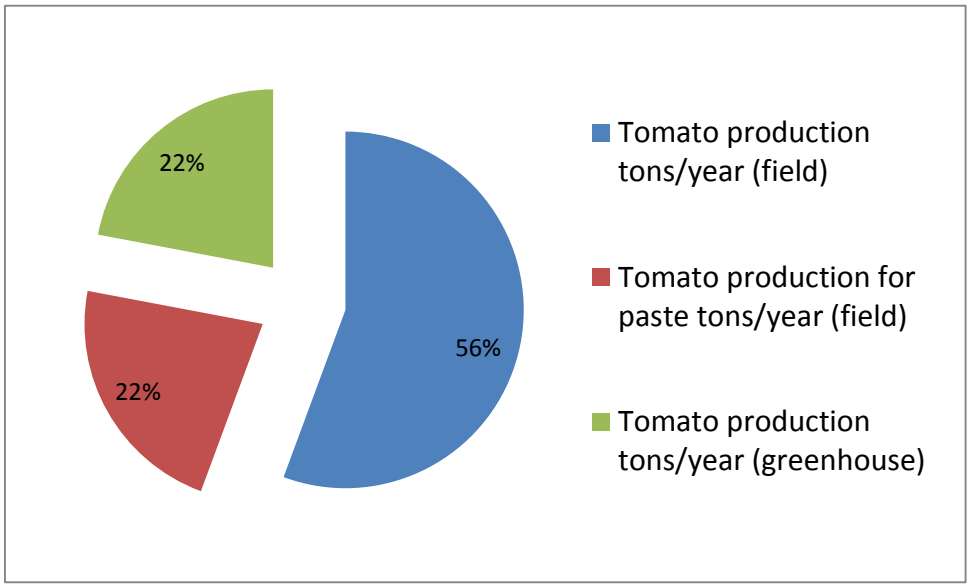

Figure 29: Production of tomato in Turkey differed to field and greenhouse production, Data Source: [35]

According to Yaldiz 2011 [2] yield of tomato waste related to greenhouse production may be assumed with 70 t/ha tomato waste and 200 t/ha tomato production. Finally the ratio tomato waste : tomato

production is 0.35. Furthermore is was assumed that the yield of greenhouse production is higher than the field production [2]. It was estimated that the amount of tomato waste refering to field production is 1/3 of greenhouse yield (70 tons/ha *1/3 = 23 tons/ha). According to data from Ulusoy et al. 2009 [62], the yield of tomato (paste) production in Bursa amounts to 52.3 tons/ha*year. Therefore a ratio tomato waste : tomato production for field production was assumed to be 0.45.

Table 19: Features of tomato waste.

	t_{FM} tomato waste/ ha *year	t_{FM} tomato prod./ ha *year	calculated ratio t tomato waste/ t tomato *year	Dry matter content %	organic Dry matter content %	m^3 CH_4/t_{oDM}	m^3 CH_4/t_{FM} tomato waste	TJ/t FM tomato waste*year
tomato waste (greenhouse)	70.0	200.0	0,35	35.0	80.0	200.0	56.0	0.00202
tomato waste (field)	23.3	52.3	0.45	35.0	80.0	200.0	56.0	0.00202

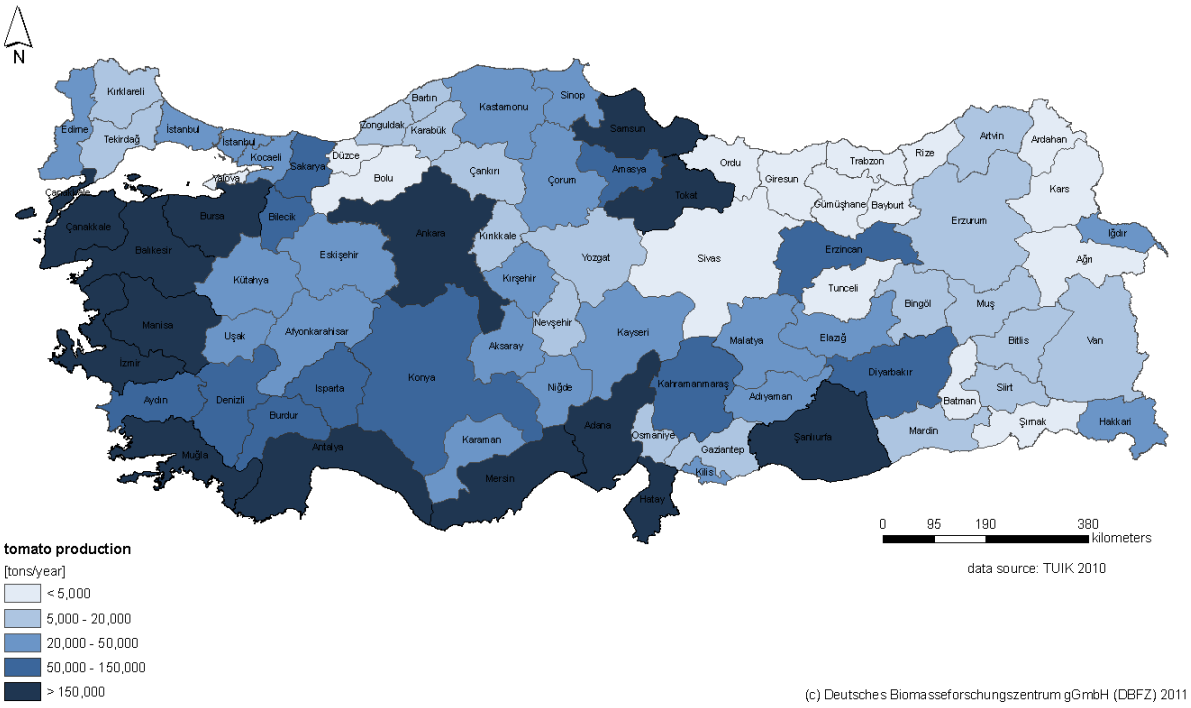

Figure 30: Distribution of tomato production (tons/year). Data base: [35].

In conclusion, the theoretical biogas potential of tomato waste amounts to 9,041 TJ/ year for field and 2,004 TJ/year for greenhouse production. For calculation of technical biogas potential it was assumed that 25 % of theoretical biogas potential resulting from field production and 90 % of the theoretical

biogas potential of greenhouse production could be used. The technical biogas potential of tomato waste amounts to 4.064 TJ/year.

Sugar beet leaf

Sugar beet productions is especially high in Konya. Residues of sugar beets are suitable for biogas production and the amount depends on technical equipment to pick them up. If the whole plant (leaves and beet) could be used, it provides positive ecological effects (reduction of greenhouse gases on field, higher biomass yield per ectare).

According to TUIK 2010 data base 3,291,669 decare were cultivated for sugar beet in Turkey. The production of sugar beet amounts to 17,942,112 tons/year. If it is assumed that the ratio beet-leaf is 0.7 the amount of sugar beet leaves is calculated as 12.559.478 tons/year.

According to the assumptions summarized in Table 20, theoretical biogas potential of sugar beet leaves could be found as 17,517 TJ/year. If estimated that 25 % of theoretical potential could be used for biogas production the technical biogas potential of sugar beet leaves could be found as 4,379 TJ/year.

Table 20: Features of sugar beet leaf. Data source: [51].

substrate	ratio beet – leaf 1:	DM %	oDM %	methane content %	methane yield [m³/ t oDM]
sugar beet leaf	0.7	16	77.5	54.5	313

Regarding the biogas potential of sugar beet leaves Konya, Aksaray, Yozgat, Kayseri could provide highest potential (Figure 31: theoretical biogas potential, Figure 32: technical biogas potential).

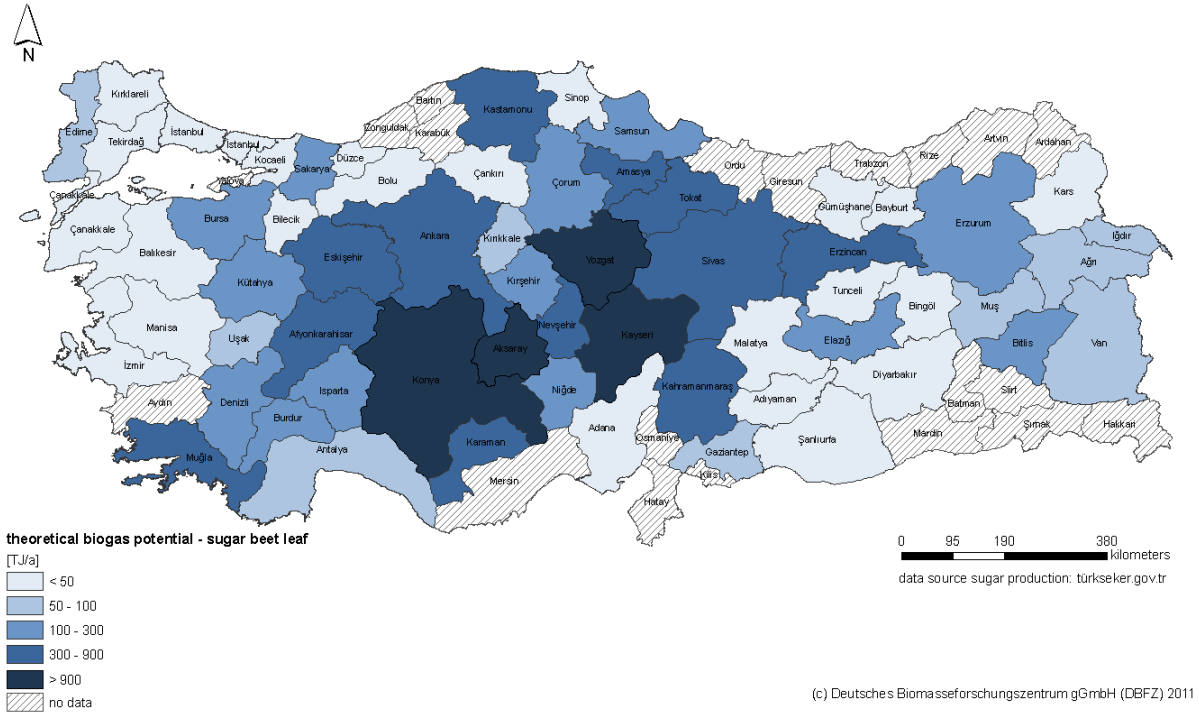

Figure 31: Theoretical biogas potential distribution of sugar beet leaves.

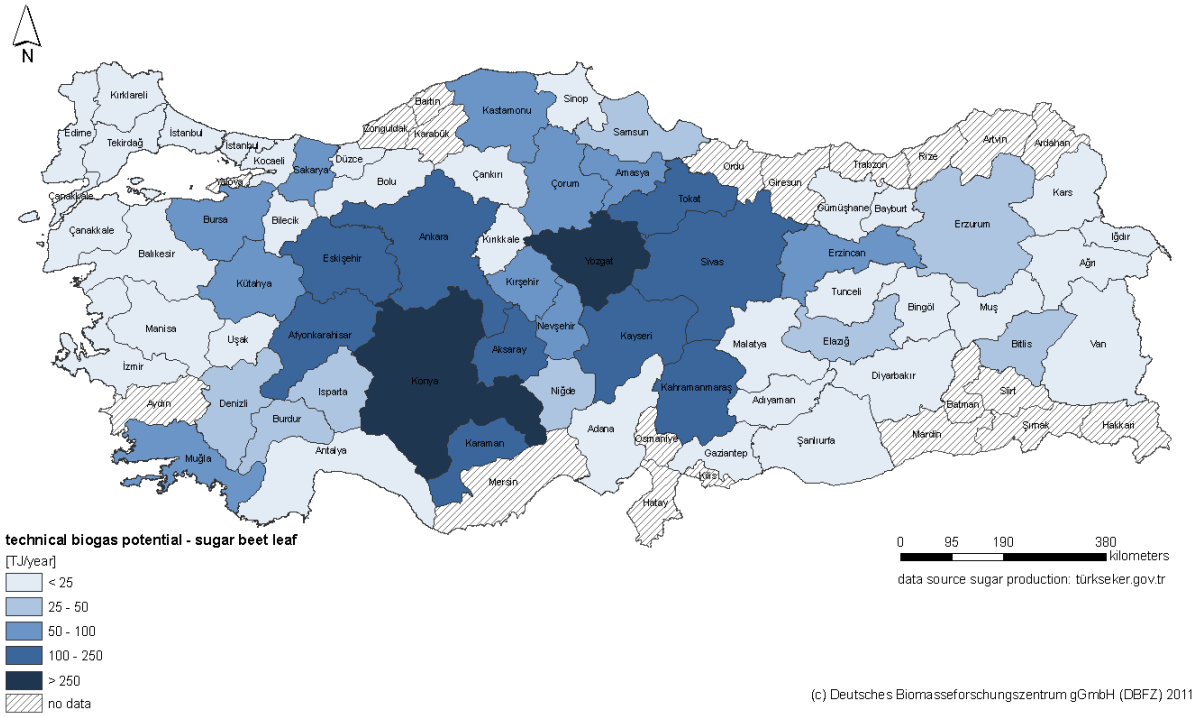

Figure 32: Technical biogas potential distribution of sugar beet leaves.

4.3.3. Energy crops on fallow land

In total, 4,249,025 ha [35] is not in use in Turkey due to irrigation problems, erosion due to deforestation, quality of the soil (high pH, low mineral content) and small size farmlands as a result of inheritance issue. Regarding to fallow land, the largest area of fallow land takes place in middle Anatolia (Figure 33).

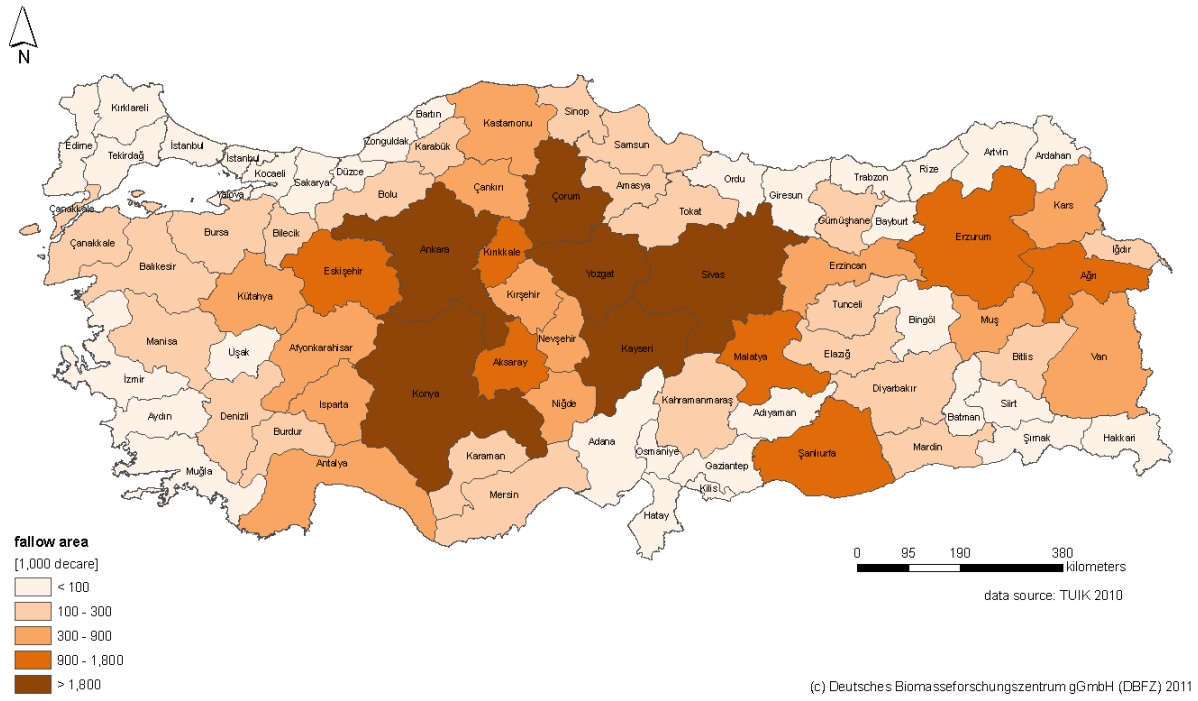

Figure 33: Distribution of fallow lands in Turkey on province level. Data source: [35].

Fallow lands in Turkey could be used for energy cropping, however, soil quality, climate conditions and seed prices are the major obstacles. Grass could be produced in any kind of soil and it helps to conserve the soil quality. Nevertheless, grass needs a higher pretreatment before using for biogas production.

The assumptions for biogas potential from energy crops on fallow land are listed below:

- Conservative approach: just grass production on fallow land (modest cropping)
- Grass: 27.1 t_{FM}/ha, 143 m^3 biogas/t_{FM}, 55 % methane content.

In conclusion, theoretical Biogas potential for 4.25 million ha fallow land could be calculated as 325.1 PJ/year. If nearly 25 % (1.06 million ha) of fallow land could be used for energy crop production (grass) a technical biogas potential equals to 81.3 PJ/year. However, it has to be considered that fodder production is more important in Turkey than using energy crops due to the demand of fodder.

Furthermore arable land could be used in order to produce energy crops, because not all arable land in Turkey is being cultivated. Furthermore some farmers are currently not able to sell their produced crops, so energy crops cultivation can be an alternative in several regions.

4.3.4. Agro-industrial residues

Turkish agro-industry mainly is based on meat, olive, sugar beet and dairy sectors. The agricultural sector employs 66 % of the population and the rural population accounts for about 35 % of the total population. One-third of the agricultural activities is in the area of livestock and there are approximately 2.5 million active business and farms [9]

Agro-industrial waste could be a serious environmental concern, if it is not properly handled. Therefore, the agro-industrial waste should be treated with the most economical and efficient technologies before being disposed into the surrounding environments. The agro-industrial waste provide different possible biogas yields. Anaerobic systems offer such an option for the safe treatment of agro-industrial wastewaters, mainly due to their special advantages such as lower energy requirement, less waste biomass generation, a useful and economically valuable end-product (methane/ biogas), suitability for seasonal operations and the elevated organic loading rates achievable. Thus, anaerobic treatment is an attractive option for agroindustrial waste that is seasonally produced, has a high organic content and the potential toxicity problems [55]. All the residues have different methane yield potentials and methane ratios.

Regarding to biogas potential of agroindustrial sector, cheese waste water, slaughterhouse residues, sugar beet press cake, molasses, olive press cake, olive mill waste water, juice residues and draff from bioethanol production were taken into account.

Residues of sugar beet factories

There are 33 sugar factories, 25 of them are governmental and 9 of them are privatized [64]. All the factories are using their waste water to cover their energy demand [2]. When 25 governmental sugar beet factories are considered their capacity, amount of molasses and pulp/press cakes can be expected as follows:

- Total amount of capacity of sugar production: 106,657 tons/day
- Total amount of molasses: 394,250 tons/year
- Total amount of pulp/press cake: 2,778,544 tons/year

Table 21: The features of molasses and beet press cake. Data source: [51].

substrate	DM	oDM	biogas yield	biogas yield	methane content	methane yield
	%	%	[m³/ t FM]	[m³/ t oDM]	%	[m³/ t oDM]
molasses	85	87.5	316	425	72.5	308
beet press cake	24	95	68.4	300	72.5	218

According to features of molasses and beet press cake which are given in the Table 21, theoretical biogas potential could be calculated as below:

- Molasses: 3,253 TJ/year = 3.25 PJ/year
- Sugar beet press cake: 4,960 TJ/year = 4.96 PJ/year

In total (press cake and molasses) the theoretical biogas potential amounts to 8.21 PJ/year. It is assumed that both (press cake and molasses) is already used as fodder.

Residues of bioethanol production

Regarding bioethanol, there are 3 bioethanol plants in Turkey (2 in operation, 1 in trail) (Bursa, Konya, Adana). Total capacity of these plants is 150.000 m^3/year (Table 22). Draff as residue of bioethanol production could be used for biogas production.

Table 22: Bioethanol plants in Turkey.

Province	District	Name of company	Production Capacity m^3/year	Feedstock	status
Konya	Meram	KONYA SEKER	84,000	suger beets	in operation
Bursa	Mustafakemalpasa	TARKIM	40,000	suger beets	in operation
Adana	unknown	TEZKIM	26,000	suger beets	in trial

The ratio between draff: bioethanol was assumed as 9 : 1 [52], methane yields were considered according to FNR 2010 (Leitfaden Biogas [68], potato draff). According to assumptions (Table 23) total amount of draff was found as 1,350,000 t/year. Theoretical Biogas potential of draff was calculated as 874.8 TJ/year = 0.87 PJ/year. Technical biogas potential of draff amounts to 0.79 PJ/year if assumed that the plants are 90 % of the year in operation.

Table 23: Parameters of draff from bioethanol production. Data source: [51].

substrate	ratio draff: bioethanol prod.	DM	oDM	biogas yield	methane yield	methane content
		%	%	[m^3/ t FM]	[m^3/ t FM]	%
draff (bioethanol production)	9 : 1	6	85	34	18	52.9

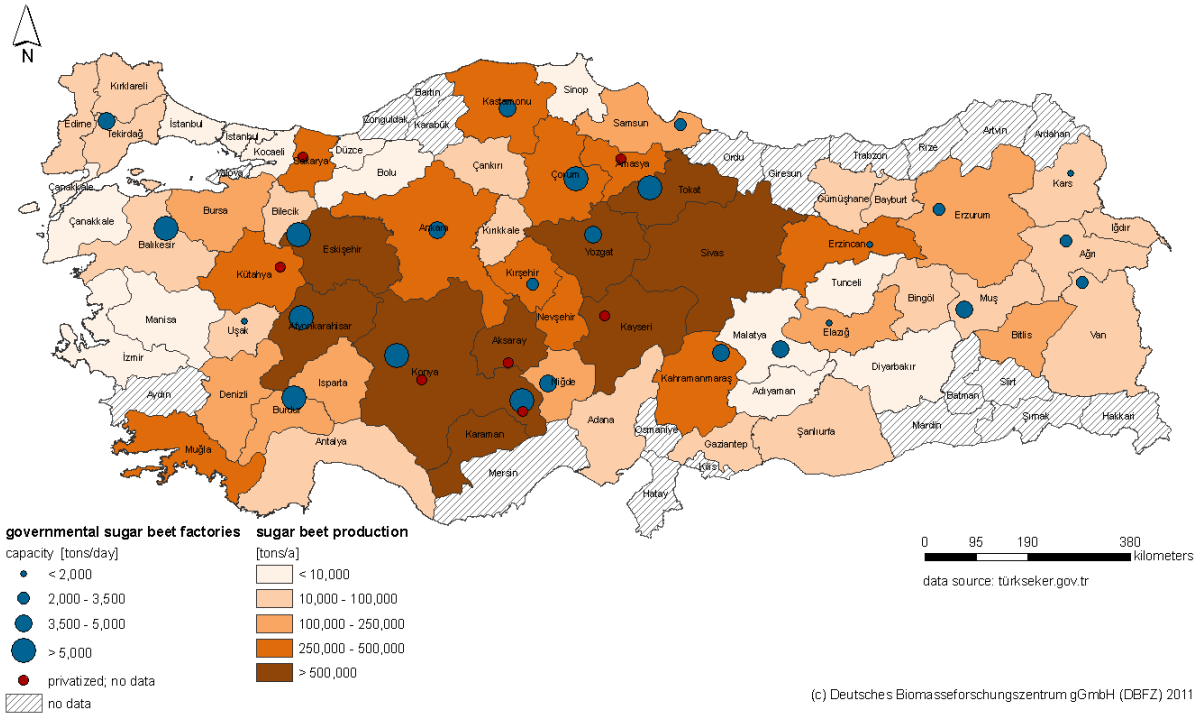

Figure 34: Distribution of sugar beet factories. Data source: [48].

Residues of fruit production

In Figure 35 the production of most common fruits in Turkey is shown. According to the produced fruits in tons/year olive production with a share of 27 % of total fruits production and nut production (24 %) are important.

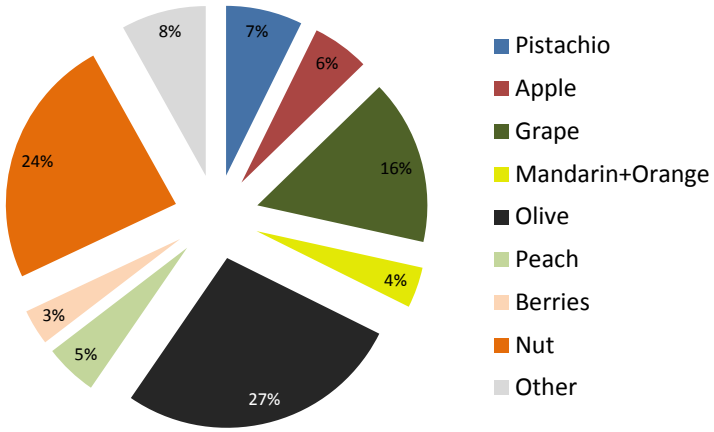

Figure 35: Production of most common fruits of Turkey (tons/year). Data source: [35]

There are high amount of olive and nut productions in Turkey (Figure 28). Whilst residues from olive oil production (press cake) are suitable for biogas production, nut residues are better for thermo-chemical conversion.

Residues of olive production

Turkey is among the most important olive and olive oil producer countries after Spain, Italy and Greece. Olive-oil mills are small agro-industrial units located mainly around the Mediterranean, Aegean and Marmara seas and account for approximately 95 % of the worldwide olive-oil production. More than 70 % of the total olive production is in Turkey for the oil mill processing. In Turkey there are around 900 olive oil mills and most of them small sized.

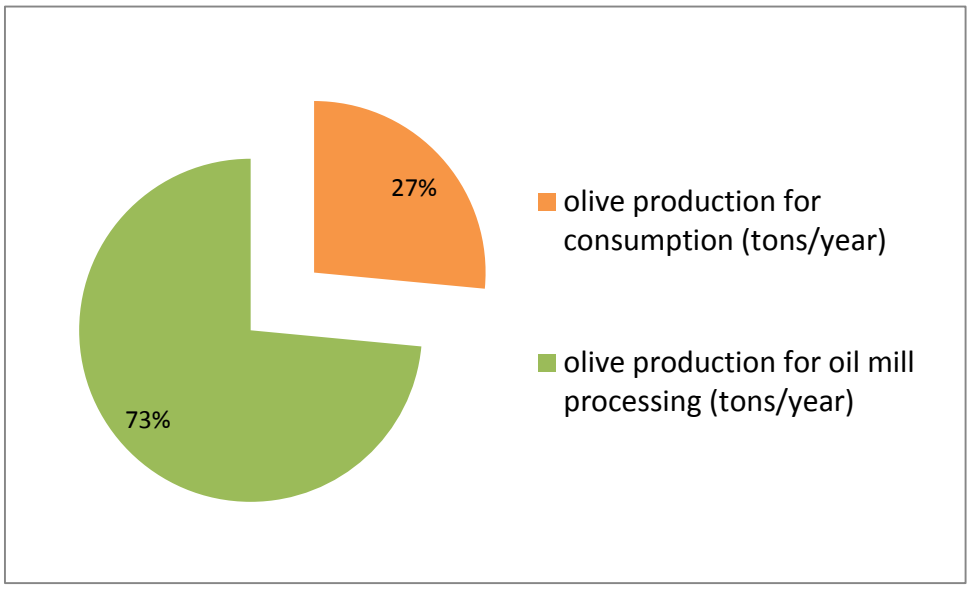

Figure 36: Olive production based on its utilization. Data base: [35].

According to TUIK, 2010 there are 1,040,000 tons/year olive production for oil mill processing. They process olives for the extraction of oil either by means of a discontinuous press (classical process), or a solid/liquid centrifuge (centrifugal process). Both processes produce two different forms of waste, namely, olive mill residual solids (OMRS or prina) which contain oil that must be recovered by solvent extraction, and olive mill wastewater (OMWW or black water). Olive-oil mill waste is a significant source of potential or existing environmental pollution. A few amounts of olive press cake is being used for heating and the rest is just being dumped into empty areas. Olive oil mill waste water is a big environmental threat due to especially seasonal production. It is trying to be treated and there is no any other utilization way [20]. The treatment difficulties of olive-oil mill effluents are mainly related with

a) high organic loading;

b) seasonal operation;

c) high territorial scattering;

d) the presence of organic compounds which are hard to biodegrade such as long-chain fatty acids and phenolic compounds.

The processing of olive (extraction of olive oil) is carried out by means of a discontinuous process press (classical process) or a solid/liquid centrifuge (continuous process) [8] (Table 24).

1.Discontinous Process (Press)

2.Continous Process (centrifugal Process) :

i) 2-phase (no OME)

ii) 3-phase (OME is generated)

Table 24: Comparative data for the three olive oil extraction processes. Data source: [8].

Production process	Input	Amount of input	output	Amount of output
Traditional pressing process	Olives	1,000 kg	Oil	c. 200 kg
	Washing water	0.1-0.12 m3	Solid waste (c. 25 % water+ 6 % oil)	c. 400 kg
	Energy	40-63 KWh	Waste water (c.88 % water)	c. 600 kg
Three phase decanter	Olives	1,000 kg	Oil	c. 200 kg
	Washing water	0.1-0.12 m3	Solid waste (c. 50 % water+ 4 % oil)	c. 500-600 kg
	Fresh water for decanter	0.5-1 m3	Waste water (c.94 % water +1 % oil)	c. 1,000-1,200 kg
	Water to polish to impure oil	c. 10 kg		
	Energy	90-117 KWh		
Two phase decanter	Olives	1,000 kg	Oil	200 kg
	Washing water	0.1-0.12 m3	Solid waste (c. 60 % water+ 3 % oil)	900-950 kg
	Energy	<90-117 KWh		

According to the data from the ministry of industry, 2011: when 5kg olives are being used, 1kg oil and 2 kg oil press cake could be obtained.

It was assumed, that 1 kg olive could produce 0.4 kg press cake (Table 24) [8]. Finally, the amount of olive press cake could be calculated as 416,000 tons per year.

The range of biogas yield of olive press cake is very broad. The content of oil within the press cake depends on the oil mill processing technology. The press cake as well as the oil mill waste water (OMWW) contain phenol (carbolic acid) which can influence the biogas process negative.

Gas yields of olive press cake were found based on the results of DBFZ-Laboratory (Table 25), where some samples of press cake from Turkey were analyzed (with and without kernel). Refering to the results, sample 1 (press cake with kernel and pulp) produced the highest amount of methane. The lowest amount of methane results from sample 3 where just the kernel were analyzed.

Methane yield of olive press cake based on the lab-test (Turkish sample) amounts to 89 m^3/t_{FM}. Total amount of methane from press cake results with 37,026,736 m^3. In conclusion, theoretical biogas potential of olive press cake could be calculated as 1,333 TJ/year (= 1.33 PJ/year). If assumed that 90 % of theoretical potential of olive press cake might be used, technical biogas potential amounts to 1.2 PJ/year.

Table 25: Features of olive samples from DBFZ laboratory.

Sample name	Biogas yield [l_N/kg_{oTS}]	DM [%]	oDM [%]	Methane content [%]	Methane yield [m^3/t_{FM}]
1. Olive press cake	203	93.13	94.16	50	89.0
2. Olive press cake (just pulp)	104	87.47	86.88	50	39.5
3. Olive press cake (just kernel)	49	89.89	97.43	50	21.5

Waste water from olive oil mill consists of high amount of organic content, high polyphenol content and has acidic nature. Therefore it causes environmental problems (e.g. pollution of surface and groundwater, phytotoxicity).

Co-digestion of olive oil mill waste water could be suitable for biogas production, however, attention should be paid on polyphenols.

Assumption of Olive-oil mill waste water (OMWW):

- According to Azbar, 2011 when traditional pressing methods applied: 1 kg olive creates 0.4 kg press cake (25 % water), 0.2 kg oil and 0.6 kg waste water (88 % water)
- Methane yield of waste water is assumed with 57.5L CH4/L [55].

According to calculations there are 624,000 tons of olive oil mill waste water per year. Methane amount of waste water in case of anaerobic digestion amounts 35,880,000 m^3 per year (assumption - density waste water: 1 kg/l). Theoretical biogas potential of olive mill waste water could be calculated as 1,292 TJ/year (= 1.29 PJ/year). If assumed that 90% of theoretical potential of olive mill waste water could be used, technical biogas potential amounts 1.2 PJ/year.

Residues of juice production

Pomace is a residues of juice production and can be used for biogas production. The amount of processed fruit and vegetable for juice production in Turkey was estimated as 771,100 tons in 2008 [66] (Table 26).

Table 26: Amount of processed fruit and vegetable for juice production 2005 - 2008 (in 1000 tons), Data source: [66].

kind of fruit	2005	2006	2007	2008
sourcherry	37,1	52,2	72,6	54,6
apricot	30,8	36,1	38,2	74,9
peach	75,9	65,3	90,1	118,8
apple	409,2	282,9	356,8	333,8
orange	33,1	37,8	53,3	63,9
pomegranate	17,6	46,6	57,5	49,5
carrot			30,6	30,7
grape	10,9	8,4	18,3	16,9
strawberry			4,1	7,7
grapefruit				5,5
quince			7,5	4,5
tomato	4,6	4,9	3,9	4,4
lemon				2,7
others	10,2	47,9	4,3	3,2
TOTAL	**629,4**	**582,1**	**737,2**	**771,1**

According to (Ruiz Fuertes 2009) [69] citrus fruits waste is a suitable substrate for anaerobic digestion due to its high carbohydrates content. Nevertheless it is expected that essential oils present in citrus peel are known to inhibit anaerobic digestion. In citrus waste limonene – an essential oil – is present at higher concentration. Thus, a special pre-treatment of citrus waste (e.g. biological pre-treatment with Penicillium, steam distillation or liquid extraction) are necessary to reduce or eliminate limonene within citrus waste and improve biogas production [69]. Citrus fruits like orange, grapefruit and lemon deliver with 72,100 tons around 9 % of total fruit and vegetable for juice production in 2008 (Table 26).

According to (Mustafa, 2009) the amount of pomace was calculated: when 100 kg citrus fruits are used for juice production the amount of pomace is 62 - 65 % [66].

For the calculation was estimated, that 65 % pomace of total processed fruit and vegetables resulting from juice production in Turkey can be expected. Therefore the amount of processed pomace in 2008 results with 501.215 tons. According to (FNR Leitfaden Biogas 2010) [68] substrates features refering fruit pomace were estimated (Table 27).

Table 27: Features of fruit pomace, Data source: [68]

substrate	ratio fruit : pomace	DM	oDM	biogas yield	methane yield	methane contenct
		%	%	[m^3/ t_{FM}]	[m^3/ t_{FM}]	%
fruit pomace	0,65	35	88	148	100	68

The theoretical biogas potential of pomace resulting from fruit and vegetable juice production amounts to 1.80 PJ/year. İt is stated that 90 % of total theoretical biogas potential of pomace can be expected as technical biogas potential and also citrus waste with pre-treatments can be used for biogas production. Finally, 1.62 PJ/year as amount of technical biogas potential of pomace can be assumed. Nevertheless, biogas lab-tests of pomace resulting from citrus fruits are necessary to observe the estimated biogas yields as well as the effects of different pre-treatments.

Meat production / Slaughtering

The livestock sector has a high potential and is a vital part of the agricultural sector and economy. The livestock products play a significant role in the Turkish economy and especially in the sustainability of rural families. In regions where agriculture is limited because of land shape or boundaries of land and high number of population, households make their living with animals, especially in Eastern and South Eastern Anatolia. However, in these regions, the production results are low compared to EU countries due to mostly used traditional techniques. Within technological developments, new techniques in husbandry and housing system and relevant subsidies resulted in long-term incline for red meat and poultry meat industry during the last years [9].

Fodder planting is limited and pasture is not properly managed. Most pasture areas in Anatolia are in poor condition or already invaded by squatters. Most animals are fed with a high portion of straw in the diet, which restricts growth rates especially for high genetic value imported animals. Animal welfare conditions are primitive and unhealthy in traditional barns. There is some progress observed in barn management especially in western parts of Turkey where big farms are developing. The cattle breeds, mainly indigenous breeds, Holstein and some Brown Swiss, are not appropriate for high quality beef production. The small-scale farmer does not have the knowledge or resources to increase production in response to growing demand for red meat. Usually Holstein males are the main source of beef production [18].

The government announced a new support program which targets East and South East Anatolia of Turkey in 2010. For this purpose a total budget of 20 million TL was allocated for the East Anatolia Region and 40 million TL for the South East Anatolia region, to support new establishments with more than 50 head of animals between 2010 and 2012 [18].

Media attention to the livestock sector has increased due to the avian influenza outbreak which caused a huge decline in the number of broiler chicken. The numbers of cattle, buffalo, sheep and goats have slight increase since 2005. Whilst the cattle population has been increasing, buffalo population has declined. However, Turkey has high net rates of population growth which causes a challenge in providing an adequate and balanced diet for the population over the last 60 years due to facing a decrease in cattle numbers, sheep and goat herds, and in production of beef [18].

It is estimated that approximately 40 % of the livestock slaughtering in Turkey is not registered or controlled (in slaughterhouses, in farms, in butcher shops). Uncontrolled slaughter is permitted only for home consumption. The annual Kurban Bayrami (Sacrifice Fest) holiday in Turkey, which is not controlled by public health authorities, concerns 40 % of sheep (1,000,000) slaughtered in a period of two to three days. The capacity of the slaughterhouses is too small to accommodate this level of

slaughter, so temporary premises are organized in large cities, and many people also slaughter animals in their backyards. Besides this festival, in rural areas there is a lot of unregistered slaughtering throughout the year. This is partly due to a custom called 'adak' which is a sacrificial offering that is distributed to the needy and is believed to help wishes come true [21].

Table 28: Number of slaughterhouses/ Meat plants in Turkey. Data source: [18].

	Number	Average capacity for cattle slaughtering
Private slaughterhouse	210	
Public slaughterhouses	445	
Total Meat Plants	**655**	
Private slaughterhouse Class 1	191	86
Private slaughterhouse Class 2	19	18
Private slaughterhouse Class 3	0	0
Public Slaughterhouse Class 1	5	42
Public Slaughterhouse Class 2	0	0
Public Slaughterhouse Class 3	440	4

According to Red Meat sector report 2006 meat plants are divided into 3 Categories, originally classified as follows:

- Class 1: >40 bovine animals/day and cold storage facility (33 % of the total, mostly private)
- Class 2: from 21 to 40 bovine animals/day; (4 % of the total number mostly public)
- Class 3: <20 bovine animals/day; (63 % of the total number, mostly public).

A new regulation has entered into force stating that categories of meat cutting and processing plants have been changed as follows:

- Class 1: No minimum and maximum cutting limits, but determined by hygiene conditions of the slaughterhouses, the capacity of cold storage and capacity of the waiting rooms for the animals.
- Class 2: up to 90 cutting units per day.
- Class 3: up to 40 cutting units per day.

The registered processing operations are located in the denser poultry populated provinces. There are 383 registered slaughtered houses named by the General Directorate of Protection and Control taken from their website [17].

Figure 37 shows the meat production capacity in Turkey according to data base of Ministry of Industry 2011. The highest capacity of meat production is located in western part of Turkey – especially in Izmir, Canakkale and Sakarya.

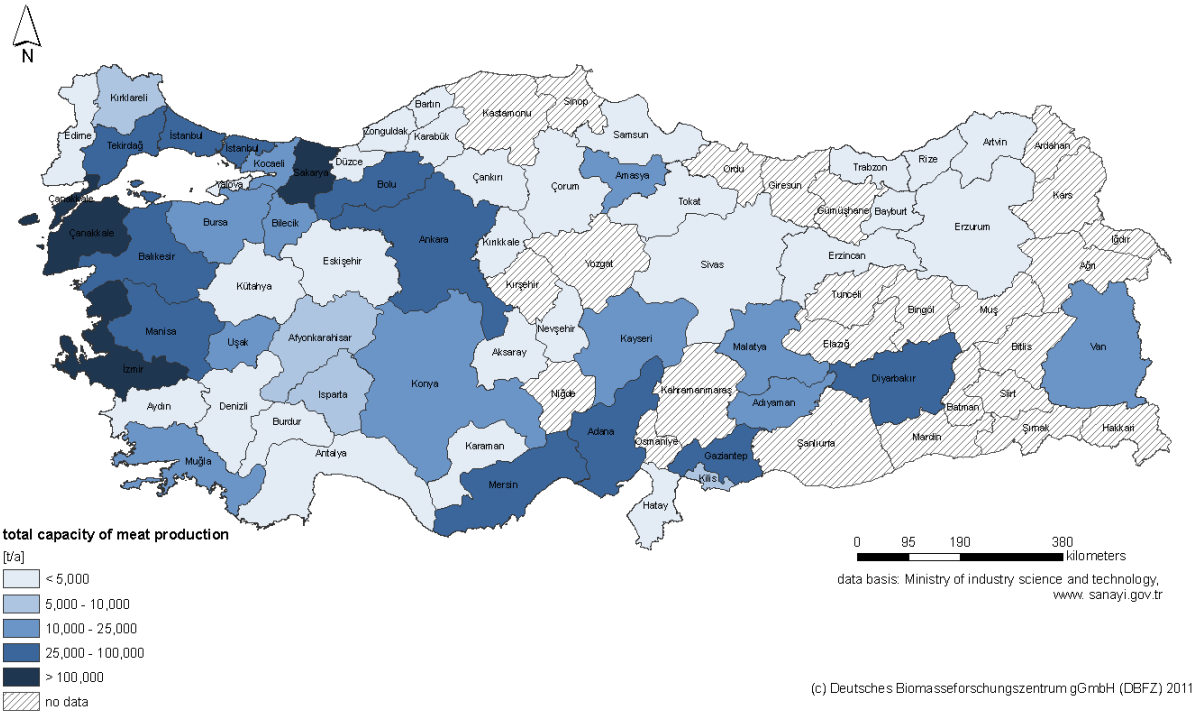

Figure 37: Total capacity of meat production. Data source: [50].

Table 29 presents the number of slaughtered poultry depending on kind of poulty between 1995 and 2009 including the amount of meat production (tons/year).

Table 29: Number of slaughtered poultry and meat production between 1995 - 2009. Data source: [36]

year	Broilers		Laying hens		Turkeys		Geese		Ducks	
	Number of slaughtered animals (number)	Meat (tons))	Number of slaughtered animals (tons)	Meat (number))	Number of slaughtered animals (number)	Meat (tons))	Number of slaughtered animals (tons)	Meat (number))	Number of slaughtered animals (number)	Meat (tons)
1995	208 034 736	270 445	7 245 706	11 593						
1996	250 034 440	406 698	8 830 930	13 910	226 960	1 027	142 400	464	108 960	266
1997	305 745 000	464 928	4 511 550	6 487	114 620	376	24 200	97	20 125	40
1998	301 549 100	476 719	6 878 250	9 990	100 550	702	27 700	106	10 600	24
1999	371 711 450	589 981	4 572 300	6 898	1 424 240	12 744	7 625	24	2 700	5
2000	411 200 300	639 342	2 762 200	4 114	2 292 350	19 274	4 370	13	2 200	4
2001	369 604 727	612 744	1 304 969	2 001	1 707 401	15 125	4 390	13	2 696	5
2002	414 707 710	694 060	1 294 580	2 127	2 412 401	30 401	3 550	13	2 900	6
2003	506 107 632	862 956	6 642 439	9 463	3 636 838	32 801	5 345	21	5 210	10
2004	505 412 926	866 862	6 825 627	9 912	4 181 881	37 623	12 955	51	5 040	10
2005	531 700 102	925 900	7 200 133	10 797	4 417 319	42 709	1 375	5	880	2
2006	490 394 162	910 226	5 172 191	7 432	1 746 569	17 062	2 490	9	1 515	3
2007	598 474 659	1 059 483	6 361 000	8 970	3 620 313	31 467	0	0	0	0
2008	604 322 129	1 069 696	13 663 482	17 985	3 453 789	35 451	0	0	0	0
2009	704 884 526	1 277 082	12 516 730	16 233	2 981 847	30 242	0	0	31 400	68

In Table 30 is shown the meat production of cattles including the number of slaughtered animals between 1999 and 2009.

Table 30: Meat production from cattle in Turkey (1999-2009). Data source:[37].

Turkey Meat production from cattle						
YEARS	CATTLE		BUFFALO		TOTAL	
	Slaughtered Animals (heads)	Meat Production (tons)	Slaughtered Animals (heads)	Meat Production (tons)	Slaughtered Animals (heads)	Meat Production (tons)
1999	2,006,758	349,681	28,240	5,196	2,034,998	354,877
2000	2,101,583	354,636	23,518	4,047	2,125,101	358,684
2001	1,843,320	331,589	12,514	2,295	1,855,834	333,884
2002	1,774,107	327,629	10,110	1,630	1,784,217	329,259
2003	1,591,045	290,454	9,521	1,709	1,600,566	292,163
2004	1,856,549	365,000	9,858	1,950	1,866,407	366,950
2005	1,630,471	321,681	8,920	1,577	1,639,391	323,259
2006	1,750,997	340,705	9,658	1,774	1,760,655	342,479
2007	2,003,991	431,963	9,532	1,988	2,013,523	433,951
2008	1,736,107	370,619	7,251	1,334	1,743,358	371,953
2009	1,707,592	341,511	6,786	1,131	1,714,378	342,642

Actually data base for bovine are represented in Table 31 regarding the red meat production (2010) in Turkey.

Table 31: Amount of red meat production in Turkey in 2010. Data source: TUIK 2011 [40]

Production of Red Meat 2010	Cattle (tons)	Buffalo (tons)	Sheep (tons)	Goat (tons)	Total (tons)
January	41,607	187	7,912	1,001	50,708
February	37,840	212	9,330	1,226	48,608
March	45,698	414	10,064	1,790	57,966
April	49,000	616	9,149	743	59,508
May	50,112	322	7,126	1,471	59,031
June	45,009	281	9,767	1,652	56,709
July	44,102	105	9,380	2,195	55,782
August	48,609	758	10,287	1,293	60,946
September	46,273	95	9,273	1,473	57,114
October	49,462	39	8,462	882	58,845
November	116,054	41	37,679	7,881	161,655
December	44,818	317	7,259	1,452	53,847
TOTAL	618,584	3,387	135,687	23,060	780,718

Total amount of total red meat production in 2010 is 780,718 tons/year. In respect of cattle and buffalo the meat production in 2010 amounts to 621,971 tons/year. Data of meat production from poultry in

2010 were not available, therefore the data base of bovine in 2010 as well as the data base of bovine and poultry in 2009 are used.

Table 32: Meat production residues for the years of 2009 and 2010. Data source: [18], [36], [37]

Poultry	2009	2010
number of slaughtered poultry	720,414,503	
meat production (tons)	1,323,625	
meat tons/slaughtered poultry	0.0018	
slaughtered residues poultry (tons)	362,522	
Bovine	**2009**	**2010**
number of slaughtered bovine (cattle+buffalo)	1,714,378	
meat production bovine (tons)	342,642	621,971
meat tons/slaughtered bovine	0.200	
slaughtered residues bovine (tons)	312,088	566,509

It is possible to use meat production residues in biogas plants. Possible residues of slaughterhouses for biogas production in Germany (materials of category 2 and 3) are e.g. animal stomach and intestine, content of stomach, fat and blood. However, fat and blood of cattles are not allowed to use for biogas production in Germany just from poultry. In Turkey almost every part of animals after slaughtering is being used. Further detailed information regarding kind and amount of residues from slaughtering in Turkey are necessary to improve the calculation.

For the gross calculation of biogas potential it is assumed that the same kind of residues can be used for biogas production as in Germany.

The average carcass weight of cattle and poultry were calculated according to the data base regarding meat production and slaughtered number of animals (Table 32).

average carcass weight = meat production / number of slaughtered animals

- Cattle carcass weight: 200 kg/animal
- Poultry carcass weight: 1.8 kg/animal

The amount of slaughtered „residues“ (in german: “Schlachttierabgang”) is assumed by using German ratio and calculated by mentioned “ratio slaughthered residues : carcass weight”.

Table 33 and Table 34 give an overview of features refering slaughtered bovine and poultry residues. In Table 35 the calculated biogas potential of residues from slaughtering is shown.

Table 33: Assumptions for carcass features of cattle and poultry.

	carcass weight related to alive weight in %	slaughtered residues related to alive weight in %	ratio slaughtered residues/ carcass weight
Cattle	52	48	0.91
Poultry	79	22	0.27

Table 34: Main features of bovine and poultry parts.

Parameters	Substrate	Bovine	Poultry
DM (%)	Stomach/ Intestine (C3)	20	
	Stomach/ Intestine content (C2)	15	15
	Blood (poultry) (C3)		18
oDM (%)	Stomach/ Intestine (C3)	90	
	Stomach/ Intestine content (C2)	84	85
	Blood (poultry) (C3)		96
Biogas yield (m^3/t oDM)	Stomach/ Intestine (C3)	400	
	Stomach/ Intestine content (C2)	485	350
	Blood (poultry) (C3)		343
Methane content (%)	Stomach/ Intestine (C3)	60	
	Stomach/ Intestine content (C2)	60	60
	Blood (poultry) (C3)		70

* fat and blood of cattleis are not allowed to use in biogas plants in Germany.

Table 35: Features of slaughtered bovine and poultry residues.

Parameters		2009	2010 Bovine	2009 Poultry
Slaughtered residue material (tons/year)		312,088	566,509	362,522
Share related to slaughtered residue material %	Stomach/ Intestine (C3)		12	
	Stomach/ Intestine content (C2)		20	21
	Blood (poultry) (C3)			10
Amount of residues (tons/year)	Stomach/ Intestine (C3)	36,639	66,508	0
	Stomach/ Intestine content (C2)	63,853	115,908	77,036
	Blood (poultry) (C3)	0	0	37.485
Theoretical biogas potential (PJ/a)	Stomach/ Intestine (C3)	0.057	0.103	
	Stomach/ Intestine content (C2)	0.084	0.153	0.074
	Blood (poultry) (C3)			0.056
Theoretical biogas potential (PJ/a)		**0.141**	**0.256**	**0.130**
Technical biogas potential (PJ/a) 50 %		**0.071**	**0.128**	**0.065**

* fat and blood of cattle are not allowed to use in biogas plants in Germany.

Theoretical biogas potential of „residues“ from slaughtering of cattle and poultry (stomach/ intestine, content of stomach/ poultry blood) are summarized below:

- Bovine (data base 2009): 141 TJ/year for 2009 and 256 TJ/year for 2010 (data base 2011)
- From Poultry (data base 2009): 130 TJ/year for 2009.

If assumed that 50 % of the theoretical potential of residues from slaughtering could be used for biogas facilities 71 TJ/year for poultry and 128 TJ/year from bovine (cattle + buffalo) results as technical biogas potential.

Milk production

Turkey is among the world's top 15 dairy producing country with an annual production of 10 billion liters of milk [17]. When Turkey´s dairy industry is taken into account, it could be said that whilst 90 % of the milk produced in cow's milk, the rest is produced from the goats, sheep. There was a milk crisis in 2008 caused by high feed prices and low milk prices, leading to the slaughter of diary herds and a meat crisis beginning in mid -2009 caused by extremely high red meat prices, which even continues today. Sheep meat prices increased 50 % in 2009 compared to 2008.

The Turkish milk processing industry is very fragmented and has a dual structure. There are around 3,300 dairies, of which only 1,320 (40 %) have a capacity of more than 1,000 MT/year. There are around 1,000 farms with more than 50 cattle and there are several new investments in large modern farm operations with more than 100 dairy cattle. The average milk yield in the modern farm is 27 kg/day and 8000 kg/lactation [17].

The government applied a milk incentive premium in 1987 in order to increase the ratio of processed milk, discourage unregistered street sales and promote raw milk production. This premium is paid for every liter of raw milk delivered to specified dairy processing plants [17].

The top three milk producing regions are Balikesir, Konya and Izmir. These regions contain some large modern farms and in these western provinces a cold supply chain system has been established.

Table 36: Localization of medium and large sized dairies (>50 000 L/day). Data source: [54]

Regions	Units	Annual Production (´000 litres)	Percentages
Mediterrannean	4	255,600	7.0
Marmara	22	2,134,800	58.1
Central Anatolia	16	541,800	14.7
Black Sea	4	118,800	3.2
Aegean	8	622,800	17.0
TOTAL	54	3,673,800	100.0

Official total milk production was 11,717,080 MT in 2009. The Ministry of Agriculture claimed that milk production reached 12.3 MMT, however traders estimate it dropped to the level of 10 MMT in 2009. The development of milk production is shown in Appendix 15.

Cheese whey waste water

Cheese whey is a protein- and lactose-rich byproduct of the cheese industry. It is highly biodegradable with a very high organic content (up to 70 g COD/L), and low alkalinity (50 meq/L). The high organic content of cheese whey renders the application of conventional aerobic biological treatment costly, mainly due to the high price of oxygen supplementation. Anaerobic treatment requires no oxygen supplementation and generates a significant amount of energy in the form of methane gas. However, Malaspina et al. (1996) stated that raw cheese whey is a quite difficult substrate to treat anaerobically because of the lack of alkalinity, the high chemical oxygen demand (COD) concentration and the tendency to acidify very rapidly [17].

The amount of cheese production in 2010 is 473,057 tons/year (Figure 41) [39].

Table 37: Production of milk and milk products during 2010 based on months. Data source: [35].

Months	Collected Cow Milk	Drinking Milk	Cheese	Yoghurt	Drink made of yogurt
January	494,351	104,323	33,314	64,395	23,591
February	492,36	95,451	33,727	63,873	25,247
March	594,8	104,528	40,164	74,452	31,559
April	610,599	99,539	43,992	74,572	33,489
May	654,696	93,957	45,539	81,797	36,454
June	622,359	70,046	46,207	77,745	37,516
July	610,645	70,285	43,635	85,155	39,591
August	560,309	74,165	40,538	90,121	31,514
September	526,132	88,076	36,790	75,795	36,521
October	531,445	100,254	36,506	74,855	35,611
November	503,311	91,863	34,686	70,072	33,861
December	544,004	98,118	37,958	75,437	32,982
Total amount (tons)	**6,745,011**	**1,090,605**	**473 ,057**	**908 ,269**	**397 ,935**

According to former Ministry of Forestry and Environment, 100 kg milk which is being used for cheese production produce 90 kg cheese whey waste water. Furthermore it is assumed that the ratio milk to cheese amounts to 7.5. Finally, the amount of milk for cheese production can be calculated as 3,547,926 tons per year. The amount of cheese waste water results with 3,193,133 tons per year.

The methane yield of cheese waste water is assumed with 23.4 L CH4/L waste water [55]. The calculated theoretical and technical biogas potential of cheese whey waste water is represented in Table 38. If assumed that 90 % of theoretical potential of cheese whey waste water could be used, technical biogas potential amounts to 2.42 PJ/year.

Table 38: Theoretical and technical biogas potential of cheese whey waste water.

Parameters	Amount
Amount of milk for cheese production	3.547.926 tons/year
Amount of waste water	3.193.133 tons/year
Amount of methane	74.719.311 m^3/year
Theoretical biogas potential	**2,7 PJ/year**
Technical biogas potential	**2,4 PJ/year**

4.3.5. Municipal waste

In Turkey, industrialization and increased living standards have contributed to an increase in the amount of solid waste and its consequent disposal problems. Turkey's traditional method of disposing of solid waste has been to dump it at open sites which there are over 2000 or even at sea. The handling of the solid waste problem starts with the accident of the Umraniye– Hekimbasi open dumpsite on 28 April 1993. This accident was caused by the explosion of gases compressed within the dumping area and resulted in the death of 39 people [44]. Today, the waste mainly is taken to controlled landfill and municipalty´s dumping site as the most common disposal methods. Disposal methods of municipal waste depending on number of facilities and amount of waste are shown in Table 39.

Table 39: Municipal waste situation in Turkey, 2008. Data source: [37].

Disposal methods	Number of municipalities	Amount of municipal waste (tons/year)
Metropolitan municipality's dumping site	59	2,276,540
Municipality's dumping site	2271	10,0520659
Another municipality's dumping site	195	347,943
Controlled landfill	423	10,947,437
Incineration plant	-	-
Burial	45	100,486
Burning in an open area	126	239,291
Sea, lake and river disposal	59	47,685
Turkey	3,129	24,360,863

Total amount of municipal solid waste (MSW) is given as 24.360.863 tons/year for whole Turkey according to TUIK, 2008 data. The amount of MSW depends on seasons and regions. The composition of municipal solid waste is represented in Figure 38.

Kitchen waste could be used for biogas production. 34 % of MSW is kitchen waste (biowaste) according to Ates, 2011 (Figure 38). Therefore, amount of kitchen waste (biowaste) within the municipal solid waste is 8,282,693 tons/year.

Regarding the calculation following parameters for biowaste according to (KTBL Faustzahlen 2007) [65] were assumed:

- 40 % DM, 50 % oDM
- biogas gas yield: 615 m^3/t_{oDM}, 60 % methane content

It is stated that the amount of methane per ton kitchen waste/ biowaste is 74 $m^3/t_{biowaste}$ respectively 25 m^3/t_{MSW}.Therefore total methane from MSW in Turkey can be calculated as 6.11 *10^8 m^3/year. The biogas potential of kitchen waste (biowaste) within MSW in Turkey amounts around 22 PJ/year.

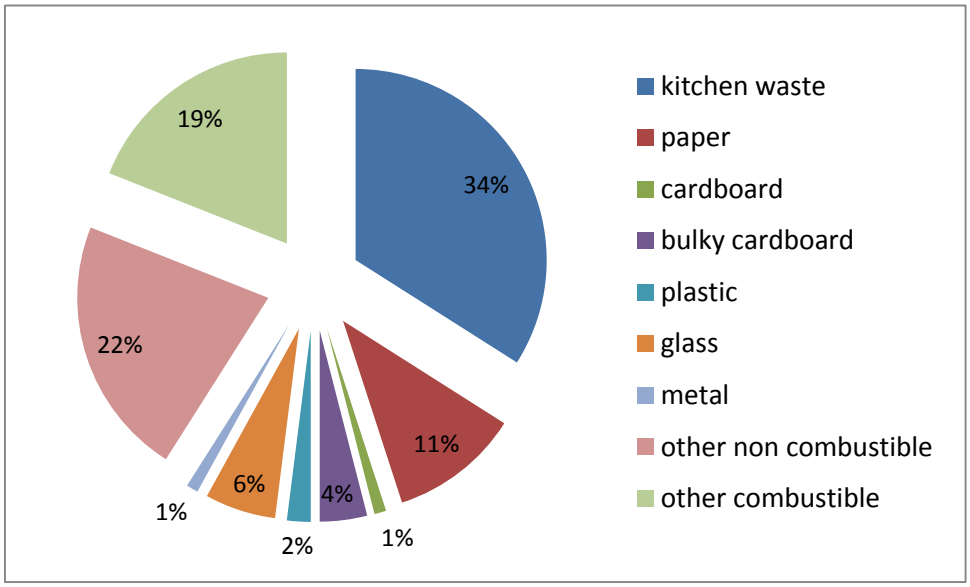

Figure 38: Municipal waste composition. Data source: [31].

4.4. Summary of Biogas Potential Analysis

The provinces with the highest biogas potential refering to the agricultural substrates (manure, straw, energy crops on fallow land, tomato waste, sugar beet leaves) were determined based on the data base on provincial level.

The provinces with the highest theoretical biogas potential of total agricultural substrates are: Konya, Sivas, Ankara, Sanliurfa, Yozgat, Kayseri, Corum, Eskisehir, Erzurum (Figure 39). According to the total technical biogas potential based on agricultural substrates are: Konya, Sivas, Ankara, Yozgat, Balikesir, Bolu, Kayseri, Corum, Sakarya and Sanliurfa (Figure 40). Figure 42 shows the provinces with the highest techical biogas potential according to each sector including the amount of technical biogas potential (TJ/year) and the share (in %) related to the total biogas potential of the substrate.

Finally, the highest (technical) biogas potential of manure is located in Bolu, Balikesir, Sakarya, Izmir, Manisa, Konya and Afyon. The highest biogas potential of cereal straw can be found in Konya, Sanliurfa, Ankara and Adana. Furthermore, Konya provides the highest biogas potential of sugar beet leaf (27.5%) and energy crops on fallow land (19 %). In Antalya can be found the highest biogas potential based on tomato waste (43.3%).

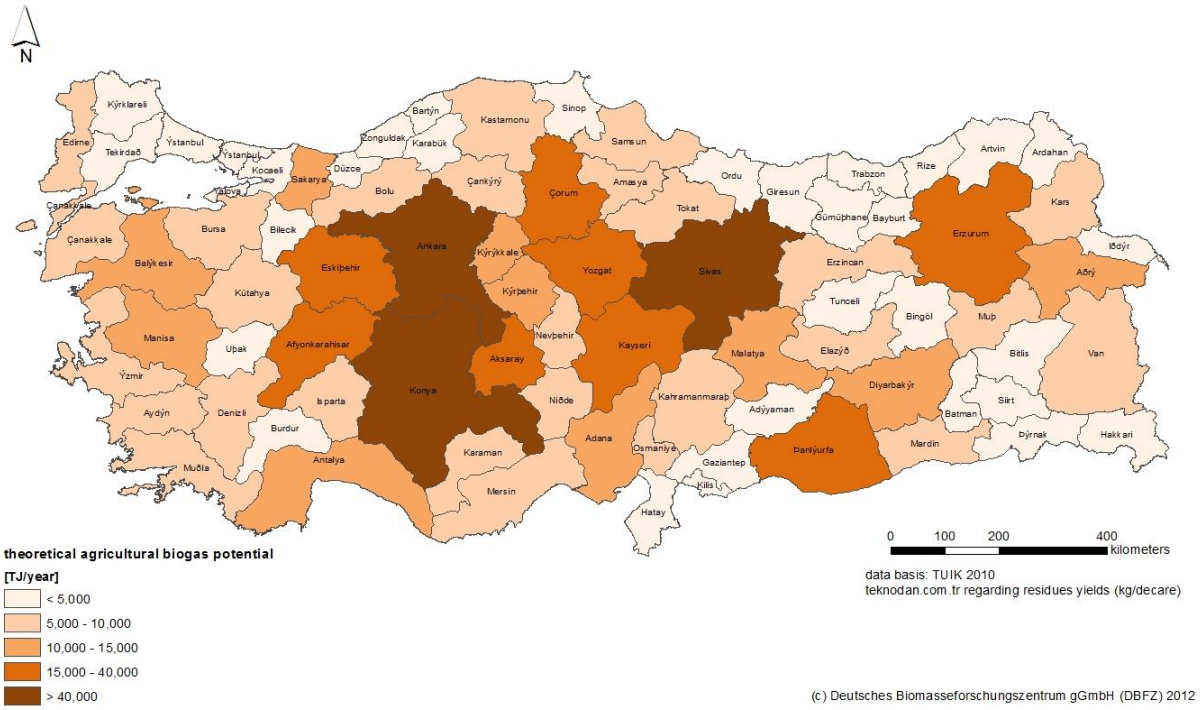

Figure 39: Distribution of theoretical biogas potential of agricultural substrates

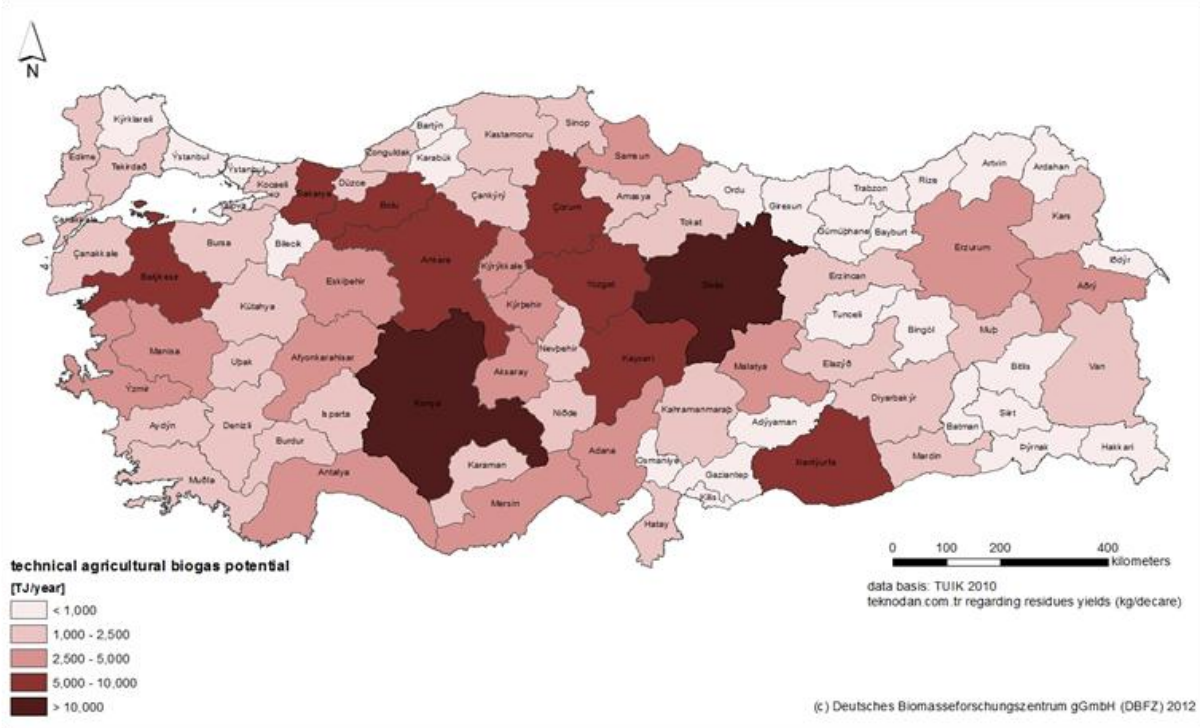

Figure 40: Distribution of technical biogas potential of agricultural substrates

Table 40: Ranking of provinces according to the highest technical biogas potential of agricultural sector (livestock manure, agricultural byproducts, energy crops) in Turkey

No.	Manure (poultry+cattle)			Cereal Straw		
	Name of province	Technical biogas potential (TJ/year)	in % of total biogas potential	Name of province	Technical biogas potential (TJ/year)	in % of total biogas potential
1	Bolu	5.899	7,5	Konya	2.101	7,6
2	Balikesir	5.674	7,2	Sanliurfa	1.842	6,7
3	Sakarya	5.373	6,9	Ankara	1.423	5,1
4	Izmir	4.171	5,3	Adana	1.100	4,0
5	Manisa	4.034	5,1	Diyarbakir	922	3,3
6	Konya	3.228	4,1	Yozgat	788	2,8
7	Afyonkarahisar	2.387	3,0	Kayseri	689	2,5
8	Adana	2.119	2,7	Mardin	674	2,4
9	Ankara	2.110	2,7	Sivas	666	2,4
10	Aydin	1.792	2,3	Corum	660	2,4

No.	Sugar beet leaf			Energy crops (grass) on fallow land		
	Name of province	Technical biogas potential (TJ/year)	in % of total biogas potential	Name of province	Technical biogas potential (TJ/year)	in % of total biogas potential
1	Konya	1.205	27,5	Konya	15.424	19,0
2	Yozgat	399	9,1	Sivas	9.185	11,3
3	Aksaray	237	5,4	Ankara	6.018	7,4
4	Kayseri	227	5,2	Yozgat	4.585	5,6
5	Eskisehir	204	4,7	Corum	3.835	4,7
6	Tokat	178	4,1	Kayseri	3.715	4,6
7	Afyonkarahisar	165	3,8	Sanliurfa	2.723	3,4
8	Karaman	141	3,2	Aksaray	2.673	3,3
9	Sivas	140	3,2	Erzurum	2.140	2,6
10	Ankara	120	2,7	Eskisehir	2.092	2,6

No.	Tomato waste (field + greenhouse)			Total - agric. techn. biogas potential		
	Name of province	Technical biogas potential (TJ/year)	in % of total biogas potential	Name of province	Technical biogas potential (TJ/year)	in % of total biogas potential
1	Antalya	1.758	43,3	Konya	21.985	11,2
2	Mugla	364	9,0	Sivas	11.706	6,0
3	Mersin	312	7,7	Ankara	9.706	5,0
4	Izmir	201	4,9	Yozgat	6.941	3,5
5	Bursa	180	4,4	Balikesir	6.437	3,3
6	Manisa	173	4,2	Bolu	6.355	3,2
7	Canakkale	111	2,7	Kayseri	6.134	3,1
8	Tokat	105	2,6	Corum	5.906	3,0
9	Samsun	89	2,2	Sakarya	5.814	3,0
10	Sanliurfa	84	2,1	Sanliurfa	5.010	2,6

According to data and calculations the results regarding biogas potentials based on sectors are summarized in more detail in Table 41 and as a short overview in Table 42.

Table 41: Calculated biogas potentials based on sectors.

Sector	Substrate	Theoretical Biogas Potential [PJ/year]	Technical Biogas Potential [PJ/year]
Agriculture - livestock	Cattle Manure	107.8	42.1
	Poultry Manure	36.6	36.2
Agricultural Residues	Straw of Cereals	276.7	27.7
	Sugar beet leaf	17.5	4.4
	Tomato Waste	11.1	4.1
Energy crops	Energy Crops on fallow land	325.1	81.3
Agro-Industrial Residues	Meat production residues	0.5	0.2
	Cheese - waste water	2.7	2.4
	Sugar beet press cake	5.0	4.5
	Molasses (sugar production)	3.3	2.9
	Olive press cake	1.3	1.2
	Olive mill waste water	1.3	1.2
	Juice residues (Pomace)	1.8	1.6
	Draff (Bioethanol-production)	0.9	0.8
Municipal Waste	Municipal Waste	22.0	11.0
	Total (with energy crops)	**813.4**	**221.5**
	Total (without energy crops)	**488.3**	**140.3**
	Total (without energy crops and straw)	**211.6**	**112.6**

Table 42: Comparison of biogas potentials based on sectors.

Sector	Theoretical Biogas Potential [PJ/year]	Technical Biogas Potential [PJ/year]
Agriculture - livestock	144.4	78.4
Agricultural Residues	305.3	36.1
Energy crops	325.1	81.3
Agro-Industrial Residues	16.6	14.8
Municipal Waste	22.0	11.0
Total (with energy crops)	**813.4**	**221.5**
Total (without energy crops)	**488.3**	**140.3**
Total (without energy crops and straw)	**211.6**	**112.6**

The highest theoretical potential could be obtained from agricultural residues, livestock sector and energy crops (Figure 41). The gross calculation for energy crops based on the assumption of energy crops production on fallow land with modest hectare yields for grass silage.

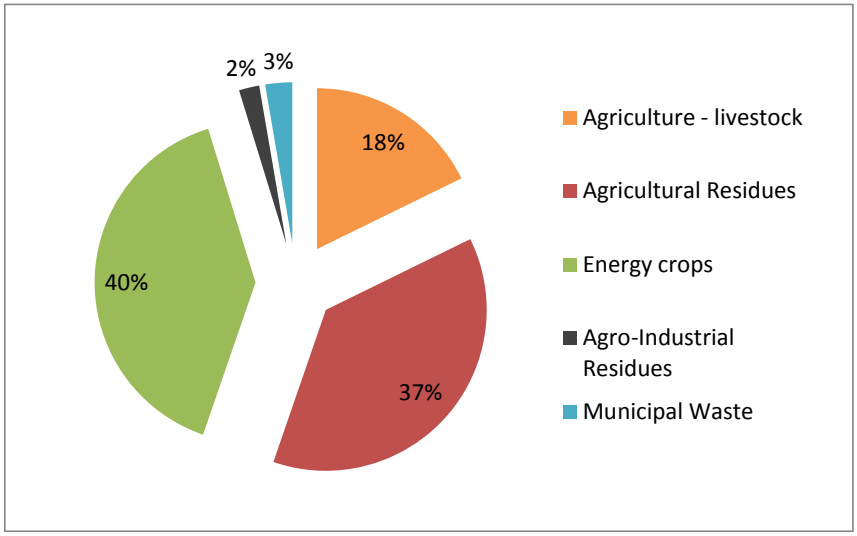

Figure 41: Theoretical biogas potentials in Turkey (PJ/year) based on sectors.

According to the technical biogas potential Turkey could obtain the highest biogas potential from livestock sector resulting from cattle manure (Figure 42). Moreover energy crops on fallow land or on unused arable land deliver high biogas potentials. Nevertheless, further analysis and determination of conditions refering energy crops production in Turkey are necessary.

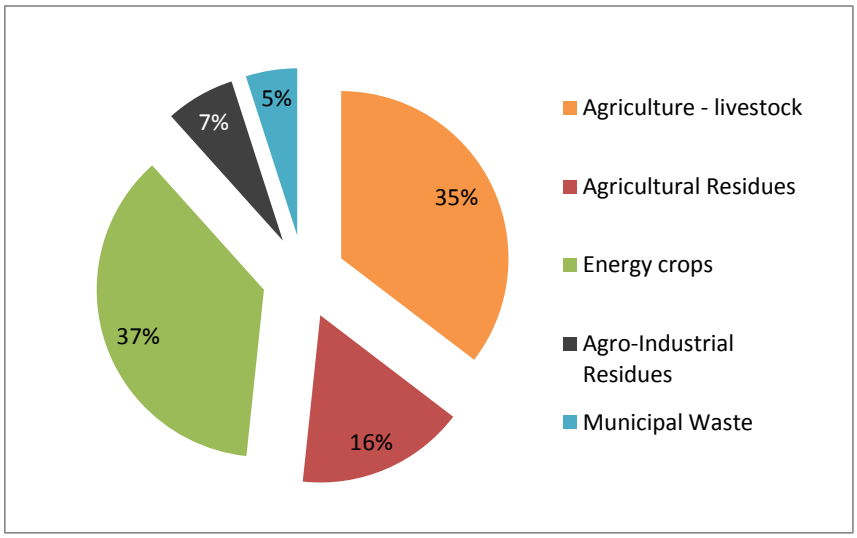

Figure 42: Technical biogas potentials in Turkey (PJ/year) based on sectors.

In conclusion, the range of technical biogas potential of organic residues in Turkey (agricultural residues, municipal waste, residues of food industry) including with and without energy crops and straw was calculated between 112.6 – 221.5 PJ/year respectively 31.3 – 61.5 TWh/year (without/with energy crops and straw). That means between 3.13 - 6.15 billion m^3 methane per year.

In Table 43 is represented, which amount of energy the calculated (technical) biogas potential can cover the Turkish energy demand and consumption. The energy-related data of Turkey used for this comparision based on the Ministry of Energy and Natural Resources (2010) [41].

Finally, the technical biogas potential could cover between 2.5 – 4.8 % of primary energy demand respectively between 3.2 – 6.3 % of total energy consumption of Turkey. According to the share of renewable energy sources (RES) for energy consumption in Turkey biogas might provide between 35.9 – 70.6 %. Furhermore biogas could replace between 19.2 – 37.7 % of the consumption of natural gas in Turkey.

If estimated, that the electrical efficiency for biogas utilization facilities is 40 %, biogas could provide between around 6 – 12 % of the total electricity production in Turkey and meet between 22 – 44 % of total Renewable Energies related to electricity production.

Table 43: Percentages of coverable energies by use of technical biogas potential of Turkey. Data source: [41]

Technical Biogas potential of Turkey can cover… % related to it's …		
	min (without energy crops and straw)	**max** (with energy crops and straw)
Primary Energy Demand	2.5	4.8
Total Energy Consumption	3.2	6.3
RES for Energy Consumption	35.9	70.6
Natural Gas for Energy Consumption	19.2	37.7
Total Electricity Production*	5.9	11.6
RES for Electricity Production*	22.4	44.1

* assumed electrical efficiency 40% for biogas utilisation facilities

4.5. Other Biogas studies

4.5.1. Comparison of the results

Up to now, biogas studies that were done, were based on different criterias. However common assumptions for all studies listed below:

- Agricultural residues have high potentials,
- Livestock residues have high potential in western and northern parts of Turkey,
- Northern part of Turkey, especially Black Sea, consists of high amount of fruit production residues,
- Hazelnut residues have high potential in Black Sea,
- Olive residues have high potential in Marmara and Aegean regions.

Figure 43: Biomass potential of Turkey. Data source: [3].

Assumptions and results of other biomass potential studies differed as follows:

- Ekinci, 2011 [4]: total methane potential of Turkey from manure: ~ 3.1 *10^9 m^3 methane /year
- TEKNODAN study [23]:
    - Bioenergy potentials: 140.1 TWh/year for agricultural waste (straw), 11.9 TWh/year for animal waste, 16.1 TWh/year forest and pasture area waste.
- "Exploitation of Agricultural Residues in Turkey" (AGRO-WASTE) EU Life Projects, Project No:LIFE03 TCY / TR / 000061 (2004-2005):
    - Turkey's regional agricultural waste potential was determined as:
    - Annual field crops production and residues are : 227 PJ (33.4 % maize , 27.6 % wheat and 18.1 % cotton)

  - Annual fruit production and residues are : 75 PJ (55.8 % hazelnut and 25.9 % olive)
  - 2 million hectare available agricultural land (currently not in use) existed in Turkey. If these areas could be irrigated for energy crop production, this means: 2.000.000 ha x 40.000 kWh/ha = 80 TWh electricity production

- Balat, 2005: Various agricultural residues such as grain dust, wheat straw and hazelnut shell are available in Turkey as the sources of biomass energy. The annual biomass potential of Turkey is approximately 32 Mtoe. The total recoverable bioenergy potential is estimated to be about 17.2 Mtoe.
- Schmack Study (Mr. Suat Karakuz), 2010:
  - There are around 10,000,000 bovine in Turkey and manure that could be obtained from an animal is 50kg/day and 70 % of this waste is possible to collect and use for biogas production.This means 86.4 PJ energy could be obtained from bovine manure.
  - There are 30,000,000 ha arable land in Turkey and the half is not being used. If 20 % of arable land could be used for energy crop production such as (fodder beet, maize, grass silage, triticale), 1,380 PJ energy could be obtained (asssumption: 50 tons maize per hectare, 210 m^3 biogas per ton maize silage).

The comparison of the different studies and assumptions shows that the calculated biogas potentials of livestock resulting from manure give nearly the same results. Regarding the calculation of energy crops there are total different assumptions depending on which kind of land (arable or fallow land) and which amount of land can be obtained for energy crops production. The fact is, within several studies a biogas potential from energy crops was stated. Therefore, it is necessary to determine in a detailled way under which circumstances and conditions energy crop production in Turkey could be possible. The calculated potential of energy crops by the DBFZ is just a conservative gross calculation to demonstrate that the utilization of fallow land or arable land currently not in use might be an alternative.

4.5.2. Biogas Potential studies

There are lots of biomass potential studies in Turkey, however they are with different focus and contents such as:

- biomass potential in total
- Potential just for one sector
- Potential just for different regions

In Turkey, biomass potential studies started to become important especially after 2000´s. Universities have been publishing their studies since early 2000´s. Private engineering companies were involved in studies through 2010. By the revisions in legal framework regarding to renewable energy, the number of studies are being expected to increase and content of the studies will be widen.

An overview of biogas potential studies in Turkey with year, authors and main topics are presented in Appendix 9.

There are also some research activities going on by national and international projects. An ongoing national biogas project aims to construct a biogas plant with 350 kW electricity production capacity. Ege University is also planning to construct 60 biogas plants around Izmir province (IEA Bioenergy Task 37, 2011).

5. Actors Analysis

Many stakeholders from ministries to livestock farms take place in biogas investments. Governmental stakeholders are responsible for appropriate law-making and they are in charge of enforcement of legal framework. The chambers and associations are mostly resposible for civil act. They can increase the public awareness regarding to biogas investments. They can also find suitable investors among their members and for the creation of potential biomass maps they can help to get the latest data. Research centres and universities might cover the lack of biogas knowledge and technology (Appendix 5 and Table 44).

Regarding to financing of biogas investments, there are a total of 45 banks (5 public) as stakeholders, operating with 9441 branches in Turkey and 63 branches abroad [56].

Table 44: Overview of biogas stakeholders.

Political stakeholders	
Governmental stakeholders	The Ministry of Environment and Urbanization
	The Ministry of Science Industry and Technology
	The Ministry of Food Agriculture and Livestock
	The Ministry of Energy and Natural Resources
	The Ministry of Water Affairs And Forestry
	National Development and Reform Commission
	Energy Market Regulatory Authority EPDK
	Technology Development Foundation Of Turkey
	Industrial Development Bank of Turkey
	Development Turkey Bank
	Investment Support and Promotion Agency of Turkey (ISPAT)
	Environmental Protection Bureau
	Development and Reform Commission
	General Directorate of Forestry
	The General Directorate of Renewable Energy
	General Directorate of Agricultural Research And Policies
Chambers/ Associations	
Chambers	Alman-Türk Ticaret ve Sanayi Odası Deutsch-Tükische Industrie und Handelskammer
	The Camber of Biogas Investment Development
	Istanbul Industry Chamber

	Bursa Industry and Trade Chamber
	Mersin Industry and Trade Chamber
	Eskisehir Industry Chamber
	Antalya Industry and Trade Chamber
	Istanbul Trade Chamber
	The Chamber of Development of Small and Medium-Sized Enterprises
Associations	Turkey Red Meat Producers' Association
	Egg Producers Association
	Afyon Güçbirliği Tavukçuluk (Poulty breeding) Association
	Cattle Breeders' Association of Turkey
	Meat Producers´ Association
	White Meat Industrialists and Breeders Association
	Turkey Milk Meat Food Industrialists and Manufacturers Association
	Association of Meat Wholesalers and retailers
	(ALBIYOBIR) Alternative Energy and Biodiesel Producers Association
	(YETA) Local Energy Technology Research Association
	Biodiesel Industrialists & Businessmen Association
Research Institutions/ Universities	
Research Centres	Turkey scientific and technical research institute
	Ceramic Research Centre
	National Productivity Centre
	Izmir Development Agency
Universities	Yildiz Technical University
	Uludağ University
	Zonguldak Karaelmas University
	Hacettepe University
	Cumhuriyet UNIVERSITY
	Aegean University
	Dokuz Eylül University, Izmir
	Karabük University
	Middle East Technical University,
	Istanbul Technical University
	Mediterranean Universiy
	Cukurova Universiy
Financing	
Banks	KfW (Kreditanstalt für Wiederaufbau)

	DEG(Deutsche Entwicklungsgesellschaft)
	EIB (European Investment Bank)
	EBRD (European Bank for Reconstruction and Development)
	IFAD (International Fund for Agricultural Development)
	KOSGEB (Turkish NGO for SME development)

Livestock farms could be possible investors by building their own biogas plants or they could sell the manure to the biogas plants. Biogas plant investor companies are responsible for importing advanced technology. They might have the opportunity for setting up the leading position of developing biogas plant in Turkey among other companies. Biogas plant design and engineering companies have special place in the sector by selling technology to Turkish market. Grid power company, heat customers, organic fertilizer companies and organic fertilizer costumers have also direct impact on operation of biogas plants (Table 45).

Table 45: Special concerns and interests of some stakeholders which have direct impact on construction and operation of biogas plants.

Stakeholders	Interests in the project	Concerns in the project
livestock farms	☐ Selling manure with good price ☐ Reducing pressure of protecting environment from local government	Chance of getting government subsidy for building own biogas plants
Biogas Plant (BP) investor company	☐ Establishing an economically feasible biogas project ☐ Importing advanced German technology ☐ Setting up the leading position of developing BP in Turkey among other companies.	☐ Local government organize manure slurry collecting company, or co-organize the company with local government ☐ Price of buying manure slurry in the future ☐ Regulations of related policies applying to BP ☐ Finding a mutual-benefit and low risk cooperation model for technology transfer
BP design and engineering company	☐ Selling technology to Turkish market ☐ Technology license cooperation model with BP investor company	☐ Intellectual propertity protection
Grid Power Company	Accepting electricity produced by the BP with electricity tariff	

Heat customer	☐ Buying the heat produced by BP and sell them to the surrounding households and schools	
Organic fertilizer company	Buying the solid digestate produced by the BP	
Organic fertilizer consumers	Using the liquid digestate and cover the transportation cost	

The list of publications of universities regarding biogas topic can be found in the Appendix 4. More detailed information regarding actors is listed in Appendix 5.

6. GAP Analysis

One of the major problems in the renewable energy sector is existing bureaucracy. The barriers holding back biomass exploitation in Turkey can be divided into two main groups: (1) barriers in the institutional, legal and administrative framework and (2) real and perceived risks and other inherent difficulties associated with promoting biomass energy [26].

The proportion of RES is quite low and in the regulations there are no measurable national targets regarding biogas, just related to wind power. According to study, Turkey is able to meet a relevant share of energy demand by itself. However, instead of focusing on RES, national targets were put related to import of natural gas and petroleum. Enforcement of Environmental Law is insufficient; therefore the non-compliance (violation) with environmental regulations does not have financial and/or penal consequences for the actors. Therefore environmental technologies such as biogas for example are economically not attractive for potential investors. Moreover the capacity-building with farmers, politicians, the industry, etc. and the public awareness raising are important tasks for the future.

There is no consensus regarding the biogas topic among the actors in Turkey. However, all actors agree that the low feed in tariffs (FiT) and insufficient incentives and the presence of only one biogas association as the main problems. They also think purchase guarantee is just till 2015, which gives no trust to investments.

Different actors were interviewed regarding the barriers and main problems for implementing biogas plants in Turkey. The main aspects are summarized as follows:

According to one of the environmental engineer representative:

- The missing regulations regarding the biogas should be found out by comparing the Turkish with the German framework, new arrangements should be implemented.
- Energy policy should be revised, manure management regulations should be created and farmers should be educated regarding the use of liquid manure.
- Furthermore new incentives which will motivate investors should be determined.

According to a representative from the Biogas Association:

- Law enforcement of the ministries is not sufficient, cooperation among the actors is weak.
- Manure management regulation, knowledge regarding to use of liquid manure and organic fertilizer facilities are missing.
- The planning of the biogas projects is sometimes insufficient
- The price of maize silage is extremely high and German technology is quite expensive. There is a need to adapt technology and to focus on residues, waste, etc
- If German experience should be taken, then instead of their technology, Turkish technology and resources should be used.

According to a Turkish expert from a German biogas company:

- Scope of the Turkish biogas association is limited.
- Due to the lack of education, associations and investors do not care about the environment; mostly they are interested in short payback period of biogas plants. This is the common Turkish mentality and it is the biggest problem.
- In Turkey there is no Turkish biogas technology and most of the equipment is more expensive in comparison to Germany.
- Regulations being implemented in Germany should be adapted to Turkey. Manure management regulation is not enough itself. National targets should be set.
- The philosophy of RES should be understood by everyone. Resource management should be done.
- Environmental impact assessments are not being done properly.
- Law making process is too slow and regulations should be made carefully in order to prevent many new revisions.
- In Turkey, biogas potentials that could be obtained from energy crops is so high. Therefore, understanding of energy crop farming should be introduced and farmers should be trained as energy crop farmers.

According to one Turkish biogas plant operator representative:

- In Turkey there are no biogas investments, because they are discouraged.
- Investors are impatient to see the payback period of their investments.
- Pilot project should be implemented in order to show a way to people who are interested in operation of biogas plants.
- When facility owners want to construct a biogas plant, mostly project proposals are extremely expensive.
- He also described the insufficient gas production and proportion of solid matter adjustment as their major operation problem.

Regarding to financing options in Turkey for biogas investments, there are some obstacles on banking side:

- Lack of knowledge/experience in this field
- No tools for evaluation/calculation of the biogas-project
- Lack of collateral on clients side

- Insufficient or delayed application documents delivered by the clients.

Obstacles regarding to bank customers can be summarized as below:

- Skeptical approach towards banks in general and loans specifically
- Lack of knowledge about products/programs
- Insufficient documentation of their business, econ Statements
- Lack of entrepreneurial knowledge [56].

Before construction of biogas plants, proactive policy, aim at securing the economic and institutional conditions for desired technology development should be created. Governmental energy planning and targets, renewable energy action plan should be implemented (Lund et al., 1999). In order to give the new technology a chance to develop and to make plants economically feasible, the Turkish Energy Agency should contribute regulations regarding to favorable feed-in tariffs and investment subsidies. Government-sponsored biomass energy resource surveys (biomass potential maps) should be conducted. Local ownership of biogas plants should be supported and careful selection of sites should be done [34].

First of all development should be initiated by different type of crops, companies and region which allows to development of technology. Development and introduction of new technologies have to be seen in connection with the specific market construction to which the technology is attached [42].

Long term government support should be provided for research, development and demonstration. Otherwise, expectations from biogas plants could not fulfill the over optimistic expectations, partly due to lack of experience and unpredictable incidents such as buildup of sand in the reactors, uncontrollable fermenting process, excessive amounts of waste from some industries, resulting in destroyed in reactors. National test and certification of biogas plants should be done [34].

After the construction of plants, status of the biogas development should be evaluated in order to develop new biogas strategies. Socioeconomic feasibility of biogas plants should be considered within the aims set up by the Turkish Parliament concerning employment, state finance, and balance of payment, greenhouse gases and others. Saved imports due to the decrease in oil and coal imports, increased employment due to the high employment effects linked to building, maintaining and running biogas plants and increased incomes and consequently increased taxes, which improve the state finance, should be taken into account. This increased revenue to the state budget more than compensates for the subsidies which have to be given to motivate the construction of biogas plants [42].

Data base that could be improved according to this study:

- The most updated database, TURKVET which belongs to ministry should be used for more realistic calculations. However, reaching that database is required to application of series of permissions which takes too long time.
- There is no certain data regarding to utilization of residues. Regarding to realistic biogas potential of energy crops on fallow lands, soil quality data and climatic conditions, irrigation situation are required.

- The reliability of TUIK livestock statistics is doubtful due to a support system which is based on payments per head, some farmers fail to notify slaughter of cattle to the system. Consequently, official cattle population numbers are overstated now. Data from associations are more realistic, since they are able to update their database quicker.
- The survey /questionnaire for residues from food industry in order to get better data quality regarding to the kind and amount of residues should be continued.

Missing studies which could help to implement biogas in Turkey can be described as follows:

- Biogas action plan/ biogas roadmap: How could the strategy for biogas in Turkey look like?
- How should typical biogas plants in Turkey look like? (Technical assessment of biogas plants)
- Economical assessments of biogas plants in Turkey.
- Ecologic effects of implementing biogas plants in Turkey (e.g. GHG-Reduction, environmental effects to soil and water, modern stable systems)

7. Conclusions

In general, the biomass potential depends on the future food and feedstock demand which is driven by population growth rate, per-capita consumption, development of yields for cropping, fodder and biomass production and climate change.

Input data problem: unclear political developments and insufficient data availability (developing countries), lack of consistent definitions for specific biomass fractions (such as logging residues), interpretation of degraded lands.

Scenario approach can be regarded as the most appropriate means in order to handle the existing uncertainties .

The sustainability of future biomass potentials depends mainly on global political agreements concerning food security and sustainability, as well as consumer behaviour in developed countries.

Additional impact assessment on regional level is a precondition for the mobilisation of the potential (i.e. biodiversity, water management, social aspects) to find options for synergies.

Regarding the biogas potential in Turkey it might be summarized as below:

- Current biomass utilization for energy production is on low level in comparison to the given biogas potentials of organic residues from agricultural, agro-industrial and municipal sector.
- There is a high biogas potential within the agricultural sector (cattle manure, poultry manure), however, this potential is currently unused. The highest agricultural biogas potential could be obtained from cattle manure. Livestock residues have in particular high potential in western and northern parts of Turkey.
- Utilization of animal residues (manure) and agro-industrial residues could provide a solution to environmental problems (e.g. river pollution, groundwater safety, greenhouse gas reduction).

- There is high straw potential especially from wheat and barley, however, straw is mostly being used as fodder or for animal breeding. Also burning is a common practice in Turkey. However, the digested material of biogas plants could close the nutrient cycle by using as fertilizer within the agriculture.
- The production of energy crops in Turkey is uncertain and needs further assessment regarding the soil and climate conditions, kind and amount of land for cropping of energy crops including achievable yield per hectare to ensure the stated assumptions. It is necessary to determine in a detailed way under which circumstances and conditions energy crop production in Turkey could be possible. The calculated potential of energy crops by the DBFZ is just a conservative gross calculation to demonstrate that the utilization of fallow land or arable land currently not in use might be an alternative.
- The disposal of animal waste, olive mill waste and cheese whey are problematic in Turkey. In general, these three waste are all being generated from small enterprises spreaded out in a large geographical area. Most of these enterprises can not invest on environmentally friendly disposal ways. A common use of this waste in the form of co-digestion would provide a good means of economically acceptable disposal system while providing ecologically acceptable solution to the disposal problems [8].
- The calculated total technical biogas potential of organic residues ranges between 112.6 – 221.5 PJ/year (without/with energy crops and straw). This estimated biogas potential could cover between 2.5 – 4.8 % of primary energy demand respectively between 3.2 – 6.3 % of total energy consumption of Turkey. In respect of the share of renewable energy sources (RES) for energy consumption in Turkey biogas could provide between 35.9 – 70.6 %. Furhermore biogas could replace between 19.2 – 37.7 % of the consumption of natural gas in Turkey. When the electrical efficiency assumed as 40 % for biogas utilization facilities, the calculated biogas potential could cover between 6 – 12 % of the total electricity production in Turkey or a share of RES for electricity production in Turkey between 22 – 44 %.
- Within the calculations, Konya has found as a province with the highest biogas potential in Turkey.

Main barriers refering to the implementation of biogas in Turkey are identified such as:

- Lack of legal regulations (e.g. Missing Manure Management Regulation: What to do with animal residues? How to store it?)
- Low feed in tariffs (FiT) for biogas facilities
- Lack of knowledge and experience in the field of biogas
- Limited scope of biogas association and networking of biogas actors

Need for action is seen in particular for:

- Promoting the use of liquid manure to produce biogas and use the digestate as fertilizer to close the nutrient cycle; education of farmers how to store and use the manure

- Improving legal framework in general to create regulations with realistic targets and time tables as well as controlling (Need for enforcement of environmental regulations, need for better FiT)
- Creating a kind of roadmap or action plan for biogas to support a long term national strategy
- Improving the knowledge of biogas and handling/operation of biogas technologies, Need for research
- Need for technology development/adaptation
- Need for assistance of planning of biogas plants (feasibility reports)
- Implementing pilot biogas projects in order to show positive effects
- Strengthening of institutions working with biogas from R&D, associations, etc.

Finally there are an initiating biogas market in Turkey and a high amount of biogas potentials which are currently unused. The utilization of biogas has a lot of advantages for environmental, agricultural, industrial as well as energy sector in Turkey. The key beneftis can be summarized as below:

Environment:

- Reduction of GHG emissions and fighting with climate change
- Improvement of water quality and soil fertility
- Reduction of pollution from agricultural and animal waste

Agriculture:

- Modernisation of agriculture: more production but in a environmental and sustainable way
- Modern manure management: promotion of the nutrient cycle (manure storage and logistics)
- 2010-2014: Strategy Plan: Rural development, sustainable and competitive agriculture

Energy:

- Strategy Plan 2010-2014: Contribution to reach the 30% Renewable Energy Target for 2023
- Energy security

Industrial and economic development:

- Strategy Plan 2010-2014: Strengthening Environment – Industry and environment- trade relations
- Biogas as a future technology in Turkey
- Local industrial production
- Green jobs and growth in Turkey

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Appendix 1: Overview of Biogas Plants in Turkey

Company	District	Address	Facility Type	Installed Capacity [MWel]	Project Status	Source of Information	Remarks
Adana							
ITC Adana Çöplüğü	Yüreğir	Sofulu Katı Atık Alanı Mevkii / ITC Adana Enerji Üretim Tesisi	Municipality (landfill)	11,328	in operation	EPDK List + Jenbacher List	
Yeni Adana İmar İnşaat Tic. A.Ş.			Undefined	0,800	licensed	EPDK Biyogaz Verilmis Lisanslar v0 090211	
Yeni Adana İmar İnşaat Tic. A.Ş.			Undefined	0,800	licensed	EPDK Biyogaz Verilmis Lisanslar v0 090211	
Batı Adana Atıksu Arıtma			Undefined (wastewater)	0,803		Jenbacher List	
Doğu Adana Atıksu Arıtma			Undefined (wastewater)	0,803		Jenbacher List	
Afyon							
afyon güc birligi /afyonkarahisar biyogaz enerji santrali			Agriculture (chicken manure)	4,200		http://afyonbiyogaz.com/	
Amasya							
Sigma Mühendislik Ve Pazarlama Limited Şirketi	Suluova	Besi Organize Sanayi Bölgesi mevkii/Sigma Suluova Biyogaz Tesisi	Undefined	2,000	licensed	EPDK Biyogaz Incelemedeki Lisanslar v0 090211	
Ankara							
ITC-KA Enerji Üretim San. ve Tic. A.Ş.	Sincan		Municipality (landfill)	5,660	licensed	EPDK List	
ITC-KA Enerji Üretim San. ve Tic. A.Ş.	Mamak	Mamak Biyogaz Santrali	Municipality (landfill)	36,000	licensed	EPDK List + Jenbacher List	Jenbacher: 25,488 MW
Bel-Ka Ankara Katı Atıkları Ayıklama Değerlendirme, Bilgisayar, İnşaat San. ve Tic. A.Ş.	Sincan	Tatlar Köyü	Municipality (landfill)	3,200	in operation	EPDK List + Jenbacher List	Jenbacher: 5,66

Ankara Büyükşehir Belediyesi			Municipality (wastewater)	2,000	in operation	Selman Cagman Mail + http://www.aski.gov.tr/	
Antalya							
infaz and akdeniz university	Kumluca		Undefined			http://www.ajansbir.com/modulles/print_haber.php?par1=14694	
Aydin							
tt group			Agriculture (ensiled maize and cattle manure)	1,063	in operation	http://ttgroupenergy.com/yatirimlar/biyogaz-enerji-yatirimlari/aydin-biyogaz-enerji-santrali/	
Balikesir							
Edincik municipality	Edincik		Agriculture (chicken manure)	2,000		http://www.haberx.com/balikesir_edincikte_biyogaz_tesisi_kurulmasi_icin_calisma %2817,n,10656575,741 %29.aspx	
Mauri Yeast Production	Bandırma	Kavakpinar Mevkii Aksakal PK 101 10200	Industry (wastewater)	1,200	in operation	Selman Cagman Plant List	0,65 mio m³ / a
TekSut Milk Production	Gönen		Industry (wastewater)		in operation	Selman Cagman Plant List	0,2 mio m³ / a
Kepsut Enerji Elektrik Üretim Sanayi Ve Ticaret Anonim Şirketi	Kepsut	Hotaşlar Köyü Beşiktepe Altı mevkii/ Kepsut Enerji	Municipality (landfill)	13,300		EPDK Biyogaz Incelemedeki Lisanslar v0 090211	
Banvit Enerji ve Elektrik Üretim Ltd. Şti.	Bandırma	Ömerköy Kavşağı / Bandırma Biyogaz Santralı	Undefined	3,066	licensed	EPDK Biyogaz Verilmis Lisanslar v0 090211	
Bolu							
Bolpat Potato Production			Industry (wastewater)		in operation	Selman Cagman Plant List	1,2 mio m³ / a
CEV Marmara Enerji Üretim Sanayi Ve Ticaret Ltd. Şti.	Centre	Yukarı Soku Mevkii	Municipality (landfill)	1,131	licensed	Jenbacher List + EPDK Biyogaz Verilmis Lisanslar v0 090211	
Burdur							

Burdur Pars Enerji Grubu			Industry (sugar beets)		in planning	http://www.haberler.com/burdur-a-2-5-milyon-euroluk-biyogaz-yatirimi-2557853-haberi/	
Burdur Sugar Plant	Burdur		Industry (wastewater)		in operation	Selman Cagman Plant List	1,3 mio m³ / a
Bursa							
Cargill Tarım ve Gıda Sanayi Ticaret A.Ş.	Orhangazi		Industry (wastewater, organic waste)	0,120	in operation	Selman Cagman List + EPDK Biyogaz Verilmis Lisanslar v0 090211	0,7 mio m³ / a
Sütas Milk Production	Karacabey		Industry (wastewater, organic waste)		in operation	Selman Cagman Plant List	3 mio m³ / a
ITC Bursa Çöplüğü			Municipality (landfill)	8,478		Jenbacher List	
Denizli							
Bereket Enerji Üretim A.Ş.	Denizli	Kumkısık Mevkii / Kumkısık LFG Santralı	Municipality (landfill)	0,635	licensed	EPDK Biyogaz Verilmis Lisanslar v0 090211	
Elazig							
municipality			Agriculture (chicken manure)			http://www.emo.org.tr/ekler/0d936dc2a4718f8_ek.pdf	
Erzincan							
Cadirtepe Landfill	Üzümlü	Cadirtepe	Municipality (landfill)		in operation	Selman Cagman Plant List	33,6 Gwhel; 14 mio m³ / a
Eskisehir							
			Industry (wastewater)	1,200	in operation	Selman Cagman Mail	
Eskisehir Sugar Plant	Eskisehir		Industry (wastewater)		in operation	Selman Cagman Plant List	1,3 mio m³ / a
ESES Eskişehir Enerji Sanayi Ve Ticaret Anonim Şirketi	Odunpazarı	Alpu Yolu 3 Km.	Undefined	2,042	licensed	EPDK Biyogaz Verilmis Lisanslar v0 090211	
Gaziantep							
solea energy		kilavuz hayvancilik tesisi	Agriculture (animal manure)			http://www.soleaenerji.com.tr/Teknolojik_Biyog	

						az-tesisi.asp	
Gaziantep M. Waste Treatment Plant municipality			Landfill gas Agriculture (grass)		in operation	Prof. Dr. Durmus Kaya plant list http://www.floraburada.com/NewsShow.aspx?id=653	3 mio m³ / a
		Gaziantep	Industry (wastewater)	2,000	in operation	Selman Cagman Mail	
Cev Enerji Üretim San. ve Tic. Ltd. Şti.	Şahinbey	Bağlarbaşı mevkii	Municipality (landfill)	5,655	in operation	Jenbacher List + Selman Cagman Plant List + EPDK Biyogaz Verilmis Lisanslar v0 090211	Jenbacher: 5,664 MW Selman Cagman: 6,786 MW
GASKİ Enerji Yatırım Hizmetleri İnşaat San. ve Tic.A.Ş.			Undefined	1,660	licensed	EPDK Biyogaz Verilmis Lisanslar v0 090211	
Isparta							
municipality /Isparta Belediyesi			Municipality (landfill)			http://www.emo.org.tr/ekler/0d936dc2a4718f8_ek.pdf	
Istanbul							
Efes Beer Production			Industry (wastewater)		in operation	Selman Cagman Plant List	0,8 mio m³ / a
Ortadoğu Enerji Sanayi ve Ticaret A.Ş.	Şile		Municipality (landfill)	7,560	licensed	EPDK List	
İstanbul Çevre Koruma ve Atık Maddeleri Değerlendirme San. ve Tic. A.Ş.			Municipality (landfill)	4,020		EPDK List	
Ekolojik Enerji Anonim Şirketi	Eyüp	Hasdal-Kemerburgaz	Municipality (landfill)	4,020	in operation	EPDK List + Selman Cagman Plant List + Jenbacher List	Jenbacher: 0,588 MW Selman: 1 MW 2,2 mio m³ / a
Kemerburgaz Landfill Area-Odayeri	Eyüp	Kemerburgaz / Odayeri Çöplüğü	Municipality (landfill)	16,980	in operation	Selman Cagman Plant List	51,6 mio m³ / a GE Press: ~

Kemerburgaz Landfill Area-Komurcuoda	Eyüp	Kemerburgaz / Komurcuoda Çöplüğü	Municipality (landfill)	7,075	in operation	Selman Cagman Plant List + Jenbacher List	35 MW (Odayeri + Komurcuoda) Jenbacher: 4,024 MW 35 mio m³ / a
Izmir							
keskinoglu			Agriculture (chicken manure)			http://www.kobiden.com/keskinoglu-biyogazdan-elektrik-uretecek_10353_haber.html	20 GWh
tt group	Cigli		Industry (wastewater)	3,880	in operation	http://ttgroupenergy.com/yatirimlar/biyogaz-enerji-yatirimlari/cigli-biyogaz-enerji-santrali/	
tt group	Harmandali		Municipality (landfill)	4,250	in operation	http://ttgroupenergy.com/yatirimlar/biyogaz-enerji-yatirimlari/harmandali-biyogaz-enerji-santrali/	
Kastamonu							
Kastamonu Inebolu(farmer)	Inebolu		Agriculture (cattle manure)			http://www.kastamonusefasi.com/showthread.php?t=68392	
Kayseri							
Her Enerji Ve Çevre Teknolojileri Sanayi Ticaret Anonim Şirketi	Koca Sinan	Molu mevkii / Her Enerji Kayseri Katı Atık Deponi Sahası Biyogaz Santrali	Municipality (landfill)	1,560	in operation	EPDK List + Selman Cagman Mail + http://www.emo.org.tr/ekler/0d936dc2a4718f8_ek.pdf	Selman: 1,35 MW
solea energy			Undefined			http://www.emo.org.tr/ekler/0d936dc2a4718f8_ek.pdf	
Kirsehir							
Kırsehir Sugar Plant			Industry (wastewater)		in operation	Selman Cagman Plant List	1,4 mio m³ / a

İlci Tarım			Undefined	0,249		Jenbacher List	
Kocaeli							
Tubitak	Izmit		Agriculture (6000t grass, 2000t fruit & veg waste, 450t slaughterhouse waste, 2000t chicken manure, 350t cattle manure)	0,330	in operation	Jenbacher List	
Pakmaya Yeast Production			Industry (wastewater)		in operation	Selman Cagman Plant List	1,1 mio m³ / a
Fritolay Suadiye / Arbiogaz	Izmit	Suadiye	Industry (wastewater, organic waste)	0,400	in operation	Arbiogaz Homepage + Jenbacher List + Selman Cagman Plant List	Jenbacher: 0,635 MW 1,7 mio m³ / a
Izaydaş İzmit Atık ve Artıkları Arıtma Yakma ve Değerlendirme Anonim Şirketi	Izmit	Solaklar Köyü mevkii/ İzaydaş Biyogaz Enerji Üretim Santrali	Municipality (landfill)	0,750		EPDK Biyogaz Incelemedeki Lisanslar v0 090211	
Körfez Enerji Sanayi Ve Ticaret Anonim Şirketi	Izmit	Solaklar mevkii / Kocaeli Çöp Biyogaz Tesisi Projesi	Undefined	2,400		EPDK Biyogaz Incelemedeki Lisanslar v0 090211	
Konya							
Seydibey Patates Entegre Üretim Tesisleri	Seydibey		Industry (potato waste)	6,000	in operation	http://www.pankobirlik.com.tr/Haber.aspx?ID=79	
Konbeltaş Konya İnşaat Taşımacılık Hizmet Danışmanlık Ve Park İşletmeciliği Ticaret Anonim Şirketi	Karatay	Tatlıcak mevkii /Konya Atıksu Arıtma Tesisi Elektrik Santralı	Industry (wastewater)	2,436	in operation	EPDK Biyogaz Verilmis Lisanslar v0 090211 + DBFZ List + Jenbacher List	DBFZ: 1,87 MW Jenbacher: 2,505 MW
ITC-KA Enerji Üretim Sanayi ve Ticaret Anonim Şirketi	Karatay	Aslım Katı Atık Alanı mevkii/ITC-KA Aslım Enerji Üretim Tesisi	Municipality (landfill)	5,804	licensed	EPDK Biyogaz Incelemedeki Lisanslar v0 090211 + Jenbacher List	Jenbacher: 5,652 MW
Mersin							
Fritolay Tarsus / Arbiogaz	Tarsus		Industry (wastewater,	0,660		Jenbacher List	

			organic waste)				
Mersin Büyükşehir Imar Inşaat Ve Ticaret A.Ş.	Akdeniz	Karaduvar Mevkii	Undefined	1,900	licensed	EPDK List	
Mugla							
Muğla Atıksu Arıtma / Arbiogaz			Undefined (wastewater)	0,249		Jenbacher List	
Sakarya							
Sakarya (farmers)			Agriculture (animal manure)	0,330	in operation	http://www.ciftciplat.com/print.php?type=N&item_id=72	
	Kaynarca		Agriculture (animal manure)		in planning	http://www.istanbulburda.com/Kaynarca %27da-ilk-ev-tipi-biyogaz-tesisinde-gaz-uretimine-baslandi-SAKARYA-66990	
Altra Enerji Üretim San. Ve Tic. A.Ş.	Söğütlü	Soğucak Köyü	Undefined	6,220		EPDK Biyogaz Incelemedeki Lisanslar v0 090211	
Pamukova Yenilenebilir Enerji ve Elektrik Üretim A.Ş. / Ak Gıda / Arbiogaz	Pamukova	Adapazari / Paşa Deresi Mevkii / Pamukova Biyogaz Santralı	Undefined	1,400	licensed	EPDK Biyogaz Incelemedeki Lisanslar v0 090211 + Jenbacher List	Jenbacher: 1,487 MW
Samsun							
	Vezirköprü		Agriculture (90 tons/day cattle manure)	0,500		http://www.netkulis.com/haber-13207-Vezirkopruye_Biogaz_Tesisi_kurulacak	
Samsun Avdan Enerji Üretim ve Ticaret A.Ş.	Ilkadim	Avdan mevkii / Samsun Avdan Biyogaz Tesisi	Municipality (landfill)	2,472	in operation	Selman Cagman Mail + EPDK Biyogaz Incelemedeki Lisanslar v0 090211	
Sanliurfa							
ŞANLIURFA ŞUTSO			Agriculture (cattle manure)		in planning	http://www.basinbatman.com/haber/ekonomi/12476/sanliurfa-biyogaz-	

						uretimi-icin-kollari-sivadi.html	
Tekirdag							
Ekolojik Enerji Anonim Şirketi	Çorlu	Karatepe mevkii	Undefined	0,800	licensed	EPDK Biyogaz Verilmis Lisanslar v0 090211	
Tokat							
Tokat Atıksu Arıtma Tesisi			Undefined (wastewater)	0,330		Jenbacher List	
Yozgat							
Yozgat Sugar Plant			Industry (wastewater)		in operation	Selman Cagman Plant List	1,4 mio m³ / a
Zonguldak							
Eregli Sugar Plant	Eregli		Industry (wastewater)		in operation	Selman Cagman Plant List	1 mio m³ / a

Appendix 2: Limitations of parameters regarding to Production, Importation and Placing on the Market of Agricultural Organic, Organomineral Fertilizers, Soil Regulators and Other Microbial Product with Enzyme Content regulation.

Parameters	Maximum value
Total Bacteria (Anaerobic, microaerophile)	1.0 x 103 kob/g or kob/ml
Enterobactericea	<3 cfu/ml
Escherichia coli	Not
Clostridium spp.	:<2 kob/g or kob/ml
Salmonella spp.	Not (25 g or ml)
Mycobacterium spp.	Not (25 g or ml)
Staphylococcus surcus	Not (25 g or ml)
Bacillus anthracis	Not (25 g or ml)
Bacillus cereus	Not (25 g or ml)
Total fungi and yeast	<3 kob/g or kob/ml
Fecal Coliform	< 1.0x103 kob/g or kob/ml
Total Coliform	<1.0x103 kob/g or kob/ml
Salmonella spp.	<3 MPN/4 g or ml
H5N1 (only for poultry manure)	Not
Analysis of lyssa virus (for bat manure)	Not
Cadmium	3 ppm
Copper	450 ppm
Nickel	120 ppm
Lead	150 ppm
Zinc	1100 ppm
Mercury	5 ppm
Chromium	350 ppm
Stannic	10 ppm

Appendix 3: Possible biogas yields in kind of substrates based on TUBITAK.

Residues	Amount (kg)	total biogas (m3)	total methane (m3)	biogas yield (m3/tons)	methane yield (m3/tons)	(%) Methane ratio
fodder beet	100	11.89	6.54	118.9	65.4	55
potato	100	10.05	5.53	100.5	55.3	55
maize	100	45.62	25.09	456.2	250.9	55
wheat	100	53.67	29.52	536.7	295.2	55
rape	100	50.59	27.83	505.9	278.3	55
grass	100	10.08	5.54	100.8	55.4	55
trefoil	100	10.18	5.6	101.8	56	55
squash	100	8.53	4.69	85.3	46.9	55
sugarbeet	100	5.02	2.76	50.2	27.6	55
rye	100	49.75	27.36	497.5	273.6	55
barley	100	63.98	35.19	639.8	351.9	55
napier grass	100	7.49	4.12	74.9	41.2	55
head of sugar beet	100	43.95	24.17	439.5	241.7	55
mustard	100	13.91	7.65	139.1	76.5	55
wheat straw	100	34.8	19.14	348	191.4	55
rice straw	100	47.36	26.05	473.6	260.5	55
sugar cane leaves	100	9.66	5.31	96.6	53.1	55
broad bean	100	13.91	7.65	139.1	76.5	55
beer production waste	100	61.57	33.86	615.7	338.6	55
silaged grass	100	30.55	16.8	305.5	168	55
vegetable waste	100	7	3.85	70	38.5	55
cereal	100	52.82	29.05	528.2	290.5	55
hay	100	41.42	22.78	414.2	227.8	55
food waste	100	6.17	3.39	61.7	33.9	55
Slaughterhouse Wastewater	100	13.25	7.29	132.5	72.9	55
leaves	100	12.75	7.01	127.5	70.1	55
branch	100	10.29	5.66	102.9	56.6	55
mix of grass, leaves and branches	100	10.05	5.53	100.5	55.3	55

Appendix 4: The list of universities and their publications in the field of biogas technologies.

MIDDLE EAST TECHNICAL UNIVERSITY

- Incecik S, Atimtay A., and Choi H., Preface. Int. J. Environment and Pollution, Vol. 39, Nos. 3/4, 2009
- Isci A. and Demirer G. N., 2007. “Biogas production potential from cotton waste”, Renewable Energy, Vol. 32, No: 5, 750-757.
- Demirer G.N. and Chen S., 2004. "Effect of retention time and organic loading rate on anaerobic acidification and biogasification of dairy manure", Journal of Chemical Technology & Biotechnology, Vol. 79, No:12, 1381-1387.
- Erguder T.H., Tezel U., Guven E., and Demirer G.N., 2001. "Anaerobic biotransformation and methane generation potential of cheese whey in batch and UASB reactors", Waste Management, Vol. 21, No:7, 643-650.
- Demirer G.N., Duran M., Erguder T.H., Guven E., Ugurlu O. and Tezel U., 2000. " Anaerobic treatability and biogas production, potential studies of different agro-industrial wastewaters in Turkey, Biodegradation, Vol. 11, No: 6, 401-405.
- Gungor G. and Demirer G.N., 2003. "Biogas production potential from broiler and cattle manure", 2. Renewable Energy Symposium, Chamber of Electrical Engineers, 15-18 October 2003, Đzmir, Turkey, 355-362. (in Turkish)
- Demirer G.N., Duran M., Guven E., Ugurlu O., Erguder T.H., Tezel U., Sen S., Korkusuz E.A., and Varolan N., 2001. "Biogas production from organic waste by anaerobic methods: applicability in Turkey", Renewable Energy Symposium, Chamber of Electrical Engineers, 18-20 January 2001, Izmir, Turkey, 99-105. (in Turkish)
- Demirer G.N., Duran M., Guven E., Ugurlu O., Erguder T.H., Tezel U., Sen S., Korkusuz E.A., Varolan N., Demirci G., Capar G., Acuner E., and Sahinkaya E., 2000. "An example for biomass energy: Biogas production from organic waste by anaerobic methods", Third National Clean Energy Symposium, Istanbul Technical University and Clean Energy Foundation, 15-17 November 2000, Istanbul, Turkey, 467-474. (in Turkish)
- Demirer G.N., Duran M., Erguder T.H., Guven E., Ugurlu O. and Tezel U., 1999. “Anaerobic treatment and biogas generation potential of organic waste: Potential and technological applicability in Turkey", Environmental Pollution Priorities of Turkey III, Gebze Yuksek Teknoloji Enstitusu, 18-19 November 1999, Gebze-Kocaeli, Turkey. (in Turkish)
- Erguder T.H. and Demirer G.N., 1999. “Anaerobic treatment and biogas generation potential of olive mill waste" First Ecological Agriculture Symposium, Ekolojik Tarim Organizasyonu Dernegi-Ege Universitesi, 21-23 Haziran 1999, Izmir, Turkey.(in Turkish)

ULUDAĞ UNIVERSITY, BURSA

- Ulusoy Y., Ulukardesler A.H., Unal H., Alibas K., 2009. “Analysis of biogas production in Turkey utilizing three different materials and two scenarios”, African Journal of Agricultural Research, 4, 10, 996-1003.
- Ulusoy Y., Unal H., Alibas K., 2009. Bursa Ili Karacabey Ilcesinde Ornek bir Biyogaz Tesisinin Kurulabilirliği icin Tarımsal ve Gıda Artıklarının Enerji Potansiyeli”, 25. Tarımsal Mekanizasyon Ulusal Kongresi Bildiri Kitabı, 1-3 Ekim 2009, Isparta.

SULEYMAN DEMiREL UNIVERSITY

• "Climatization of Renewable Energy Sourced heat - Use Potentials in the Cooling Processes " (TUBITAK)

HACETTEPE UNIVERSITY

• "Use of Electricity generated during biological treatment and Enhancing The potential using ways", Master Thesis, Zehra Esra Ilhan, Associate Advisor. Dr. Selim Sanin.

• "Long-Term Energy Demand of Turkey and the estimated emission of CO_2", Master Thesis, David KocabasTuncar, Dr. Advisor. Koksal AYDINALP.

CUMHURiYET UNIVERSITY

• Murat TOPAL, E. Thermal Arslan, 2008. 'Biomass Energy and Turkey. VII. National Clean Energy Symposium, UTES 2008, ITU, Istanbul, 17-21 December 2008, 241-248.

• Heat E. Arslan, Sibel LION, Murat TOPAL, 2007. 'Evaluation of Biomass Waste'. The National Environment Symposium, University of Mersin. Department of Environmental Engineering, Çiftlikköy Campus, Mersin, 18-21 May 2007, 1-7.

• Heat E. Arslan, Sibel LION, Murat TOPAL, Ubaida IPEK, 2007. 'Biomass Farming'. I. Climate Change Congress of Turkey, Istanbul Technical University, Maslak KSB Hall, Istanbul, Turkey, April 11-13, 2007, 479-484.

• Heat E. Arslan, Sibel LION, Murat TOPAL, 2007. 'Biomass energy conversion.' I. Climate Change Congress of Turkey, Istanbul Technical University, Maslak KSB Hall, Istanbul, Turkey, April 11-13, 2007, 485-492.

• Sibel LION, Murat TOPAL, E. Thermal Arslan, 2006. ' Solution for Depleted Energy Resources: Biomass Energy'. VI. National Clean Energy Symposium, UTES, Suleyman Demirel University, Isparta, Turkey, 25-27 May 2006, 788-795.

• Murat TOPAL, E. Thermal Arslan, Ferhat Kilinc, 2009. 'The World and the Biomass Energy', 17 National Thermal Science and Technology Congress, Sivas, 24-27 June 2009.

Appendix 5: Contacts of different institutions in the field of biogas in Turkey.

Name	Address	Tel.	Mail	Website	Remarks
Associations					
Türkiye Kırmızı Et Üreticileri Merkez Birliği **Turkey Red Meat Producers' Association**	Mustafa Kemal Mahallesi 2140. Sokak Demirler Plaza 18/3 Çankaya/ANKARA	0090 312 219 51 84	tuketbir@ketbir.org.tr	http://ketbir.org.tr	They could provide information regarding red meat potential of Turkey
Yumurta Üreticileri Merkez Birliği **Turkish Egg Producers Association**	Mustafa Kemal Mahallesi 2140. Sokak Demirler Plaza 18/3 Çankaya/ANKARA	0090 312 473 20 00	bilgi@yum-bir.org	www.yum-bir.org/	They could provide information regarding poultry potential of Turkey
Afyon Güçbirliği Tavukçuluk	Derviş Paşa Mah. Bilgi Cad. Dörtler Apt. No:25/A Afyonkarahisar Merkez, Afyonkarahisar	0090 272 214 73 00			They could provide information regarding poultry potential of Turkey
Türkiye Damizlik Siğir Yetiştiricileri Merkez Birliği **Cattle Breeders' Association of Turkey**	Eskişehir Yolu üzeri, Mustafa Kemal Mh. 2120 Cadde, No: 5 Gözüm İş Merkezi Daire: 1-2 06520 Çankaya - ANKARA	0090 3 12 219 45 64 (Pbx)	dsymb@dsymb.org.tr	www.dsymb.org.tr	They could provide information regarding bovine potential of Turkey
ETBİR Et Üreticileri Birliği **Meat Producers´ Association**	Atlantis İş Merkezi C Blok No: 14 Osmanlı Bulvarı Kurtköy İstanbul	0090 216. 478 62 79	etbir@etbir.org	www.etbir.org	They could provide information regarding meat industry potential of Turkey

Beyaz Et Sanayicileri Ve Damizlikcilar Birligi White Meat Industrialists and Breeders Association	Çetin Emeç Bulvarı 8. Cad 86.Sokak 5/A Öveçler ANKARA	0090 312 472 77 88	besd-bir@besd-bir.org	www.besd-bir.org	They could provide information regarding white meat potential of Turkey
Alternatif Enerji ve Biyodizel Üreticileri Birligi (ALBIYOBIR) Alternative Energy and Biodiesel Producers Association	8. Cadde 81. Sokak 12/A Daire: 1 TR- A.Öveçler Çankaya/ Ankara	0090 312 472 13 65 0090 312 472 13 66	bilgi@albiyobir.org.tr	www.albiyobir.org.tr	They could provide information regarding industries which are interested in renewable energy
SETBİR Türkiye Süt Et Gida Sanayicileri ve Üreticileri Birligi Turkey Milk Meat Food Industrialists and Manufacturers Association	Şehit Ersan Caddesi Çoban Yıldızı Sokak 100. Yıl Apt. No: 1/14 06680 Çankaya - Ankara	0090 312 428 47 74-75	setbir@setbir.org.tr	http://www.setbir.org.tr	They could provide information regarding Turkey´s milk, meat and food industry residues potential and distribution
BEYAZ DER Beyaz Et Toptancıları ve Perakendicileri Derneği Association of Meat Wholesalers and retailers	MERKEZ-Yeni Mahalle Hekimsuyu Cad. No:35 Küçükköy / G.O.Paşa- İST.	0090 212 609 33 33	info@beyazder.com	www.beyazder.com/	They could provide information regarding Turkey´s poultry meat industry residues potential and distribution
Yerli Enerji Teknolojileri Araştirma Derneği (YETA) Local Energy Technology Research Association	Mithatpaşa Mah. Adnan Menderes Cad. No:142 TR-54000 Adapazarı/ Sakarya	0090 264 291 44 70	bilgi@yeta.org.tr	www.yeta.org.tr	They could provide analyses regarding local energy technologies

Private					
Biovizyon Energy Ltd. (BIOVIZYON)	Kutay Han No: 103/14 TR- 34752 İçerenköy, Ataşehir/ Istanbul	0090 216 574 9443	info@biovizyon.com	www.biovizyon.com	They doing projects regarding renewable energy
Recydia Atık Yönetimi A.Ş.	Kemalpaşa Caddesi No:19 Kat:2 Işıklı Bornova - İzmir	0090 232 472 10 50	info@recydia.com	http://www.recydia.com	They provide studies regarding sustainable resource management
MTB Enerji Mühendislik Danismanlik	Nasuh Akar Mahallesi 1402. Sokak No: 11/1 Balgat - ANKARA / TÜRKIYE	0090 312 2847125 (Pbx)	info@mtbenerji.com.tr	www.mtbenerji.com.tr	Energy, engineering and consultancy studies
TTGroup Energy	Veko Giz Plaza, Meydan Sk. No.3, Kat.21 D.75, 34396, Maslak Istanbul, Türkiye – TR	0090 212 290 2780 (pbx)		http://ttgroupenergy.com	Biogas studies and construction of biogas plant facilities
ProWind Alternatif Enerji	Kayseri K. Maras Yolu Üzeri 6. km. TR-46000 K. Maras	0090 344 234 21 10	info@alternatifenerji.de	www.alternatifenerji.de	Consultancy firm in the field of renewable energy
TEKNODAN	Ahmet Rasim Sk. Yuvam Apt. No: 44/7 Yukarı Ayrancı /ANKARA	0090 312 440 16 11	info@teknodan.com.tr ertan.tas@teknodan.com.tr omer.kuzu@teknodan.com.tr	http://www.teknodan.com.tr	Consultansy firm and Turkey´s potential renewable energy maps
Prokom Madencilik	Erzincan Organize Sanayi Bölgesi 3.Cadde No:17 Erzincan Türkiye	0090 3123545437	info@prokomelektronik.com.tr	www.prokomelektronik.com.tr	They could provide technology which is necessary for biogas plants

Abalaco Enerji, Biyogaz ve Geri Dönüşüm A.Ş. (ABALACO) Abalaco Energy, Biogas and Recycling Co.	Tonguç Caddesi 17/2 TR-07000 Antalya	0090 532 265 7922	gokcenalatas@hotmail.com	www.abalaco.com	Biogas projects within Turkey
ITC-KA Enerji Üretim San. ve Tic. A.Ş.	Nato Yolu Ege Mah. Mamak Katı Atık Alanı Ankara	0090 312 390 87 01	info@itcturkiye.com	www.itcturkiye.com	Waste management and projects regarding producing energy from waste
Ege Biyoteknoloji A.Ş. EGE BIYOTEKNOLOJI Inc.	Şehit Nevres Bulvarı, Kızılay İş Merkezi No:3/5 TR-5210 Alsancak/ İzmir	0090 232 464 57 67 - 0090 232 464 57 68	info@egebiyoteknoloji.com	www.egebiyoteknoloji.com	They could provide workshops regarding energy
Paksoy Ticaret Ve Sanayi A.Ş.	Paksoy Ticaret Ve Sanayi A.Ş. Karataş Cad. No:184 TR-01280 Yüreğir/ Adana	0090 322 311 4830	paksoy@paksoy.com.tr	www.paksoy.com.tr	They work with biodisel
En-Cev	Mahatma Gandi Cad. No : 92/ 2-3-4-6-7 06680 G.O.P. ANKARA	0090 312 447 26 22	encev@encev.com.tr	www.encev.com.tr	Labtests, they do environmental impact assessments
ANDRITZ HYDRO	Hollanda caddesi, 695 Yildiz - Cankaya 06550 Ankara Türkiye	0090 3124088000	contact-hydro.tr@andritz.com	http://www.andritz.com	They supply technologies for renewable energy
Asmaz Enerji	ASMAZ Plaza Fatih Caddesi 35 77200 Yalova Türkiye	0090 226 813 67 07	info@asmaz.com.tr	http://www.asmaz.com.tr	Construction company

Tarimsal Kimya Teknolojileri A.S. (TARKIM) Agricultural Chemical Technologies Inc.	Valikonagi Caddesi, No: 173, K:4, D:3 TR-34365, Nisantasi/ Istanbul	0090 212 219 2893	info@tarimsalkimya.com.tr	www.tarkim.com.tr	They produce bioethanol
Entec Biogas Gmbh	Schilfweg 1 A-6972 Fussach	0043 5578 7946	office@entec-biogas.at	www.entec-biogas.com	Biogas projects
EKOLOJİK ENERJİ A.Ş	Hasdal Yolu 6.km Kemerburgaz-Eyüp İstanbul Türkiye	00902123602981	caglar.alsu@ekolojikenerji.com.tr	http://www.ekolojikenerji.com.tr	Energy from solid waste
GMK - Gesellschaft für Motoren und Kraftanlagen mbH	Reuterstraße 5 18211 Bargeshagen Germany	0049 3 82 03 - 77 58-0	info@gmk.info	www.gmk.info	Biogas company
Solea Enerji	Gazcılar Cd. / Ata Sk. / PETEK BOZKAYA İŞHANI / Blk: D / No: 5/104 Bursa Türkiye	0090 224 253 30 22	info@soleaenerji.com	http://www.soleaenerji.com	Investments in renewable energy
RWE			muratzekeriya.aydin@rwe.com	www.rwe.com	energy company
Anksan Meat Co. Inc.			sayans@anksanet.com		Agribusiness, possible investor
Aydoganlar Tarim		+90 358 486 81 97			Agribusiness, possible

Hayvancilik A.S.				investor
2G Energietechnik GmbH	+49 2568 9347 1865	c.yayla@2-g.de		Energy company
Godd Energy	+49 30 859 759 41	dursun.yigit@goddenergy.com	www.goddenergy.com	Energy company
Bilgin Energy		bkilic@bilgin.com.tr		Energy company
Biogas Weser-Ems GmbH & Co. KG		michael.schlie@biogas-weser-ems.de	+49 44 91 93 800 165	Energy company
BIOLAK Group - BINOBA	+90 312 475 41 03	s.basol@binoba.com.tr		
Biyogaz Teknolojileri Danışmanlık ve Projelendirme		altan@elitpazarlama.com.tr		Energy Consultancy
BM Holding	+90 312 286 53 53	sibel.hacioglu@bmmuh.com.tr		Energy company
Borusan		gerdogan@borusan.com		Energy company
Burdan Yumurta	+90 224 676 32 07	ibrahim.coskan@matli.com.tr	www.burdanyumurta.com	Agribusiness, possible investor
CRES Energy	+90 332 261 01 54	gablay@cres-consulting.com	www.cres-consulting.com	Energy Consultancy
E.ON International Energy	+90 212 371 46 79	buelent.mutlu@eon.com	www. eon.com	Energy company
EDSM Enerji	+90 212 275 5234	akunar@edsmenerji.com.tr	www. edsmenerji.com.tr	Energy Consultancy
EnBW		f.schuetz@enbw.com		Energy company
Ençev Enerji		pelin@encev.com.tr		Energy company
Hun Biyogaz	+90 216 325 84 89	altan.denizsel@hunbiyogaz.com		Energy company
Keskinoglu	+90 236 427 25 72	a.pestemalcioglu@keskinoglu.com.tr	www.keskinoglu.com.tr	Possible investor
Kozlu		mahmut@kozlu.com.tr	www.kozlu.com.tr	Possible investor
Opal Enerji ve Gübre		tugrul.durakbasa@opalenerji.c	www. opalenerji.com.tr	Energy and fertilizer

Üretim Tic. ve San. A. S.			om.tr		company
Pinar		90 232 877 09 20	zeki.ilgaz@pinaret.com.tr	www. pinaret.com.tr	Agribusiness, possible investor
Schmack Biogas GmbH		+49 9431 751 235	suat.karakuz@schmack-biogas.com		Energy company
WIP - Renewable Energies		+49 89 720 12 739	dominik.rutz@wip-munich.de	www. wip-munich.de	Energy company
Ministires					
Enerji ve Tabii Kaynaklar Bakanlığı Ministry of Energy and Natural Resources	İnönü Bulvarı No: 27 TR-06100 Bahçelievler / Ankara	0090 312 212 64 20	bilgi@enerji.gov.tr	www.enerji.gov.tr	They have power the make law, invest projects and they could provide special permission to reach more detailed database
Gida Tarim ve Hayvancilik Bakanligi Ministry of Food Agriculture and Livestock	Eskişehir Yolu 9 km. Lodumlu / ANKARA	0090 312 287 33 60 (10 hat)	bilgi@tarim.gov.tr	www.tarim.gov.tr	They have power the make law, invest projects and they could provide special permission to reach more detailed database
Türkiye Orman ve Su Isleri Bakanligi Ministry of Water Affairs	Söğütözü Cad. No14/E Beştepe 06560 Yenimahalle - ANKARA	0090 312 207 50 00		www.ormansu.gov.tr	They have power the make law, invest projects and they

and Forestry					could provide special permission to reach more detailed database
Türkiye Cumhuriyeti Çevre ve Sehircilik Bakanlığı Ministry of Environment and Urbanisation	Vekaletler Cad. No:1 Bakanlıklar Ankara	0090 312 410 10 00		www.cevresehircilik.gov.tr	They have power the make law, invest projects and they could provide special permission to reach more detailed database
Bilim Sanayi ve Teknoloji Bakanligi Ministry of Science Industry and Technology	Mustafa Kemal Mahallesi Dumlupınar Bulvarı Eskişehir Yolu 2151.Cadde No154 06510 Çankaya /ANKARA	0090 312 201 50 00	webmaster@sanayi.gov.tr		They have power the make law, invest projects and they could provide special permission to reach more detailed database
Chambers					
Alman-Türk Ticaret ve Sanayi Odası Deutsch-Tükische Industrie- und Handelskammer	Yeniköy Cad. No. 88 TR-34457 Tarabya/ Istanbul	0090 212 363 05 00	info(at)dtr-ihk.de	www.dtr-ihk.de	They could create a bridge between Turkish and German investors and researchersinvest projects

Biyogaz Yatırımları Geliştirme Derneği (BiyogazDer) Biogas Investment Development Association	Uzun Çayır Caddesi Yapı İş Merkezi B2 Blok Kat: 1 D:32 TR-34722 Hasanpaşa / Kadıköy – İstanbul	0090 216 325 84 89	info@biyogazder.org	www.biyogazder.org	They could find out possible investors for biogas
Biyodizel Sanayicileri ve Isadamlari Dernegi (BİYOSIAD) Biodiesel Industrialists & Businessmen Association	TR-5210 Sehit Nevres Bulvari 3/5, Alsancak/ Izmir	0090 232 464 42 53	info@biyosiad.org	www.biyosiad.org	They could provide information regarding biodiesel businesses
Orman Genel Müdürlüğü General Directorate of Forestry	Gazi Tesisleri TR-06560 Gazi/ Ankara	0090 312 296 4000	gdf@ogm.gov.tr	www.ogm.gov.tr	They could invest projects and they could provide special permission to reach more detailed database
Elektrik Isleri Etüt Idaresi Genel Müdürlügü General Directorate of Electrical Power	Eskisehir youl 7. Km No:166 06520 Cankaya-Ankara	0090 312 295 50 00	elektriketut@eie.gov.tr	www.eie.gov.tr/	They are responsible from electrical affairs
TAGEM General Directorate Of Agricultural Research And Policies	Tarım Kampüsü İstanbul Yolu Üzeri, No :38, P.K.51 06171 Yenimahalle Ankara	0090 312 315 76 22-26	bilgi@tagem.gov.tr	www.tagem.gov.tr	They are responsible from agricultural policies and researches

Başbakanlık Yatırım Destek ve Tanıtım Ajansı (TYDTA) **Investment Support and Promotion Agency of Turkey (ISPAT)**	Akay Caddesi no:5 TR-06640 Çankaya/Ankara	0090 312 413 89 00	info@invest.gov.tr	www.invest.gov.tr	They could provide investment for possible projects
TÜBİTAK Marmara Araştırma Merkezi **Turkey scientific and technical research institute**	TÜBİTAK Gebze Yerleşkesi Marmara Araştırma Merkezi Barış Mah. Dr. Zeki Acar Cad. No:1 P.K. 21 41470 Gebze Kocaeli	0090 262 677 20 00	bilgi@mam.gov.tr	www.mam.gov.tr	They could provide scientific and technical research
Izmit Atik ve Artiklari Aritma Yakma Ve Değerlendirme (İzaydaş) A.Ş. **Izmit Waste and Residue Treatment, Incineration and Recycling Co. Inc.**	Solaklar Köyü Mevkii PK 66 TR-41000 İzmit/ Kocaeli	0090 262 319 44 44	him@izaydas.com.tr	www.izaydas.com	Biogas projects
Universities					
Dokuz Eylül Üniversitesi, Cevre mühendisligi bölümü **Prof.Dr. Ayse Filibeli**	Dokuz Eylül Üniversitesi,Mühendislik Fakültesi, Çevre Mühendisliği Bölümü, Kaynaklar Kampüsü, 35160,Buca-İzmir	0090 232453 10 08/1117	ayse.filibeli@deu.edu.tr	www.deu.edu.tr	They could provide researches, knowledge, data, labtests and workshops

Karabük Üniversitesi, Mühendislik Fakültesi, Cevre mühendisligi bölümü, Prof. Dr. Durmuş KAYA	Balıklarkayası Mevkii 78050 KARABÜK	0090 370 4332021	dkaya@karabuk.edu.tr	http://muh.karabuk.edu.tr	They could provide researches, knowledge, data, labtests and workshops
Middle East Technical University, Environmental Engineering Department, Prof. Dr. Göksel N. Demirer	İnönü Bulvarı 06531 Ankara - Türkiye	0090 312-210-5867	goksel@metu.edu.tr	www.metu.edu.tr	They could provide researches, knowledge, data, labtests and workshops
Istanbul Teknik Üniversitesi, İnşaat Fakültesi, Çevre Mühendisliği Bölümü, Prof.Dr. İzzet Öztürk	Maslak, 34469, İstanbul	0090 212 2853790	ozturkiz@itu.edu.tr	http://www.cevre.itu.edu.tr	They could provide researches, knowledge, data, labtests and workshops
Akdeniz Üniversitesi, Ziraat Fakültesi, Tarım Makinaları Bölümü, Prof.Dr.Osman YALDIZ	Akdeniz Üniversitesi, Ziraat Fakültesi, Tarım Makinaları Bölümü 07070 ANTALYA	0090 242 310 24 36	yaldiz@akdeniz.edu.tr	http://makina.ziraat.akdeniz.edu.tr	They could provide researches, knowledge, data, labtests and workshops
Cukurova Üniversitesi, Ziraat Fakültesi, Doç. Dr. Hasan Hüseyin ÖZTÜRK	Çukurova Üniversitesi Ziraat Fakiltesi Tarım Makinaları Bölümü 01330 Balcalı/ ADANA	0090 322 338 64 08	hhozturk@cu.edu.tr	http://tarimmakinalari.cu.edu.tr	They could provide researches, knowledge, data, labtests and

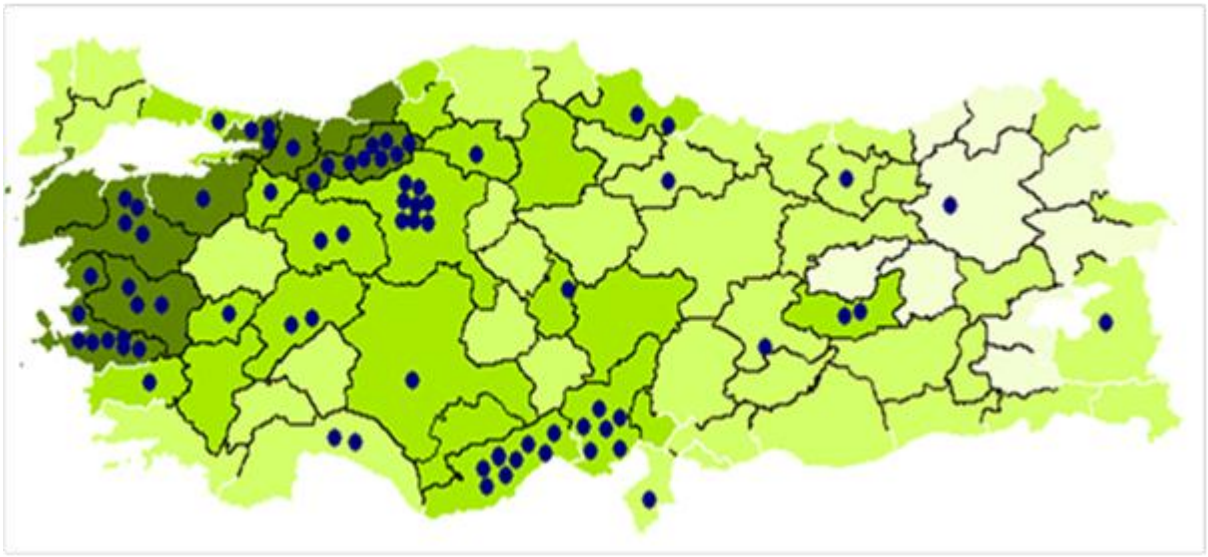
					workshops
Süleyman Demirel University, Faculty of Agriculture Department of Agricultural Machinery, Kamil Ekinci	Süleyman Demirel University, Faculty of Agriculture Department of Agricultural Machinery, Isparta 32260/ TURKEY	0090 246 2113864	kekinci@ziraat.sdu.edu.tr	www.sdu.edu.tr	They could provide researches, knowledge, data, labtests and workshops
Ege Üniversitesi, Mühendislik Fakültesi, Boyomühendislik Bölümü, Prof. Dr. Nuri Azbar	Ege Üniversitesi bilim teknoloji uygulama ve arastirma merkezi binasi 3. Kat 35100 bornova izmir	0090 232-3880378 (138)	nuri.azbar@ege.edu.tr	http://biyomuhendislik.ege.edu.tr	They could provide researches, knowledge, data, labtests and workshops
Yildiz Teknik Üniversitesi, Insaat Fakültesi Cevre Mühendisligi Bölümü Ass. Prof. Dr. Kaan Yetilmezsoy	Davutpaşa Kampüsü Z-036 34220 Esenler - İstanbul / TÜRKİYE	0090 212 383-53-76	yetilmez @yildiz.edu.tr	www.cem.yildiz.edu.tr	They could provide researches, knowledge, data, labtests and workshops

Appendix 6: Number of cattle and broiler slaughterhouses based on provinces. Data source: [18].

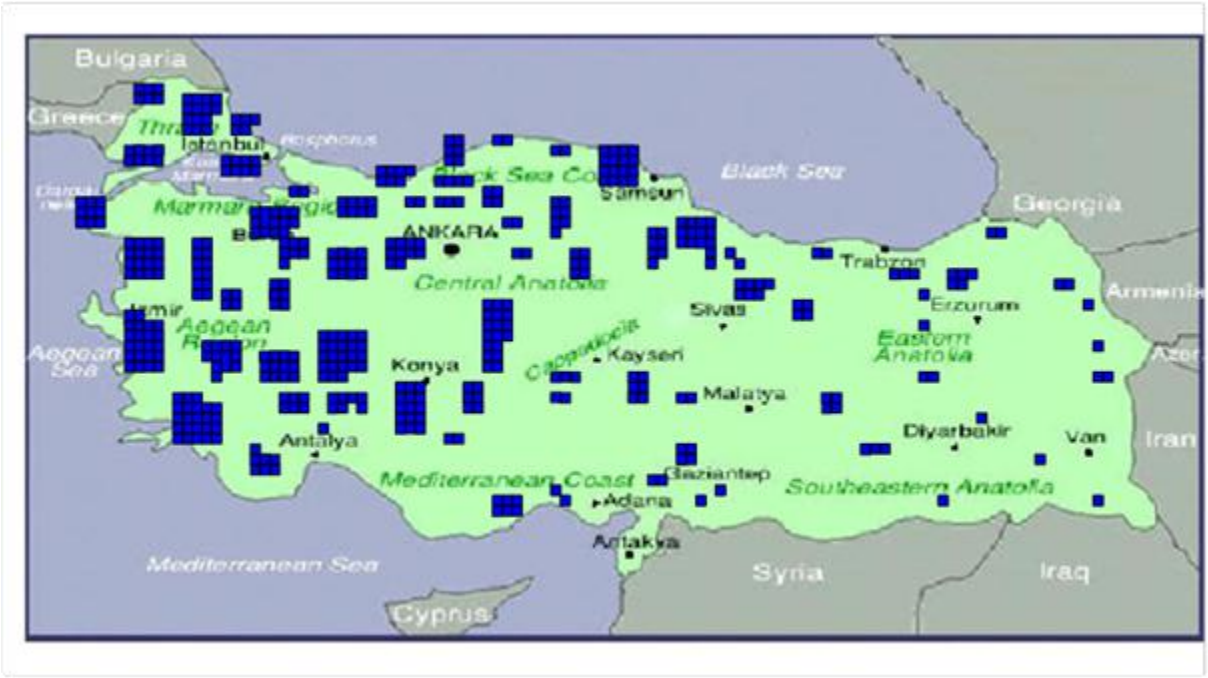
Province	Number of slaugtherhouses (Broiler chicken)	Number of integrated facilities (Broiler chicken)	Number of slaugtherhouses (Cattles)
Adana	4	4	
Afyon	1	1	
Ankara	1	5	
Antalya	1	1	
Aydin	1		
Balikesir		4	
Bilecik		1	
Bolu	1	8	
Bursa	1		
Çankiri		1	
Elaziğ		2	
Erzincan		1	
Erzurum		1	
Eskişehir		2	
Hatay		1	
İstanbul		1	
İzmir	1	7	
Kayseri		1	
Kocaeli		3	5
Konya		1	16
Malatya		2	6
Manisa	1	2	13
Mersin	3	2	6
Sakarya	1		7
Samsun		2	16
Tokat	1		7
Uşak		1	5
Van		1	2
Kirklareli			13
Kirsehir			6
Kutahya			6
Mardin			1
Mugla			13
Mus			1

Nevsehir			3
Nigde			2
Ordu			13
Osmaniye			1
Rize			1
Sanliurfa			1
Siirt			1
Sinop			2
Sirnak			1
Sivas			7
Tekirdag			10
Trabzon			1
Tunceli			1
Yozgat			6
Zonguldak			5
Total	17	55	178

Appendix 7: Poultry slaughterhouse units distribution in Turkey. Data source: [48]



Appendix 8: Distribution of total slaughterhouse facilities. Data source: [16].



Appendix 9: Biogas Potential Studies in Turkey based on years.

Year	Author	Name Of The Study	Main content
2011	I. Kocaman, F. Konukcu, G. Ozturk	Measures To Protect Environmental Problems Caused By Animal Waste In Rural Areas: A Case Study From Western Turkey	Biogas potential of animal waste in western Turkey
2011	Halil Baki Unal, Halil Ibrahim Yılmaz, Bulent Mıran	Optimal Planning Of Central Biogas Plants And Evaluation Of Their Environmental Impacts: A Case Study From Tire, Izmir, Turkey	Optimized model for biogas production from manure in Tire, Izmir, Turkey
2010	Emrah Alkaya	Effect Of Operational Parameters On Anaerobic Co-Digestion Of Dairy Cattle Manure And Agricultural Residues: A Case Study For The Kahramanmaras - Region In Turkey	Effect of temperature and HRT on anaerobic digestion
2010	Filiz Karaosmanoglu	Türkiye Biyoyakit Potansiyeli Ve Son Gelismeler	Biofuel potential of Turkey
2010	Erkan Erdogdu	A Paper On The Unsettled Question Of Turkish Electricity Market: Balancing And Settlement System (Part I)	Questioning of Turkish electricity market
2010	E. Toklu, M.S. Guney, M. Isık, O. Comaklı, K. Kaygusuz	Energy Production, Consumption, Policies And Recent Developments In Turkey	Energy production, consumption, policies and recent developments in Turkey
2010	Ibrahim Yuksel	Energy Production And Sustainable Energy Policies In Turkey	Energy policies in Turkey
2010	Elif Kirtay	Current Status And Future Prospects Of Renewable Energy Use In Turkey	Renewable energy use in Turkey
2010	Kamil Ekinci, Recep Kulcu, Durmus Kaya, Osman Yaldız, Can Ertekin, H. Huseyin Ozturk	The Prospective Of Potential Biogas Plants That Can Utilize Animal Manure In Turkey	Potential analyses of biogas production from animal manure for whole Turkey

2009		An Economic Analysis for Estimation Future of Cattle Farms: A Case Study in Erzurum	Estimation of Cattle farms´ future in Erzurum
2009	Melih Soner Celiktas, Gunnur Kocar	A Quadratichelix Approach To Evaluate The Turkish Renewable Energies	Evaluation of Turkish renewable energy potentials
2009	Yahya Ulusoy, A. Hilal Ulukardesler, Halil Ünal and Kamil Aliba	Analysis Of Biogas Production In Turkey Utilising Three Different Materials And Two Scenarios	Energy production in Turkey: the utilization of waste from tomato and pea paste production and the utilization of cattle manure.
2009		Analysis Of Renewable Energy And Its Impact On Rural Development In Turkey	Analyses of renewable energy
2009	Teknodan	Biogas Potential Study by TEKNODAN company	Turkey biogas potential analyses and various maps
2009	Durmus Kaya, Selman Cagman, Muharrem Eyidogan, Cihangir Aydoner, Volkan Coban, Mustafa Tiris	Türkiyenin Hayvansal Atik Kaynakli Biyogaz Potansiyeli Ve Ekonomisi	Turkey´s biogas potential derived from animal manure
2009	Cicek Bezir Nalan, Ozturk Murat, Ozek Nuri	Renewable Energy Market Conditions And Barriers In Turkey	Renewable energy and its barriers in Turkey
2009	F. Fusun Tatlidil, Zeki Bayramoglu and Duygu Akturk	Animal Manure As One Of The Main Biogas Production Resources: Case Of Turkey	Biogas production from animal waste in Turkey
2008	Erkan Erdogdu	An Expose Of Bioenergy And Its Potential And Utilization In Turkey	Situation of bioenergy in Turkey
2008	Ayhan Demirbas	Importance Of Biomass Energy Sources For Turkey	Biomass as a source of electricity production
2008	Neslihan Manav, Tamer Coskun, Eyüp Debik	Büyükbas Hayvan Atıklarının Yönetimi	Evaluation and management of cattle manure for energy production within suitable technologies

2008	Adem Akpınar, Murat Ihsan Komurcu, Murat Kankal, Ismail Hakkı Ozolcer, Kamil Kaygusuz	Energy Situation And Renewables In Turkey And Environmental Effects Of Energy Use	Energy situation and renewables in Turkey and environmental effects of energy use
2008	Selcuk Bilgen, Sedat Keles, Abdullah Kaygusuz, Ahmet Sarı, Kamil Kaygusuz	Global Warming And Renewable Energy Sources For Sustainable Development: A Case Study In Turkey	Global warming and renewable energy
2008	Kaya, Durmus; Çanka Kılıç Fatma; Baban, Ahmet; Dikeç Stephanie	Administrative, Institutional And Legislative Issues On Agricultural Waste Exploitation In Turkey	Legislative issuess on agricultural waste
2008	Nazmi Oruç	Seker Pancarından Alternatıf Yakıt Kaynagı Olarak Bıyoetanol Üretımı: Eskısehır Seker-Alkol Fabrıkası	Production of bioethanol as a fuel source from sugar beet:
2007	Harun Kemal Ozturk, Ahmet Yilanci, Oner Atalay	Past, Present And Future Status Of Electricity In Turkey And The Share Of Energy Sources	Evaluation of electricity in Turkey
2007	Atilla Akkoyunlu	Türkiye'de Enerji Kaynaklari Ve Çevreye Etkileri	Presentation: Energy sources and their environmental impacts in Turkey
2007	Emel Kocak Enturk, Kaan Yetilmezsoy and Mustafa Ozturk	A Small-Scale Biogas Digester Model For Hen Manure Treatment: Evaluation And Suggestions	Evaluation of hen manure for biogas production
2007	Murat Sacli	Türkiyenin Enerji Üretimi, Enerji Ithalati Ve Kullanim Alanlari	Energy production, importation and utilization in Turkey
2007	Berna Kavacık, Bahattin Topaloğlu	Peynir Alti Suyu Ve Gübre Karişimindan Biyogaz Üretimi	Biogas production from codigestion of cheese whey and manure
2006	LAYMAN REPORT	Exploitation Of Agricultural Residues in Turkey	
2006	Mehmet Caglar	Renewable Energy In Turkey	Presentation related to renewable energy current situation in Turkey
2005	Mustafa Balat	Use Of Biomass Sources For Energy In Turkey And A View To Biomass Potential	Biomass potential of Turkey and its potential for energy production
2003	Fadime Taner, Bülent Halisdemir, Ergün Pehlivan, İlker Ardıç	Türkiye'de Biyokütle Potansiyeli Ve Enerjisi	Potential of biomass and bioenergy in Turkey

2003	Kamil Kaygusuz, Ahmet Sarı	Renewable Energy Potential And Utilization In Turkey	Current situation of renewable energy in Turkey
2002	Kamil Kaygusuz	Renewable And Sustainable Energy Use In Turkey: A Review	Energy use in Turkey
2002	Kamil Kaygusuz, Abdullah Kaygusuz	Renewable Energy And Sustainable Development In Turkey	Renewable energy for sustainable development in Turkey
2001	Ayhan Demirbas	Energy Balance, Energy Sources, Energy Policy, Future Developments And Energy Investments In Turkey	Energy current situation in Turkey
2000	Göksel N. Demirer, Metin Duran, Tuba H. Ergüder, Engin Güven, Örgen Ugurlu & Ulas Tezel	Anaerobic Treatability And Biogas Production Potential Studies Of Different Agro-Industrial Wastewaters In Turkey	Biogas production from waste water

Appendix 10: Literature of biogas studies

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Appendix 11: Theoretical biogas potential of agriculturial substrates on province level

Province	Theoretical agricultural biogas potential (TJ/year)					
	manure (poultry+cattle)	cereal straw	tomato waste (field + greenhouse)	sugar beet leaf	energy crops (grass) on fallow land	total
Adana	3.088	10.996	159	22,2	581	14.847
Adiyaman	591	3.211	19	4,3	43	3.868
Afyonkarahisar	3.692	6.387	32	660,4	5.298	16.071
Agri	2.234	3.113	0,2	87,8	7.678	13.113
Aksaray	1.051	3.786	21,4	949,8	10.691	16.499
Amasya	1.427	2.899	105,3	394,6	1.214	6.040
Ankara	3.199	14.233	135,7	481,6	24.071	42.120
Antalya	1.285	4.241	3.374,4	83,1	2.922	11.905
Ardahan	2.303	483	0,0		110	2.896
Artvin	477	300	8,0		34	819
Aydin	3.142	2.348	112,8		195	5.798
Balikesir	7.894	3.937	271,4	30,6	1.174	13.306
Bartin	623	1.235	15,0		207	2.081
Batman	413	1.941	3,5		165	2.522
Bayburt	623	709	0,5	42,2	319	1.694
Bilecik	483	791	117,8	12,7	982	2.385
Bingol	706	335	6,0	13,8	575	1.635
Bitlis	477	764	7,3	130,0	1.107	2.485
Bolu	6.483	1.383	2,9	4,6	1.262	9.136
Burdur	1.409	1.949	51,5	198,0	790	4.398
Bursa	2.364	3.075	717,9	224,0	1.353	7.734
Canakkale	2.282	2.995	443,6	4,7	1.568	7.292
Cankiri	981	2.118	13,3	29,0	4.689	7.831
Corum	2.239	6.604	35,1	270,8	15.339	24.489
Denizli	2.120	4.005	65,6	168,2	928	7.287
Diyarbakir	2.478	9.219	89,9	0,0	1.757	13.543
Duzce	1.421	334	1,2	1,0	43	1.800
Edirne	1.418	4.442	25,0	2,0	8	5.896
Elazig	1.392	2.027	22,0	100,7	2.062	5.603
Erzincan	805	1.342	66,7	300,9	3.104	5.619
Erzurum	5.156	2.929	5,1	105,9	8.560	16.756
Eskisehir	1.521	6.099	32,4	817,8	8.367	16.836
Gaziantep	948	2.744	11,3	50,7	537	4.291
Giresun	823	941	1,6		492	2.258
Gumushane	591	702	2,1	29,0	2.014	3.338

Hakkari	315	218	18,4		142	693
Hatay	1.481	2.615	203,8		0	4.300
Igdir	827	704	34,5	62,8	1.812	3.441
Isparta	763	1.838	63,6	136,2	2.687	5.488
Istanbul	880	726	19,1	0,7	8	1.634
Izmir	6.076	2.306	753,1	2,7	337	9.475
Kahramanmaras	970	5.334	77,8	412,2	881	7.675
Karabuk	473	440	6,5		1.760	2.679
Karaman	475	3.031	35,9	562,5	1.790	5.895
Kars	3.803	2.251	0,0	42,8	2.515	8.611
Kastamonu	2.481	1.793	33,1	319,2	2.494	7.120
Kayseri	2.541	6.893	30,0	907,6	14.861	25.233
Kilis	78	579	28,6		0	685
Kirikkale	510	2.804	6,8	64,6	7.878	11.264
Kirklareli	1.061	2.803	9,5	27,2	86	3.986
Kirsehir	970	5.043	18,0	285,0	6.669	12.985
Kocaeli	1.621	1.516	22,5	1,1	384	3.545
Konya	5.371	21.005	107,0	4.818,3	61.697	92.998
Kutahya	1.539	4.133	36,3	268,9	3.748	9.725
Malatya	1.242	2.461	33,0	0,7	7.649	11.385
Manisa	4.997	5.162	664,9	4,0	1.005	11.832
Mardin	764	6.735	10,2		807	8.317
Mersin	2.096	4.088	853,3		2.131	9.168
Mugla	1.804	1.481	722,5	359,3	657	5.025
Mus	2.262	2.938	8,4	58,1	3.733	9.000
Nevsehir	570	4.318	16,6	300,5	3.937	9.143
Nigde	744	2.275	26,6	121,7	5.566	8.733
Ordu	1.016	1.251	2,0		306	2.575
Osmaniye	663	4.928	7,2		4	5.601
Rize	177	42	0,1		0	219
Sakarya	6.098	3.575	47,9	260,0	23	10.003
Samsun	2.987	4.620	317,5	156,7	1.228	9.309
Sanliurfa	1.844	18.420	332,0	43,6	10.892	31.532
Siirt	230	1.101	8,9	0,0	48	1.388
Sinop	798	1.201	19,7	9,1	2.228	4.256
Sirnak	328	1.633	1,9	0,0	251	2.214
Sivas	3.392	6.665	2,5	561,8	36.741	47.362
Tekirdag	1.367	3.515	9,3	25,8	6	4.922
Tokat	2.185	3.371	418,5	711,8	2.240	8.927
Trabzon	1.131	1.076	1,9		0	2.210
Tunceli	233	493	1,2	0,7	1.050	1.779
Usak	1.380	3.086	32,1	50,5	112	4.660

Van	1.588		2.217	8,8	66,5	5.936	9.816
Yalova	99		57	2,7	0,0	164	323
Yozgat	2.218		7.875	8,6	1.595,4	18.340	30.038
Zonguldak	1.780		1.515	4,8		9	3.309
total		**144.366**	**276.743**	**11.045**	**17.458**	**325.054**	**774.665**

Appendix 12: Technical biogas potential of agricultural substrates on province level

Province	Technical agricultural biogas potential (TJ/year)					
	manure (poultry+cattle)	cereal straw	tomato waste (field + greenhouse)	sugar beet leaf	energy crops (grass) on fallow land	total
Adana	2.119	1.100	63	5,6	145	3.432
Adiyaman	110	321	5	1,1	11	448
Afyonkarahisar	2.387	639	10	165,1	1.325	4.526
Agri	356	311	0,1	21,9	1.919	2.608
Aksaray	539	379	5,4	237,5	2.673	3.833
Amasya	772	290	32,2	98,7	304	1.496
Ankara	2.110	1.423	34,4	120,4	6.018	9.706
Antalya	671	424	1.757,7	20,8	730	3.604
Ardahan	357	48	0,0		28	433
Artvin	72	30	2,1		9	113
Aydin	1.792	235	31,1		49	2.106
Balikesir	5.674	394	67,9	7,7	293	6.437
Bartin	348	124	6,7		52	530
Batman	78	194	0,9		41	315
Bayburt	97	71	0,2	10,5	80	259
Bilecik	303	79	37,8	3,2	245	668
Bingol	117	33	1,5	3,5	144	299
Bitlis	82	76	1,8	32,5	277	469
Bolu	5.899	138	0,9	1,1	316	6.355
Burdur	716	195	16,9	49,5	198	1.175
Bursa	1.600	307	179,6	56,0	338	2.481
Canakkale	1.459	299	110,9	1,2	392	2.263
Cankiri	583	212	3,4	7,2	1.172	1.978
Corum	1.334	660	8,9	67,7	3.835	5.906
Denizli	1.245	401	20,7	42,1	232	1.941
Diyarbakir	408	922	23,3	0,0	439	1.793
Duzce	1.225	33	0,4	2,4	11	1.272
Edirne	721	444	6,3	13,1	2	1.186
Elazig	539	203	5,6	25,2	515	1.288
Erzincan	148	134	16,8	75,2	776	1.150
Erzurum	792	293	1,4	26,5	2.140	3.253
Eskisehir	1.017	610	8,8	204,5	2.092	3.931
Gaziantep	237	274	2,8	12,7	134	661
Giresun	127	94	0,5		123	345
Gumushane	99	70	0,6	7,2	504	680
Hakkari	55	22	4,6		35	116

Hatay	908	261	54,7		0	1.224
Igdir	137	70	8,6	15,7	453	685
Isparta	391	184	18,2	34,0	672	1.299
Istanbul	552	73	5,4	0,2	2	632
Izmir	4.171	231	200,7	0,7	84	4.687
Kahramanmaras	512	533	19,6	103,0	220	1.388
Karabuk	290	44	2,6		440	777
Karaman	297	303	9,0	140,6	448	1.197
Kars	584	225	0,0	10,7	629	1.448
Kastamonu	1.258	179	9,6	79,8	623	2.150
Kayseri	1.495	689	7,7	226,9	3.715	6.134
Kilis	35	58	7,2		0	100
Kirikkale	282	280	1,7	16,1	1.970	2.550
Kirklareli	549	280	2,4	6,8	22	860
Kirsehir	502	504	4,5	71,3	1.667	2.749
Kocaeli	1.249	152	6,9	0,3	96	1.504
Konya	3.228	2.101	27,0	1.204,6	15.424	21.985
Kutahya	855	413	10,4	67,2	937	2.284
Malatya	738	246	8,2	0,2	1.912	2.904
Manisa	4.034	516	172,6	1,0	251	4.975
Mardin	138	674	2,5		202	1.016
Mersin	1.571	409	312,4		533	2.825
Mugla	1.098	148	363,9	89,8	164	1.864
Mus	370	294	2,1	14,5	933	1.614
Nevsehir	330	432	4,2	75,1	984	1.825
Nigde	417	227	6,7	30,4	1.391	2.073
Ordu	171	125	0,8		77	374
Osmaniye	346	493	2,1		1	841
Rize	28	4	0,0		0	32
Sakarya	5.373	357	12,6	65,0	6	5.814
Samsun	1.681	462	89,1	39,2	307	2.578
Sanliurfa	350	1.842	83,8	10,9	2.723	5.010
Siirt	45	110	2,4	0,0	12	170
Sinop	410	120	5,3	2,3	557	1.094
Sirnak	55	163	0,5	0,0	63	282
Sivas	1.713	666	0,8	140,4	9.185	11.706
Tekirdag	709	351	3,6	6,4	1	1.072
Tokat	1.110	337	105,0	178,0	560	2.290
Trabzon	172	108	0,6		0	280
Tunceli	38	49	0,3	0,2	263	350
Usak	1.012	309	9,5	12,6	28	1.370
Van	270	222	2,2	16,6	1.484	1.995

Yalova	58	6	1,2	0,0	41	106
Yozgat	1.167	788	2,3	398,8	4.585	6.941
Zonguldak	1.483	151	2,1		2	1.639
total	**78.372**	**27.674**	**4.064**	**4.379**	**81.263**	**195.753**

Appendix 13: Theoretical and technical biogas potential of poultry manure on province level

			Theoretical biogas potentialof poultry manure (TJ/year)			Technical biogas potential poultry manure (TJ/year)		
Province	Number of broiler	Number of laying hen	broiler chicken	laying chicken	total	broiler chicken	laying chicken	total
Adana	6.342.055	573.417	1.108	64	1.173	1.097	64	1.161
Adıyaman	750	229.350	0	26	26	0	25	26
Afyonkarahisar	302.300	9.382.179	53	1.052	1.105	52	1.041	1.094
Ağrı		216.826	0	24	24	0	24	24
Aksaray		251.452	0	28	28	0	28	28
Amasya	32.480	1.012.423	6	113	119	6	112	118
Ankara	3.998.922	3.071.717	699	344	1.043	692	341	1.033
Antalya		519.151	0	58	58	0	58	58
Ardahan	5.500	110.092	1	12	13	1	12	13
Artvin		5.186	0	1	1	0	1	1
Aydın	2.145.098	673.642	375	76	450	371	75	446
Balıkesir	16.745.848	5.334.806	2.927	598	3.525	2.897	592	3.489
Bartın	315.000	180.113	55	20	75	54	20	74
Batman	20.700	143.600	4	16	20	4	16	20
Bayburt		40.485	0	5	5	0	4	4
Bilecik	634.000	133.795	111	15	126	110	15	125
Bingöl	582	118.605	0	13	13	0	13	13
Bitlis		110.677	0	12	12	0	12	12
Bolu	30.859.500	266.600	5.393	30	5.423	5.339	30	5.369
Burdur	2.000	199.157	0	22	23	0	22	22
Bursa	3.643.770	1.933.380	637	217	854	630	215	845
Çanakkale	3.561.700	240.411	622	27	649	616	27	643
Çankırı	914.000	252.683	160	28	188	158	28	186
Çorum	25.000	3.864.377	4	433	438	4	429	433
Denizli	1.067.400	1.715.344	187	192	379	185	190	375
Diyarbakır	8.000	374.683	1	42	43	1	42	43
Düzce	5.782.500	361.100	1.011	40	1.051	1.000	40	1.041
Edirne		211.227	0	24	24	0	23	23
Elazığ	2.015.500	361.679	352	41	393	349	40	389
Erzincan		290.300	0	33	33	0	32	32
Erzurum	10.312	181.475	2	20	22	2	20	22
Eskişehir	2.345.310	1.009.915	410	113	523	406	112	518
Gaziantep	305.206	532.525	53	60	113	53	59	112
Giresun		41.680	0	5	5	0	5	5
Gümüşhane	9.000	94.086	2	11	12	2	10	12
Hakkari		77.100	0	9	9	0	9	9

Hatay	1.714.261	376.880	300	42	342	297	42	338
Iğdır	9.870	121.330	2	14	15	2	13	15
Isparta	6.610	167.135	1	19	20	1	19	20
İstanbul	677.000	983.526	118	110	229	117	109	226
İzmir	10.971.072	3.531.263	1.917	396	2.313	1.898	392	2.290
Kahramanmaraş	110.500	315.550	19	35	55	19	35	54
Karabük	490.000	211.012	86	24	109	85	23	108
Karaman		1.082.281	0	121	121	0	120	120
Kars		144.650	0	16	16	0	16	16
Kastamonu	21.014	292.654	4	33	36	4	32	36
Kayseri	537.850	3.238.910	94	363	457	93	359	453
Kilis	104.000	84.500	18	9	28	18	9	27
Kırıkkale	84.000	364.150	15	41	56	15	40	55
Kırklareli	31.950	296.086	6	33	39	6	33	38
Kırşehir	18.000	275.715	3	31	34	3	31	34
Kocaeli	4.871.140	392.855	851	44	895	843	44	886
Konya	740.448	8.723.304	129	978	1.107	128	968	1.096
Kütahya	647.634	555.596	113	62	175	112	62	174
Malatya	1.238.849	191.200	217	21	238	214	21	236
Manisa	14.518.790	5.324.684	2.537	597	3.134	2.512	591	3.103
Mardin	750	247.093	0	28	28	0	27	28
Mersin	5.486.452	971.900	959	109	1.068	949	108	1.057
Muğla	1.724.900	879.923	301	99	400	298	98	396
Muş		326.990	0	37	37	0	36	36
Nevşehir		810.800	0	91	91	0	90	90
Niğde	200.000	496.891	35	56	91	35	55	90
Ordu	3.215	196.030	1	22	23	1	22	22
Osmaniye	64.450	160.840	11	18	29	11	18	29
Rize		11.752	0	1	1	0	1	1
Sakarya	26.627.017	810.345	4.653	91	4.744	4.607	90	4.697
Samsun	1.361.400	1.286.778	238	144	382	236	143	378
Şanlıurfa	45.000	709.347	8	80	87	8	79	87
Siirt	20.100	83.600	4	9	13	3	9	13
Sinop	49.500	112.030	9	13	21	9	12	21
Şırnak		65.317	0	7	7	0	7	7
Sivas	500	312.933	0	35	35	0	35	35
Tekirdağ	3.050	471.875	1	53	53	1	52	53
Tokat	40.000	257.563	7	29	36	7	29	36
Trabzon		25.613	0	3	3	0	3	3
Tunceli		26.363	0	3	3	0	3	3
Uşak	3.636.300	185.682	635	21	656	629	21	650
Van		338.950	0	38	38	0	38	38

Yalova	28.000	116.122	5	13	18	5	13	18
Yozgat	20.000	1.023.004	3	115	118	3	114	117
Zonguldak	6.788.670	212.300	1.186	24	1.210	1.175	24	1.198
total	163.984.725	70.928.560	28.658	7.951	**36.609**	28.372	7.872	**36.243**

Appendix 14: Features of cereals straw for biogas production. Data source: [51].

Features	Wheat	Rye	Barley	Oat	Triticale	Meslin	Maize (Corn)	Sor-ghum	Rice
Corn-straw-ratio	0.85	1.4	0.95	1.2	1.1	1.1	1.3	1.3	1.2
DM %	86	87.5	86	87.5	87.5	87.5	86	86	87.5
oDM %	91.9	87	93.7	87	87	87	72	72	87
Biogas yield [m³/ t oDM]	380	300	427	300	300	300	350	350	300
Methane content %	52	52	52	52	52	52	52	52	52
Methane yield [m³/ t oDM]	198	156	222	156	156	156	182	182	156

Appendix 15: Milk production from cattle in Turkey (1999-2009). Data source: [17].

Turkey: Milk production from cattle					
YEARS	CATTLE MILKED	CATTLE MILK	BUFFALO MILKED	BUFFALO MILK	TOTAL MILK
1999	5,537,892	8,965,489	79,973	75,243	9,040,733
2000	5,279,569	8,732,041	69,602	67,330	8,799,371
2001	5,085,814	8,489,082	65,356	63,327	8,552,409
2002	4,392,568	7,490,634	51,626	50,925	7,541,559
2003	5,040,362	9,514,138	57,378	48,778	9,562,916
2004	3,875,722	9,609,326	39,362	39,279	9,648,604
2005	3,998,097	10,026,202	38,205	38,058	10,064,260
2006	4,187,931	10,867,302	36,353	36,358	10,903,660
2007	4,229,440	11,279,340	30,460	30,375	11,309,715
2008	4,080,243	11,255,176	31,440	31,422	11,286,598
2009	3,879,209	10,861,785	32,516	32,000	10,893,785

Appendix 16: Type of milk products based on businesses, production and installed capacity. Data source: [48].

Type of products	Number of businesses (units)	Installed capacity (tons/year)	Production (tons/year)
White cheese	832	1,138,536	218,259
Yoghurt	718	1,083,284	613,946
Ice cream	650	113,714	18,528
Kashar (yellow) cheese	552	215,056	54,291
Butter	340	107,416	33,546
Turkish butter milk	290	1,154,487	1,018,137
Curd cheese	197	6,506	2,722
Tulum cheese	194	28,666	9,870
Other cheese	169	20,095	9,100
cream	114	15,302	8,656
Other products	76	15,422	10,802
Cream cheese	50	24,506	11,799
Strained yoghurt	50	45,765	18,805
Pasteurized milk	48	286,629	170,645
Whey powder	42	35,380	14,043
milk powder	38	21,558	9,863
Sterilized milk	35	231,728	91,125
Milk CC (raw milk)	15	80	57
Edible ice	6	83	67
Gruyere cheese	4	120	62
Flavored milk	2	11,367	6,102
TOTAL	4,422	4,555,700	2,320,425

Appendix 17: Survey for Livestock Sector (English Version)

- Survey for Livestock Sector -

This animal waste survey was prepared for "Turkish-German Biogas Project" that is being conducted by German International Cooperation Agency (GIZ) and General Directorate of Environmental Management within the framework of a joint bilateral co-operation protocol between Turkish Ministry of Environment and Urbanisation and Ministry of German Environment Nature Conservation and Nuclear Safety. The obtained information will be evaluated without giving any firm names and will not be shared with third parties, institutions and organizations. Therefore, fact reflection of the answers will be vital for the health of the project. Thanks for your interest.

1. CONTACT

Name of the facility:		
Livestock Sector: ☐ Bovine (e.g. dairy cow breeding, bull breeding, young cattle breeding) ☐ Poultry (e.g. egg or broiler producers) ☐ others:		
Contact person:		
Address:	Postal Code:	
Province:	District:	
Phone number:	E-mail / Internet address:	

2. LIVESTOCK

	Kind and categorie of animals [1]	Amount of animals	Amount of animal waste (tons/year)		Days of grazing (days/years)	Kind of Housing system *	Kind of dunging system **	Utilisation of Litter (e.g. stones, straw, wood, sand, rice husks or nothing)	
			Liquid manure	Solid manure/ Dung				Type	Amount (kg/day)
Cattle breeding	Calf (< 0,5 years)								
	young cattle (0,5 – 2 years)								
	adult cattle (>2 years)								
	Dairy cow								
	fattening bull								
	Cattle in total:								
Poultry	Poult (< 0,5 years)								
	Laying hen (> 0,5 years)								
	Broiler /fattening hen								
	Turkey hen								
	Poultry in total:								
Others									

* **Housing system e.g.** girth-tethered, housed in stall / barn, housed in group of xx animals, with/ without straw)

** **Dunging system e.g.** cleaning the stable with water, with a special sweeper or others

1

3. CURRENT STORAGE AND UTILIZATION OF RESIDUES

Manure Pit available ?	☐ YES ☐ NO	**If there is a manure pit, construction of pit** (whether existence of impermeability):
Current utilization /disposal of animal waste	Utilization: ☐ Forage industry ☐ compost ☐ biogas plant ☐ others: Disposal: ☐ store ☐ burn ☐ land spreading ☐ discharge to the water ☐ waste collection contract ☐ field storage ☐ others:	
Costs or revenues of disposal / transport of animal waste	In case of costs: Liquid manure: TL/ton Solid manure: TL/ton Others:	in case of revenues: Liquid manure: TL/ton Solid manure: TL/ton
Other organic residues of the facility available?	☐ kind of slaughtering residues: amount (tons/year): ☐ kind of fodder residues (for animals): amount (tons/year):	☐ kind of harvesting residues: amount (tons/year): ☐ others:
Do you use kind of **disinfectants** in your barn/coop-system?	☐ YES ☐ NO	
Background related to biogas - Whether previous biogas studies were done before?		
Are you **interested in biogas facilities** for your organic residues?	☐ YES ☐ NO	

4. AGRICULTURAL LAND

Availability of agricultural land belongs to facility	☐ YES	If agricultural land is available:	Size of land (ha)	Average plot size of the land (ha):	Kind of the land (e.g. grass land, arable land, uncultivated land, trees, horticulture)	Yield of the cultivated crops (tons/ha)	Average distance between field and farm (km)
		own land					
		purchase of land					
	☐ NO						
Availability of other agricultural land around the facility which can be used for the manure	☐ NO ☐ YES	If YES: Amount of Area (ha): Distance to the facility (km):					

Please send the survey by mail to: funda.ertem@dbfz.de or by fax to: 0049 341 2434 133 Thank you very much!

Appendix 18: Survey for Livestock Sector (Turkish Version)

- Hayvancılık Sektörü İçin Biyogaz Potansiyeli Analizi Anketi -

Bu anket, Türkiye Cumhuriyeti Çevre ve Şehircilik Bakanlığı ile Alman Çevre Doğa Koruma ve Nükleer Güvenlik Bakanlığı arasında ortak ikili işbirliği protokolü çerçevesinde, Alman Uluslararası İşbirliği Kurumu (GIZ) ve Çevre Yönetimi Genel Müdürlüğü tarafından yürütülmekte olan "Türk-Alman Biyogaz Projesi" kapsamında hazırlanan hayvansal atık envanteri çalışması için hazırlanmıştır. Elde edilen bilgiler üçüncü şahıs, kurum ve kuruluşlarla paylaşılmayacak ve envanter çalışmaları esnasında firma ismi belirtilmeden değerlendirilecektir. Bu nedenle verilecek bilgilerin gerçeği yansıtması projenin sağlıklı yürütülmesi açısından önem arzetmektedir. İlginiz için teşekkür ederiz.

1. İLETİŞİM

Şirket adı:	
Hayvancılık sektörü: ☐ Büyükbaş (e.g. süt ineği, besi, sığır) ☐ Kanatlı (besi ya da yumurta) ☐ Diğer:	
İrtibat edilen kişi:	
Adres:	Posta Kodu:
İl	İlçe:
Telefon numarası:	E-mail / İnternet adresi:

2. HAYVANCILIK

	Hayvanın türü (1)	Hayvan sayısı	Hayvansal Dışkı Miktarı (ton/yıl)		Otlatma günü (gün/yıl)	Barınak Türü *	Gübre temizleme yöntemi **	Altlık kullanımı (taş, saman, odun, kum, pirinç kabuğu ya da hiçbir şey)	
			Sıvı gübre	Katı gübre				Tür	Miktar (kg/gün)
Sığır Yetiştirme	Dana - Buzağı (< 0,5 yıl)								
	Tosun/Düve (0,5 – 2 yıl)								
	Yetişkin Sığır (>2 yıl)								
	Süt ineği								
	Besi sığırı								
	Toplam Büyükbaş:								
Kanatlı	civciv (< 0,5 yıl)								
	Yumurta tavuğu (> 0,5 yıl)								
	Broiler /besi tavuğu								
	Hindi								
	Toplam Kanatlı:								
Diğer									

* **Barınak sistemi:** telle çevrelenmiş bir alanda, durak/ahır sistemi, x adet grup hayvan barınak içinde altlıkla veya altlıksız)

** **Gübre temizleme yöntemi:** su ile veya kürek ile temizleme

3. ATIK İÇİN UYGULANAN KULLANIM VE DEPOLAMA YONTEMİ

Gübre çukuru ?	☐ VAR ☐ YOK	**Eğer var ise çukurun durumu (sızdırmazlığı var mı?):**
Atık için belirlenmiş mevcut kullanım ve bertaraf yöntemi	Kullanım: ☐ Yem Sanayii ☐ Kompost ☐ Biogas tesisi ☐ Diğer: Bertaraf: ☐ Depolama ☐ Yakma ☐ Araziye yayma ☐ Su ortamına deşarj ☐ Atık alım sözleşmesi ☐ Sahada depolama ☐ Diğer:	
hayvansal atıkların bertaraf / taşınmasından kaynaklı gelir veya maliyetler	Maliyet varsa: Sıvı gübre: TL/ton Katı gübre: TL/ton Diğer:	Gelir varsa: Sıvı gübre: TL/ton Katı gübre: TL/ton
Başka organik atık çıkıyor mu?	☐ kesimden kaynaklı atıklar: miktar (ton/yıl): ☐ Hasat atıkları: miktar (ton/yıl): ☐ yem atıkları (hayvanlar için): miktar (ton/yıl): ☐ Diğer:	
Barınak ya da kümes için dezenfektan kullanıyor musunuz?	☐ EVET ☐ HAYIR	
Biyogazla alakalı özgeçmiş – Daha önce biyogaz çalışması yaptınız mı?		
Organik Atıklarınızın değerlendirilmesi için biyogaz tesisi düsünür müsünüz?	☐ EVET ☐ HAYIR	

4. TARIM ARAZİSİ

İşletmeye ait tarım arazisi var mı	☐ EVET	Eğer var ise	Arazinin büyüklüğü (ha)	Ortalama parsel büyüklüğü (ha):	Arazinin tipi (otlak, ekilebilir alan, ekilmeyen arazi, ağaçlık, bahçe)	Ekilen ürün verimi (ton/ha)	Arazi ve çiftlik arasındaki ortalama mesafe (km)
		Kendine ait					
		Kira					
	☐ HAYIR						
İşletme civarındaki diski için kullanilabilecek mevcut diğer tarım arazisi		☐ HAYIR ☐ EVET EVETSE:		Arazinin büyüklüğü (ha): İşletmeye mesafesi (km):			

Lütfen bu anketi maille: Funda.Ertem@dbfz.de ya da faxla: 0049 341 2434 133 en kısa sürede cevaplandırıp yollayınız. Teşekkür ederiz!

Appendix 19: Survey for Food industry Sector (English Version)

- Survey for Food Industry

This organic residue survey was prepared for "Turkish-German Biogas Project" that is being conducted by German International Cooperation Agency (GIZ) and General Directorate of Environmental Management within the framework of a joint bilateral co-operation protocol between Turkish Ministry of Environment and Urbanisation and Ministry of German Environment Nature Conservation and Nuclear Safety. The obtained information will be evaluated without giving any firm names and will not be shared with third parties, institutions and organizations. Therefore, fact reflection of the answers will be vital for the health of the project. Thanks for your interest.

1. Contact Information:

Name of the facility:
Industrial Sector (1):
Contact Person:
Address:
Province/district:
Phone number:
E-mail / Internet address:

2. Organic Residues from Process

No.	Kind of organic residues (1)	Amount (ton/year)	Dry matter content (%)	Availability (2) (days/year)	waste requiring special supervision (yes / no)	Biogas background (3)
1						
2						
3						
4						
5						

3. Current utilization of residues

No.	Kind of organic residues (1)	Kind of current utilisation/ disposal of residues (4)	Amount (ton/year)	Disposal costs / fees TL/ton (fresh matter)	Revenues TL/ton (fresh matter)
1					
2					
3					
4					
5					

(1) Organic residues from:

- Meat production: e.g. slaughterhouse residues, meat and bone meal, blood, grease separator/ fat separator
- Sugar industry: e.g. press cake of sugar beet, molasse,
- Brewery, Distillery: e.g. brewer grains, draff, yeast
- Starch industry: e.g. waste water,
- Fruit production and processing: e.g. pomace of oranges, apples, bananas,
- Vegetable production and processing: e.g. olive press cake, potato peels, peas, tomatoes, pulses, maize
- Creamery: Grease separator/ fat separator, waste water
- Cheese Dairy
- Bakery: e.g. old bread
- Beverage industry
- Fish processing
- Canning / Frozen foods production: food condemned to be unfit for consumption
- ...

(2) Availability of organic residues: seasonal, all the year, few days/ xx month per year

(3) Biogas background: Whether previous biogas studies were done before

(4) Kind of utilisation/disposal:

- utilisation: animal cadaver utilisation plant (further utilisation e.g. carcass meal/animal meal for the production of fertilizer), fats for chemical industry, fodder industry, composting, biogas plant
- disposal: landfill, waste incineration

Please send the survey by mail to: funda.ertem@dbfz.de or by fax to: 0049 341 2434 133 Thank you very much!

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Appendix 20: Survey for Food industry Sector (Turkish Version)

- Gıda Sektörü İçin Biyogaz Potansiyeli Analizi Anketi

Bu anket, Türkiye Cumhuriyeti Çevre ve Şehircilik Bakanlığı ile Alman Çevre Doğa Koruma ve Nükleer Güvenlik Bakanlığı arasında ortak ikili işbirliği protokolü çerçevesinde, Alman Uluslararası İşbirliği Kurumu (GIZ) ve Çevre Yönetimi Genel Müdürlüğü tarafından yürütülmekte olan "Türk-Alman Biyogaz Projesi" kapsamında hazırlanan organik atık envanteri çalışması için hazırlanmıştır. Elde edilen bilgiler üçüncü şahıs, kurum ve kuruluşlarla paylaşılmayacak olup, envanter çalışmaları esnasında firma ismi belirtilmeden değerlendirilecektir. Bu nedenle verilecek bilgilerin gerçeği yansıtması projenin sağlıklı yürütülmesi açısından önem arzetmektedir. İlginiz için teşekkür ederiz.

1. İletişim bilgileri:

Şirket adı:
Sanayi Sektörü :
İrtibat edilen kişi:
Adres:
İl/ilçe:
Telefon numarası:
E-mail / Internet adres:

2. Prosesten Kaynaklanan Organik Atıklar

No.	Organik atık türü (1)	Miktar (ton/yıl)	Katı madde içeriği (%)	Bulunma durumu (2) (gün/yıl)	Özel denetim gerektiren atık (evet / hayır)	Biyogaz özgeçmişi (3)
1						
2						
3						
4						
5						

3. Atıkların mevcut kullanım durumu

No.	Organik atık türü	Atıkların mevcut kullanım/bertaraf durumu (4)	Miktar (ton/yıl)	Bertaraf maliyeti/ücreti TL/ton	Gelirler TL/ton
1					
2					
3					
4					
5					

(1) Organik atıklar:
- Et üretimi: örn. mezbaha artıkları, et ve kemik unu, kan, yağ ayırıcı / yağ ayırıcı
- Şeker sanayi: örn. şeker pancarı pres kek, molas,
- Mayalanan, damıtılan: örn. bira tahıl, tortu, maya
- Nişasta sanayi: örn. atık su,
- Meyve üretimi ve işleme: örn. prina, portakal, elma, muz,
- Sebze üretim ve işleme: örn. zeytin pres keki, patates soyma, bezelye, domates, bakliyat, mısır
- Mandıra: Gres ayırıcı / yağ ayırıcı, atık su
- Peynir
- Fırın, örn. bayat ekmek
- İçecek endüstrisi
- Balık işleme
- Konserve / Dondurulmuş gıda üretimi: gıda tüketimi için uygun olmayan

(2) Organik atıkların bulunma durumu: Mevsimlik, tüm yıl, yıl içinde x gün/ay
(3) Biyogaz özgeçmişi: Daha once biyogazla alakalı bir çalışmada bulunuldu mu
(4) Atıkların mevcut kullanım/bertaraf durumu:
- Kullanım: hayvan kadavrası kullanım tesisi (ek tesisler: örn. gübre üretimi için karkas besin/hayvan besini), kimyasal endüstri için yağlar, yem sanayi, kompostlama, biyogaz santrali
- Bertaraf: depolama, yakma

Lütfen bu anketi maille: Funda.Ertem@dbfz.de ya da faxla: 0049 341 2434 133 en kısa sürede cevaplandırıp yollayınız. Teşekkür ederiz!

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