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ABBREVIATIONS

TÜİK: Statistical Agency of Turkey
ADSYB: Association of Cattle Breeders in Aydın
KTA: Available Agricultural Land
EU: European Union
TEP: Tons of oil Equivalent
DM: Dry Matter
ODM: Organic Dry Matter
OECD: Organization for Economic Co-operation and Development
IEA: International Energy Agency
TEİAŞ: Turkish Electricity Transmission Corporation
EEG: The German Renewable Energy Act
DBFZ: Deutches Biomasse Forchungs Zentrum
U.S.A: United States of America
İSTAÇ: Istanbul Environmental Administration of Industry and Trade Inc.
CHP: Combined Heat and Power Plant
EPA AgSTAR: Environmental Protection Agency's Program
Tübitak-MAM: Scientific and Technical Research Council of turkey- Marmara Research Center
DüMV: The German Fertilizer Regulation
DüV: Regulation of Fertilizer Applications
DPT: The State of Planning Organization
TEUAS: Turkish Electricity Generation Co. Inc.
TEDAŞ: Turkish Electricity Distribution Co. Inc.
TETAŞ: Electricity Trading and Contracting Co. Inc.
DSİ: The State of Water Supply Administration
TPAO: Turkish Petroleum Joint Stock Company
BOTAS: Petroleum Pipeline Transportation Co. Inc.
TKI: Turkish Coal Enterprises
TTK: Turkish Coal Board
YEK: Document: Document of Renewable Energy Sources
EPDK: Energy Market Regulatory Authority
EWP: Energy White Paper
AbPR: Animal By-Products Regulations of EU
AB 27: Member Countries of the EU
EBRD: European Bank of Reconstruction and Development
TURSEFF: Turkey Sustainable Energy Financing Facility
MIDSEFF: Mid-size Sustainable Energy Financing Facility
TCSEP: Turkey and Caucasus Countries Sustainable Energy Project

TERMINOLOGY

BOD: Biological Oxygen Demand
K: Potassium
COD: Chemical Oxygen Demand
Total N: Total Nitrogen
Total P: Total Phosphate
VFA: Volatile Fatty Acids
CH_4: Methane
CO_2: Carbon dioxide
g: gram
kg: kilogram
m^2: square feet
m^3: cubic meter
kcal/year: annually kilocalories
kW: kilowatt
KWh: kilowatt hour
kWh_e: Kilowatt hours for electricity production
t: ton
TWh/year: 1 tera watt hour/ year= (10^{12}) watt.hour/year
PJ/year: 1 petajul /year = 10^{15} Joule/year
Digestate: Residues after the biogas process
Broiler: Meat chicken
Substrate: Nutrient

1. INTRODUCTION

Today, energy has become the basic need of all societies. The clean energy demand must be meet in a way that is cheap, reliable and sustainable price for economic and social development. Moreover, the structure of the global energy sector which is the chain of supply and demand start to be fully shaped depending on the environmental factors. Climate change draws the world's new route in energy policy like other all policies.

Currently, the worldwide energy demand is provided from mainly the fossil fuel sources like coal, oil, natural sources. However, they are rapidly exhausted depending on the use due to the limited resources. In contrast to them, wind energy, solar energy, hydrogen energy and biomass are called renewable energy. Reducing carbon emissions, reducing foreign dependency, increasing employment and receiving support from the public can be classified as the advantages of renewable energy sources.

One of the major energy sources of Turkey is biomass as a renewable energy. Biomass can be used in energy technologies by directly incinerating or obtaining alternative biofuels (easily portable, stored and available fuels) that have equivalent properties to existing fuels enhancing fuel quality in various processes. Bio-waste (animal waste, forest and agricultural wastes, municipal wastes, etc.) has traditionally been used for cooking or heating in many parts of the world. As biomass resources can be used directly as fuel, they also have high potential to be used for the production of biogas, biochar and biodiesel.

Aydın is one of the most important provinces of Turkey in terms of animal production. 85% of households classified in agricultural business do both agricultural and livestock production, but the number of households specialized in animal production represents only a 15% portion in Aydın. The number of animal and the specialization of animal production are seen as a significant potential to achieve economic development in province, which has predominantly polycultural production structure. Modernization and intensive operation of the rapidly developing livestock sector has brought problems as a team. Animal waste, which is an important economic potential, becomes the major problem for the environment depending on the increase in the number of animal. If necessary precautions are not taken, waste sourced from animal farms causes the pollution of ground and surface water sources, soil and air. Also, they become a financial burden for farm operators.

In the concept of this project, the number of animals and the amount of animal wastes sourced from the farms located in Aydın Merkez and its 16 country are determined, and also the energy potential of these wastes are calculated for Aydın. The energy potential of all wastes is given with the obtained data. Moreover, types and capacities of energy production plants are given with different scenarios, and their investment costs are explained. The main purpose of the project is determining the energy production potential from existing animal waste of Aydın and guidance people with accurate information for establishing this kind of facilities. Animal wastes (bovine, ovine and poultry animals) and slaughterhouse wastes are classified under the animal waste term in this project concept. However, feasibility studies are done for only animal wastes (manure) because the amount of slaughterhouse wastes can be negligible depending on the low values. Therefore, animal wastes refer to wastes sourced from only animal manures except slaughterhouse wastes in terms of terminological.

2. LITERATURE SURVEY

2.1. Husbandry Sector

In the developing and changing World, one of the most important problems of the human kind is the shortage in food, which we are facing today and will be facing in the future more. Livestock products are indispensable and cannot be replaced by other food sources, when they were considered with their biological specifications. Livestock products are very important for human diet (meat, milk, egg, honey and etc.) The livestock sector is very important for with the following reasons; an important role for humans for a sufficient and balanced diet, to increase the national employment and national income, to support the meat, milk, cosmetics, leather, textile and the pharmaceutical industry with the final and by-products and to support the economy by bringing foreign exchange with exportation.

Developed countries are supporting the livestock and agricultural production with logical and innovative ideas in order to support national stability. Countries became important exporters of those goods with the increased production capacities. Within this century, the production of agricultural and livestock goods will be more strategic and is going to be used as a political and economic weapon against less developed or developing countries. Livestock sectors shows its important with the population of 1 billion people suffering from hunger in a total population of 6,9 billion. 7 million people are dying because of starvation and this number is increasing every year.

2.1.1. Livestock Sector in The World and Turkey

2.1.1.1. Bovine Livestock

Bovine livestock consists of cattle (cow, ox, calf, and water ox), horse, donkey and mule breeding activities. In Turkey, the most popular type of bovine livestock is the cattle farming. Starting from the first days of the establishment of Turkish Republic, cattle farming became very popular and gained more interest than the other types due to the market demand. Therefore, cattle breeding became the common definition for the bovine livestock in Turkey. The most important reason for that is not only their advantage in its trade mechanism, but also its share of consumption in the developed countries. The cattle farming provide almost all of the milk demand and 24% of meat demand in the world. According to TÜİK data, the milk generation efficiency of an animal increased from 1.400 kg to 2.800 kg, starting from year 1991 to 2009. The annual milk productions for 1991 and 2009 are 8,6 million tons and 11,6 million tons respectively. The Turkish cattle population presence is given in Table 2.1.

Table 2.1. Cattle Presence in Turkey (TÜİK, Statistics of Animal Production, 2009)

YEARS	Cattle--Culture	Crossbreed Cattle--Culture	Cattle-native	Total
1991	1.253.865	4.033.375	6.685.683	11.972.923
1995	1.702.000	4.776.000	5.311.000	11.789.000
2000	1.806.000	4.738.000	4.217.000	10.761.000
2005	2.354.957	4.537.998	3.633.485	10.526.440
2009	3.723.583	4.406.041	2.594.334	10.723.958

Water ox is dependent in water presence and therefore living around water sources, such as rivers or marshlands. Their milk is generally used for butter and cream production due to the high fatty content. The population of water oxen decreased in the last years.

2.1.1.2. Ovine Livestock

There is an importance of this type of farming in Turkey. It has a high potential due to Turkey's geographical conditions, large grasslands and low cost with high meat quality in that type of farming. Especially, sheep and goat farming is the cheapest type of live bovine livestock in Turkey. Sheep are using the grassland with highest efficiency in the whole year amongst other animals. Also the grasslands have low efficiency and are more suitable for such animals in Turkey.

Turkey has an importance for the bovine population. In 2009, the population increased up to 26.87.000. The important role in employment, providing goods for textile sector and importance for local and international trade, show the necessity for bringing out supportive mechanisms for the sheep and goat farming. Turkey has a tradition in cattle and ovine farming with 24 million sheep, 5,6 million goats and 10,9 million cattle population approximately.

Goat is the second most breeded type of ovine after sheep. Hair goat and Angora goat (Ankara goat) are the two species of goats, which are available all around the country. But the farming of those types is generally done in mountainous regions. Among them, hair goat is breeded for its hairs and milk while the Angora goat is breeded in the middle Anatolian region. Even its homeland is Turkey, Angora goat are mainly being breeded in U.S.A., South Africa and New Zealand. Maltiz goat farming is done in the Aegean region for its high milk production rate.

2.1.1.3. Poultry

The fastest growing sector of animal husbandry is poultry in Turkey. There are many integrated facility adorned with modern technology. Poultry sector, which started to develop since 1950 and turned into commercial businesses after 1970's, has reached a huge export capacity outside of the country's demand after establishment of breeding enterprises in 1980.

The number of poultry increased by 1,1% according to the previous year and reached to 241.498.538 at the end of 2011. The number of laying hen increased by 11,3% according to the previous year and reached to 78.956.861 at the end of 2011.

On the other hand, broiler production is concentrated on the Marmara, Aegean, Central Anatolia and Mediterranean regions. The reasons can listed as the consumption is more in there regions because of the closeness to large residential centers, the simplicity to get energy supply, the suitability of climate and geographical structure and the easiness for transportation. Egg production also shows density at the same regions. In particular, producers generated stronger unions through cooperative association and incorporation in Çorum, Kayseri, Afyon and Bolu provinces in central Anatolia. Cage system, which is provided benefit from closed area, is generally applied in egg production.

2.1.1.4. Slaughterhouses/Abattoirs

The number of livestock farms and slaughterhouses increases directly proportional to the population growth in order to meet demand of meat in Turkey. Butchers in veterinary controlled slaughterhouses carry out slaughtering operations. The number of existing slaughterhouses in Turkey is given in the following table according to their classes.

Table 2.2. Numbers of Slaughterhouses in Turkey (Red Meat Sector Report, 2006)

Categorizing	Numbers	The capacity of Cattle Cutting
Private Slaughterhouses	210	
Class 1	191	86
Class 2	19	18
Class 3	0	0
Public Slaughters	445	
Class 1	5	42

Class 2	0	0
Class 3	440	4

According to the new "Regulation on the Procedures and Principles of Establishment, Opening and Operation of Red Meat and Meat Products Production Facilities", the slaughtering limitations of meat processing plants were changed. Slaughterhouses are classified according to the daily number of animal slaughtered.

According to this,

- ***Class 1:*** There is no minimum or maximum limits. Limitations are determined according to hygiene conditions, the capacity of cold storage and the size of the waiting room for animals.
- ***Class 2:*** Maximum 90 animals daily
- ***Class 3:*** Maximum 40 animals daily

The number of slaughtered cattle between the years of 1999-2009 in Turkey is given in the following table.

Table 2.3. The Numbers of Slaughtered Cattles in Turkey between 1999-2009 Years (TUİK Livestock Statistics, 2010)

YEARS	Cattle	Mandate	Total
1999	2.006.758	28.240	2.034.998
2000	2.101.583	23.518	2.125.101
2001	1.843.320	12.514	1.855.834
2002	1.774.107	10.110	1.784.217
2003	1.591.045	9.521	1.600.566
2004	1.856.549	9.858	1.866.407
2005	1.630.471	8.920	1.639.391
2006	1.750.997	9.658	1.760.655
2007	2.003.991	9.532	2.013.523
2008	1.736.107	7.251	1.743.358
2009	1.707.592	6.786	1.714.378

2.1.2. Livestock's in Aydın

Livestock sector has important economical functions that have importance and integration with rural economic structure in the regional and provincial level as well as the development of country. These functions are providing inputs to the industrial sectors, preventing migration from rural areas and creating new employment in several sectors. The number registered cattle in E-ıslah system, which was established for sharing and recording the database related to cattle breeding studies (online breeding system), are 3.250.556 in Turkey and 157.789 in Aydın. A counties average number of presence for cattle is expected to be 1,2% in Turkey with 81 provinces. The presence of cattle is almost 4,5% in Aydın according to the E-ıslah system. This shows that Aydın is one of the most important cities in terms of the presence of cattle.

When businesses connected to pedigree are taken into consideration, the average number of cattle and cow per facilities are slightly above the average values in Turkey. The average number of animals in Aydın shows an increase over the years.

Detailed field study related to livestock sector in Aydın was performed. The results of the study are given in the Chapter 4.

2.2. Animal Wastes

In order to meet the demand for animal-derived protein, development in the livestock sector became a necessity. However, this causes some environmental problems especially in enterprises close to large residential areas. Wastes from livestock sector, leaks caused by the storage of agricultural products such as silage and waste from slaughterhouses cause water, soil and air pollution. Generally, many of the developments in bovine livestock technologies have been developed as a result of environmental problems. These potential pollutants are generally reduced, but are not removed completely.

The environmental problems like odor and visual disturbance, were caused by the disordered manure storage, burial of dead animals in pits without spreading lime on them, unsuitable slaughterhouse and unavailable fodder storage areas. Therefore, the storing and design criteria should be investigated in order to minimize those environmental problems.

The pollution source caused by the livestock farms is different from domestic and industrial pollution sources, because they are wide spread and not point sources of pollutants. Therefore the cumulative impacts are not measureable for the farms like the industrial and domestically sources of pollution. Also, they could make the groundwater and surface water sources unusable by contaminating them.

2.2.1. Description and Quantity of Wastes

Wastes are materials that were generated due to an activity or left in a location in an environment. They could be also defined as the materials, which depleted their lifetime and usage period, and have to be removed or disposed from the environment that we live actively.

Animal wastes could be classified into two; the manures and the wastes caused during bovine livestock activities (fodder residues, cleaning waters of barns). The livestock manures are cattle, horse, sheep and poultry wastes. The internal organs are also classified in the wastes generated during live bovine livestock activities.

The livestock wastes could be classified under three main topics;

1. Bovine livestock wastes
2. Ovine farming wastes
3. Poultry farming wastes

In the last few years, the capacity of farms and manure generation of those farms has been increased. The number of cattle, sheep and poultry animals is 11, 30 and 320 million respectively. And the total livestock waste amount is 150 million approximately. Daily animal waste that is determined by various literature studies is given in the following table.

Table 2.4. The daily manure and urine wastes of animals (Karaman, 2006)

Animal Specie	**Alive Weight** (kg)	**Manure+ urine** (%)	**Daily manure + urine** (kg)
Cattle	500	9	45
Horse	400	8	32
Sheep	50	7	3,5
Chicken	1,8	10	0,18

During the slaughtering of the animals breeded in livestock farms, wastes such as tripe, blood and intestines are generated. The amount of such wastes in Turkey for year 2009 is given in the table below.

Table 2.5. Wastes of Meat Production in 2009 (DBFZ, 2011)

Meat Production Wastes	**2009**
The numbers of Slaughtered Cattles	1.714.378
Meat (ton)/ Slaughtered Cattles	0,200
The Slaughter wastes of cattle (ton)	312.088

The numbers of Slaughtered Poultry	720.414.503
Meat (ton) /Slaughtered Poultry	0,0018
The wastes of Poultry (ton)	362.522

The characterization of livestock wastes taken from different sources is summarized in Table 2.6 and 2.7. The properties of solid livestock wastes are shown varies depending on many factors such as animal species, weight of animal, eating habits and season.

Table 2.6. The physical Properties of Animal Wastes (Hart, 1960, Ohio State Univ., 1993).

Parameter	**Cattle** (milk production)	**Cattle** (meat production)	**Chicken** (meat and egg)	Sheep
Animal weight, (Kg)	636	431	2,0-2,3	45
Production of dry matter, (l/day)	36,8	28,3	0,095-0,160	3,1
Waste density , (t/m^3)	0,99	0,96	0,96	1,04
Amount of dry matter (%)	15	15	15-85 (72)	23

Table 2.7. Characterization of animal wastes as organic and food elements
(For every animal weight kg/day)

Animal	BOD	COD	NH_3-N	Total N	Total P	K	Source
Cow (the average of feeding cow for meat)	1,1-2,2 - 1,02 1,87 1,84 - - - 1,61	10,0 - - 3,26 - 15,0 - - 9,42	- - - 0,11 - - - - 0,11	0,36 0,35- 0,44 0,29 0,26 0,26 0,41 0,16 - 0,32	0,115 0,11- 0,12 - - - 0,25 0,31 - 0,18	0,29 - - - - - - - 0,29	Moore, 1969 Tainganides and et al., 1966 Hart, 1960 Loehr and et al., 1967 Witzel, 1966 Vollenweider, 1968 Townshed and et al., 1969 Dale and et al., 1967
Cow (the average of feeding cow for milk)	0,31 - - - - 0,31	1,53 1,53 1,32 0,44 0,95 1,15	8,4 19,1 5,8 - 5,7 9,8	- - 0,23 - - 0,23	0,38 - 0,37 0,49 0,16 0,35	0,12 - - - 0,11 0,12	Hart and et al., 1965 Jeffrey and et al., 1963 Witzel, 1966 Water Poll. Rep., 1964 Townshend and et al., 1969
Sheep (average)	- - -	- - -	- - -	0,86 0,34 0,60	- 0,25 0,25	- - -	Hart, 1960 Vollenweider, 1968
Chicken (average)	-	-	-	0,52	0,12	2,36	Ohio State Univ., 1993

The efficiency of animal manure could be in different amounts, according to the animal species. For the calculation of manure amount; 10-20 kg/d (wet) manure production or 5-6% of live weight could be taken for bovine livestock, 2 kg/d (wet) manure or 4-5% of live weight for sheep and goat and 0,08-0,1 kg/d (wet) or 3-4% of live weight for poultry could be accepted.

2.2.2. Environmental Impacts

Solid livestock wastes used as fertilizer after drying or fuel source throughout the history. Environmental problems caused by the manures came up due to increase in the capacity of farms in the last years. Environmental health problems caused by the livestock wastes can be as dangerous as industrial wastes. Drainage of surface water into environment, returning wastewaters from agricultural activities and lands used as permanent storage area for livestock wastes, appear as the main sources for water pollution.

Considering the 13 million cattle, there is a significant livestock waste potential in our country. In recent years, increased capacities of large-scale farms and their wastes have caused environmental problems. Main problems such as global warming from greenhouse gases from livestock wastes, pollution of soil, surface and groundwater and pathogenic environmental problems arise due to the release of untreated wastes. Leaks caused due to the storage of agricultural products such as silage also cause water and soil pollution.

Organic wastes are water pollutants due to their high biological oxygen demand (BOD). Also, livestock wastes are sources for nitrogen and phosphate in water and cause eutrophication. Also, they cause pathogenic contamination. There are no waste related problems in small farms. Wastes are used in land reclamation in such farms. The distribution of livestock waste is the main problem in farms, which have intensive breeding of cattle and poultry. The most adverse effect of the livestocks on environment is forming a source for a number of infectious disease agents. The impacts of those effects to environment are directly and indirectly related to waste disposal. The excavated pits where livestock wastes are buried pose a great threat for humans and animals as being a source of disease.

Livestock wastes consist of organic materials that are 50-75% biodegradable with the help of microorganisms. Odor problem occurs depending on the decomposition of organic materials due to the oxygen conditions. Inorganic compounds of nitrogen and sulphur occur when livestock wastes are rapidly decompose in aerobic conditions. While a small amount of carbon dioxide gases spread, high amounts of odor compounds also occur. Manure makes a weak odor in the livestock farms. Then, bacteriological fermentation starts due to the high temperature and moisture. Uric acid is rapidly converted to ammonium salts. An unpleasant smell spreads to environment depending on the increase in ammonia. Some chemical materials that are occurred and spread after the decomposition of manure are listed in Table 2.8. Most of these compounds could be detected, even from long distances.

Table 2.8. The Components Result in Anaerobic Decomposition of Animal Wastes (Anonymous, 2003)

Components	Chemical Substances
Volatile Fatty acids	• Acetic acid • Propionic acid • Butyric acid • Izobutyric acid
Phenols and Cresols	• Mercaptans • Methylmarcaptans • Ethylmercaptans • Propylmercaptans
Sulfides	• Hidrogensulphide • Dimethylsulphide • Dietlhylsulphide • Disulphides
	• Amonmonia • Methylamine • Ethylamine • Dimethylamine • Dietihylemine
Heterocyclic’s with nitrogen	• Indole

	• Skatole
Inert gases	• Carbon dioxide • Methane
Alcohol	
Aldehides	
Esters	

The transportation is another problem during the management of livestock wastes. A sufficient amount of livestock waste should be transported to a facility economically, in the context of livestock waste disposal methods. Accepted transport distances of the livestock wastes are given in the table below. If convenient transportation distances for waste handling are not applied, odor, hygiene and transportation costs become problems.

Table 2.9. Dry Matter Amounts of Various Animal Groups and the Suggested Transport Distance

Group	Amount of Dry Matter (%)	Transporting distance (km)
Cattle and sheep	8-15	10
Egg production and Poultry farming (only manures)	30 (70)	40
Ones for grilling, turkey, and other poultries (the wastes as rubbish + manures)	70	40

2.2.3. Waste Management

Wastes resulting from livestock breeding are livestock manure and internal organs left after the slaughter of animal. Currently, these wastes are spread on agricultural land without pre-processing, disposed to environment after shoveling up with water for physicochemical and/or biological processes, sent to landfills, or burned in an uncontrolled manner. Application of unprocessed livestock wastes on agricultural, decreases the efficiency of crop production and causes environmental pollution.

Disadvantages of the wrong management of livestock wastes can be summarized as follows:

- Cause soil, water and air pollution
- Cause arsenic, manganese, zinc, nitrate and phosphate pollution in water
- Cause unpleasant smell (odor)
- Provide a favorable environment for growth of insect, affect the spread of infectious diseases and adversely affect public health.
- Cause pollution and destruction of natural resources
- Contain pathogenic organisms such as leptospira and histoplazma capsulatum

Appropriate waste management methods should be used, due to the importance of those pollutants. Landfilling and burning in an uncontrolled manner and discharging into water sources of these wastes are loss of energy because of their high energy potential with the high organic content. Furthermore, there are some discharge limits in “Water Pollution Control Regulations”. However, expensive advanced treatment technologies such as; the removal of biological nitrogen and phosphorus in membrane bioreactors and then nano-filtration should be applied to livestock wastes that have reached the limit values.

Considering all these wrong practices, sustainable waste management approach has to be adopted. The purpose of livestock waste management is to increase the potential use of large amounts of livestock wastes on the basis of healthy environment, economic and social benefits in regions where the production of cattle, sheep and poultry are occurred. Livestock wastes can be evaluated in order to get energy with appropriate technologies depending on the amount and properties of wastes in the concept of waste management.

2.3. Energy and Renewable Energy Resources

Energy demand is increasing depending on population growth, industrialization and the production. Energy has become a necessity for economic and social development and increase social life level in all countries. Turkey has second largest economy after China and also is the fastest country in OECD countries in terms of increase in the demand of natural gas and electricity.

Turkey's electricity demand and installed electricity capacity has achieved a rapid increase graph in 2011 reflecting of the major economic developments and increase in the welfare level. The electricity production increase 9% and becomes 229 billion 344,4 million kWh in 2011 according to 2010. 3600 MW of new capacity and 105, including 75 new, electric power plants have been activated. Installed power of country reaches to 51.547 MW as a result of increase in demand at the end of 2011. Both the legal infrastructure studies and studies for activating the sector have been implemented to increase the share of renewable energy sources in energy supply.

Energy sources are classified as non-renewable and renewable energy. Non-renewable energy sources are fossil fuels such as coal, lignite, oil and natural gas and also nuclear power energy sources, which have limited reserves. Today, the primary sources of world energy production are non-renewable energy sources such as oil, natural gas and coal. If new technologies do not apply in energy sector, current energy sources will be exhausted and won't meet the energy needs. In the light of these problems, alternative energy sources are determined for the solution of energy problem. The most important features of renewable energy sources are to reduce carbon dioxide emissions, reduce dependency on foreign energy and increase in employment. Renewable energies are resources that renew themselves like solar energy, wind energy, hydrogen energy, and biomass.

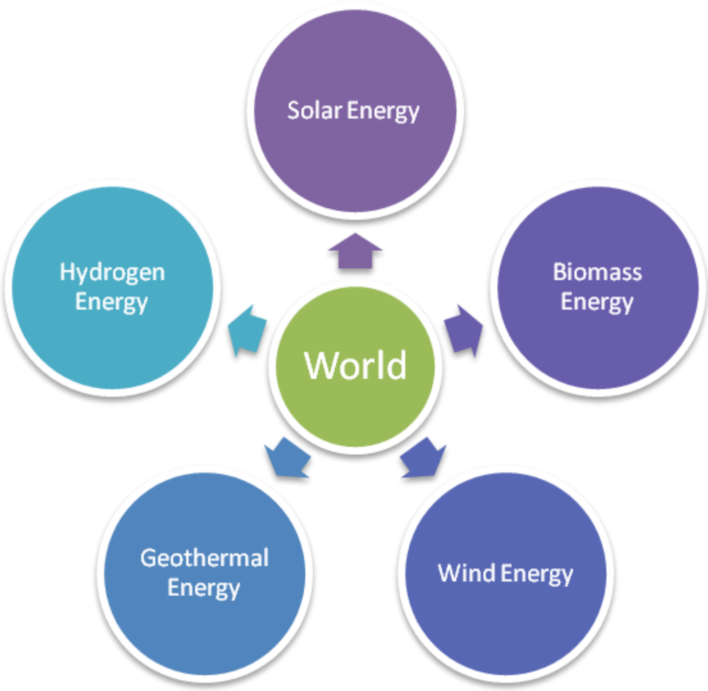


Figure 2.1. The Sources of Renewable Energy

Considering the benefits from the use of renewable energy, Law No. 6094 amending in Law No.5346 came into force on January 8, 2011 in order to reorganize the price promotion for renewable energy plants and determine the additional incentives given for local producers. In this concept, additional price support between 0,4-3,5 US dollar/cent is given to plants that produce energy from renewable sources if plants use local manufactured equipment.

Renewable energy sources met the 18% of total world energy demand in 2007. 80% of this demand was done by biomass energy supply facilities that used conventional combustion system.

Total energy consumption was shown 3,6% increase between 1990 and 2008 in Turkey. Coal and lignite as the main substances fuel forms 27,5%, whereas oil and gas forms 29,8% and 31,8% respectively of total energy consumption of 2008. Biomass, waste and hydrogen energy from renewable sources forms only 8,8% of the Turkish energy production. Turkey's electricity production methods are given in the following figure according to 2008 data of The International Energy Agency and Turkey Power Generation Inc.

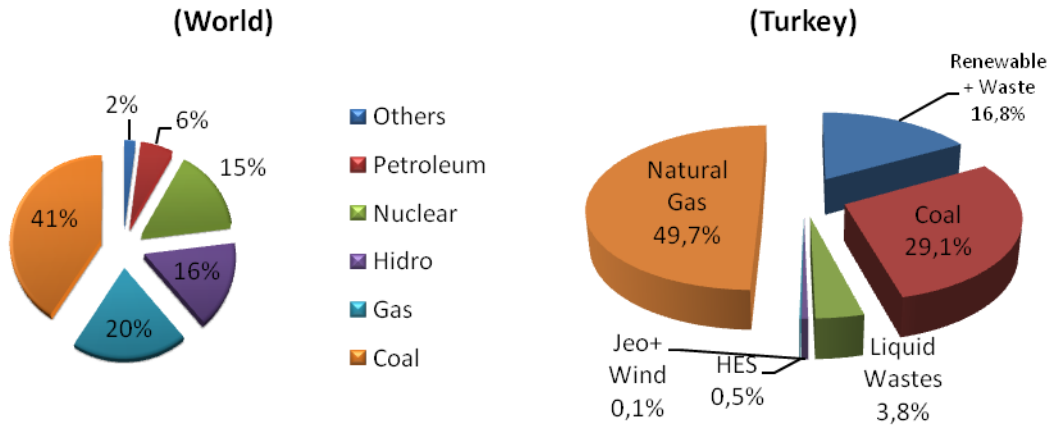


Figure 2.2. The Methods of Electricity Production in Turkey and World (International Energy Agency (IEA, 2008) and Turkey Electricity (TEİAŞ), 2008)

While Turkey's energy obtaining matter becomes important with each passing day due to the depletion of conventional energy resources and foreign policies, governmental sources expect that Turkey's energy demand will double in 2020. Because of these realities, alternative energy sources should be evaluated with the best possible technologies and they should be turned into economic benefits.

2.3.1. Biogas Production

2.3.1.1. Description of Process

Biogas is the gaseous product of the anaerobic digestion of organic matter. Gas called biogas released from organic matter in an oxygen free condition (anaerobic). This process is widely seen in nature, for example; swamps, sea bottoms, liquid manure pits and ruminants. In the meantime, organic matter is almost completely converted to biogas by microorganism, certain amounts of energy (heat) and new biomass form.

Biogas consists mainly of methane and carbon dioxide, but also contains several impurities. It is typically made up of 55-70% methane (CH4), 30-45% carbon dioxide (CO2), and traces of other gases such as hydrogen, hydrogen sulfide, carbon monoxide, and nitrogen. Physical properties of biogas are listed in table below.

Table 2.10 General Features of Biogas (Deublein and et al., 2008).

Composition	Equivalents
Energy content	6.0-6.5 $kWhm^{-3}$
Fuel equivalent	0.60-0.65 L oil/m^3 biogas
Explosion limits	6-12% biogas in air
Ignition temperature	650-750°C
Critical pressure	75-89 bar

Critical temperature	-82.5°C
Normal density	1.2kg m^{-3}
Smell	Bad eggs (the smell of desulfurized biogas is hardly noticeable)
Molar Mass	16.043kg $kmol^{-1}$

The gas components are specific to the plant and substrate and should be checked regularly on a long-term basis. The characteristic properties and impurities of biogas are listed in the following table.

Table 2.11. Typical Compounds and Impurities in Biogas (Deublein and et al., 2008).

Compound s	Content	Effect
CO_2	25-50%	– Lowers the calorific value – Increases the methane number and the anti-knock properties of engines – Causes corrosion if the gas is wet
H_2S	0-0,05%	– Corrosive effect in equipment and piping systems – SO_2 emissions after burners or H_2S emissions with imperfect combustion – upper limit 0.1 by vol.% – Spoils catalysts
NH_3	0-0,05%	– NO_x emissions after burners damage fuel cells – Increases the anti - knock properties of engines
Water vapor	1-5%	– Causes corrosion of equipment and piping systems – Condensates damage instruments and plants – Risk of freezing of piping systems and nozzles
Dust	>5 µm	– Blocks nozzles and fuel cells
N_2	0-5%	– Lowers the calorific value – Increases the anti - knock properties of engines
Siloxane	0-50 mgm^{-3}	- Act like an abrasive and damages engines

The composition of biogas shows difference depending on the substrates, process and various technical applications. The production of biogas can be actualizing in various stages. In the meantime, the whole process must be compatible with each other not to create a negative effect on the decomposition process. Decomposition stages are; hydrolysis, acidogenesis, acetogenesis and methanogenesis respectively.

In the first stage of ***hydrolysis***, complex organic matters (carbohydrates, albumins, fatty, etc.) turn into water-soluble more simple organic structures (amino acids, sugars, fatty acids, etc.). Hydrolytic bacteria release enzymes that decompose materials. Once complex organics are hydrolyzed, these various bacteria convert sugars, amino acids and fatty acids to low molecular weight organic acids, hydrogen, and carbon dioxide in ***acidogenesis*** stage. The products formed vary with the types of bacteria as well as environmental conditions. In the third stage that is ***acetogenesis***, convert the products of the second phase to simple organic acids, carbon dioxide (CO_2) and hydrogen (H_2) and acetic acid (CH3COOH) due to anaerobic oxidation. Finally, in ***methanogenesis*** phase, methanogenic bacteria (also known as methanogens) turn acetic acids, hydrogen and carbon dioxide into methane. The schematic shown of anaerobic digestion is given in below.

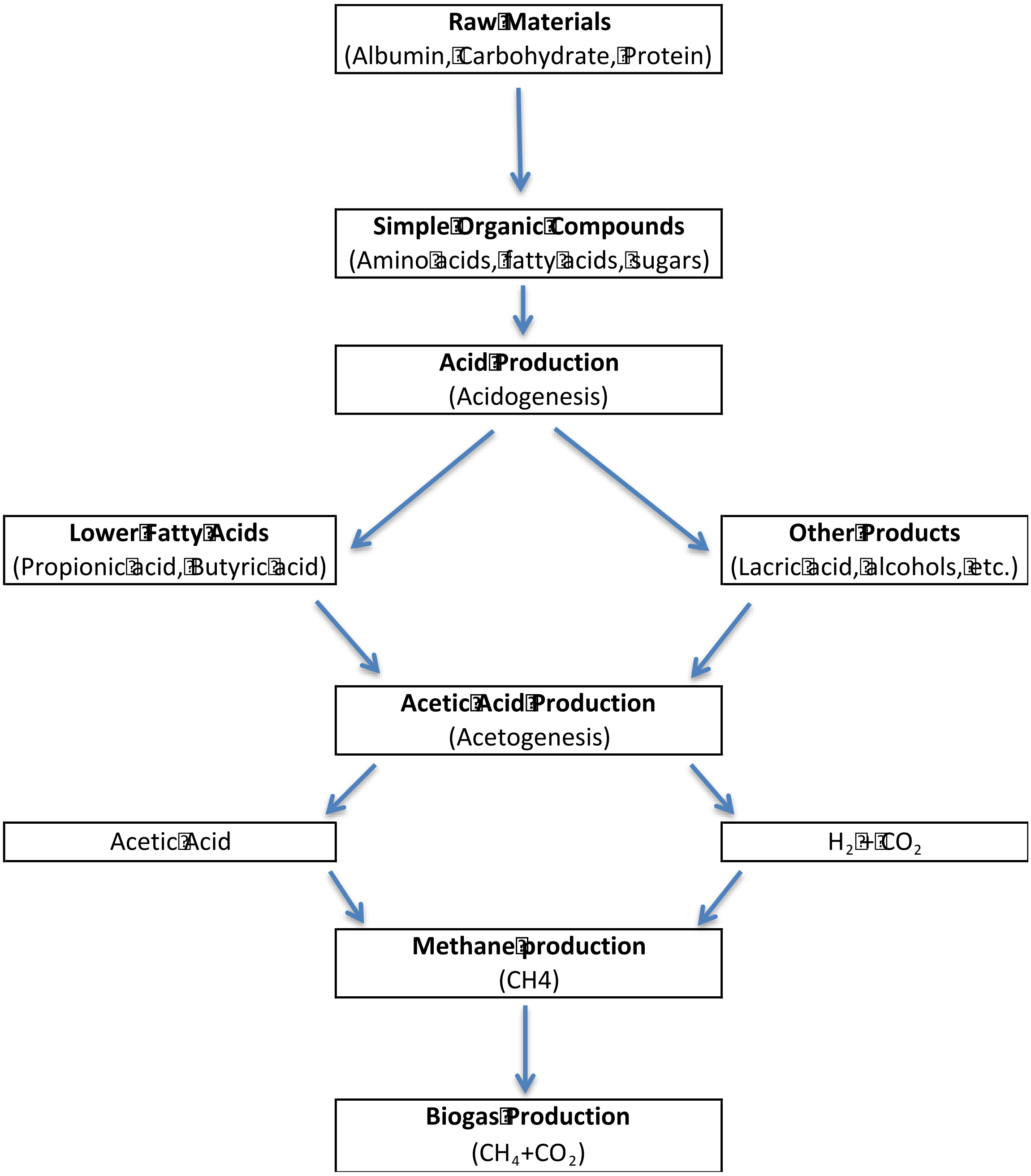


Figure 2.3. Schematic Figure of Anaerobic Digestion
(German Biomass Research Center and et al., 2010).

Four phases of the anaerobic system occur in a one-step process parallel with each other. However, settlement conditions should be in terms of process technique (pH, temperature) provided because the demands of each living bacteria have different living conditions. Optimum conditions should be designed to the methanogenic bacteria because they are the weakest link in the process due to low growth rates and are very sensitive to changes.

2.3.1.2. Substrates

In general, all types of biomass can be used as substrates as long as they contain carbohydrates, proteins, fats, cellulose, and hemicelluloses as main components. It is important that the following points are taken into consideration when selecting the biomass:

- The content of organic substance should be appropriate for the selected fermentation process.
- The nutritional value of the organic substance, hence the potential for gas formation, should be as high as possible.
- The substrate should be free of pathogens and other organisms which would need to be made innocuous prior to the fermentation process.
- The content of harmful substances and trash should be low to allow the fermentation process to take place smoothly.
- The composition of the biogas should be appropriate for further application.
- The composition of the fermentation residue should be such that it can be used, e.g., as fertilizer.

Lignin, the main constituent of wood and most synthetic organic polymers (plastics) simply decompose slowly. That's why; these kinds of wastes are not required in substrates that are used in anaerobic digestion. Easily biodegradable and homogenized materials are chosen for the digestion system. Substrates that are used in biogas plants are listed in the below.

- Livestock wastes (manures, slaughterhouse wastes)
- Agricultural wastes
- Renewable sources
- Forestry and industrial wastes
- Leather and textile industry waste
- Paper industry waste
- The food industry waste
- Vegetables, fruits, grains and oil industry waste
- Yard wastes
- Food wastes
- Animal waste (bovine livestock, ovine farming and poultry)
- Sugar industry waste
- Domestic solid waste
- Wastewater treatment sludge

Table 2.12. The features of the products, which could be used as substrate in Biogas Plants (Berg, 2011)

Substrate	TS [%]	oTS [%TS]	N[a]	P_2O_5 [%TS]	K_2O	Biogas Efficiency [Nm^3/tFM]	CH4-efficiency [Nm^3/tFM]	CH4-Ausbeute [$Nm^3/toTS$]
Organic Manure								
Liquid cattle manure	10	80	3,5	1,7	6,3	25	14	210
Liquid Pig Manure	6	80	3,6	2,5	2,4	28	17	250
Rindermist	25	80	5,6	3,2	8,8	80	44	250
Poultry manure	40	75	18,4	14,3	13,5	140	90	280
Horse manure without straw	28	75	n.a.	n.a.	n.a.	63	35	165
Renewable Raw Materials								
Corn silage	33	95	2,8	1,8	4,3	200	106	340
Grain plants silage	33	95	4,4	2,8	6,9	190	105	329
Green Rye silage	25	90				150	79	324
Grain	87	97	12,5	7,2	5,7	620	329	389

Grass silage	35	90	4,0	2,2	8,9	180	98	310
Sugar beet	23	90	1,8	0,8	2,2	130	72	350
Sunflower silage	25	90	n.a.	n.a.	n.a.	120	68	298
Sugar panicum	22	91	n.a.	n.a.	n.a.	108	58	291
Green Rye$_b$	25	88	n.a.	n.a.	n.a.	130	70	319
Cultivation Industry								
Beer dreg	23	75	4,5	1,5	0,3	118	70	313
Grain dreg	6	94	8,0	4,8	0,6	39	22	385
Potato dreg	6	85	9,0	0,7	4,0	34	18	362
Fruit Dreg	2,5	95	n.a.	0,7	n.a.	15	9	285
Potato pulp	13	90	0,8	0,2	6,6	80	47	336
Potato juice	3,7	73	4,5	2,8	5,5	53	30	963
Pressed sugar beet dreg	24	95	n.a.	n.a.	n.a.	68	49	218
Molasses	85	88	1,5	0,3	n.a.	315	229	308
Apple dreg	35	88	1,1	1,4	1,9	148	100	453
Grape Dreg	45	85	2,3	5,8	n.a.	260	176	448
Wastes of fresh grass and lawn								
Wastes of fresh grass	12	87,5	2,5	4,0	n.a.	175	105	369

a. Nitrogen content in fermentation waste as independent from storage loss
b. be faded
c. The results of practices in biodiesel production can have serious differences depending on the practice method.

Substrates that are used in biogas plant and their sustainable cycle are given in the following figure.

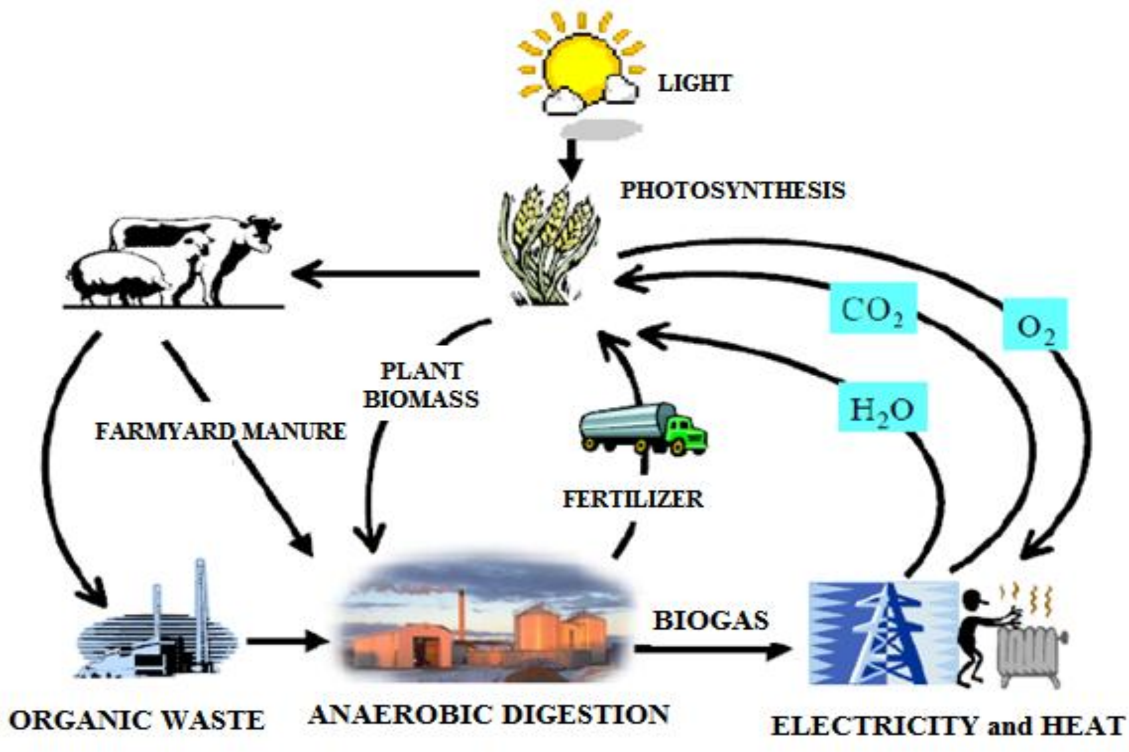


Figure 2.4. Sustainable Cycle of Biogas (Al Seadi, 2008)

Large amounts of pruning and grass wastes are composed as a result of maintenance of landscaped areas and roadside parks by the municipalities. However, these wastes should be silage to use as a substrate in biogas plant for a year because they are seasonal waste. Conditional use of these wastes is more suitable because of transportation costs. If there is low volumes and delayed in time, wastes can also use in fresh conditions.

The highest biogas production potential of sectorial areas is determined according to the theoretical and technical studies in Turkey. The best biogas potential can be obtained theoretically from agricultural wastes, livestock sector and also energy crops. The distribution of these sectors due to their theoretically biogas production are given in the Figure 2.5.

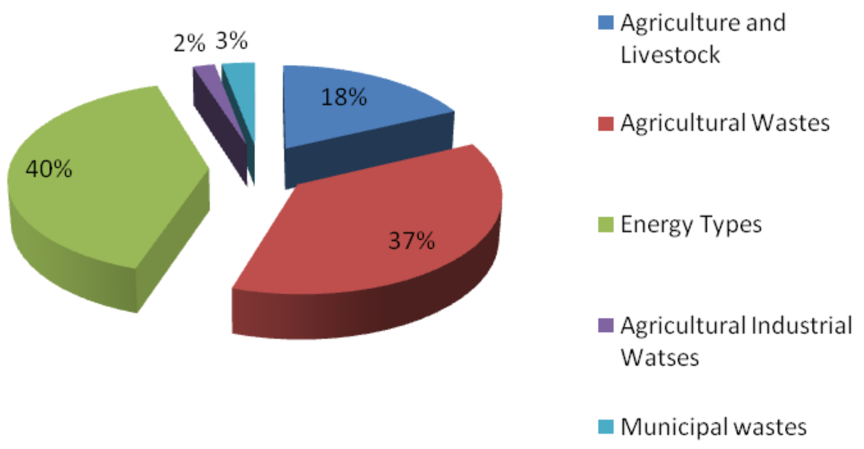


Figure 2.5. The Theorical Biogas Potential depending on sectors in Turkey (DBFZ-Deutches Biomasse Forchungs Zentrum, 2011)

Moreover, the highest technical biogas potential of Turkey can be provided from cattle waste. Also, agricultural activities are very important in terms of biogas production potential. The distribution of the theoretical biogas production potential is given based on the sectors in Figure below.

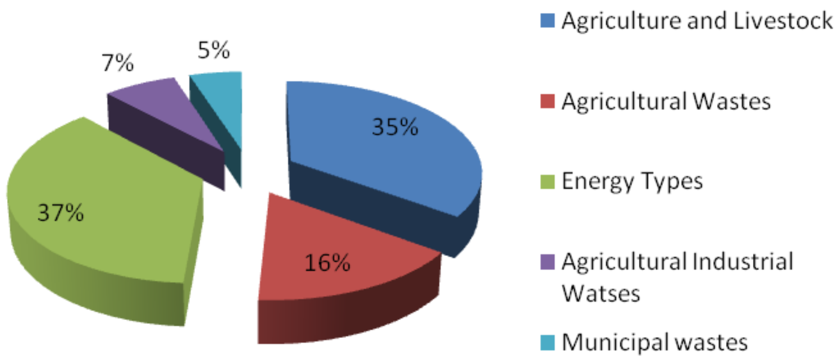


Figure 2.6. The Technical Biogas Potential depending on sectors in Turkey (DBFZ-Deutches Biomasse Forchungs Zentrum, 2011)

As a result, technical biogas production values that can be obtained from organic wastes (agricultural wastes, municipal wastes, food industry wastes) are calculated between the values of 112,6 - 221,5 PJ/year or 31,3 - 61.5 TWh/year (included and excluded energy products). This shows that Turkey has 3,13 - 6,15 billion m3/year methane production potential.

2.3.1.3. The Quantity of Livestock Waste Production

While projecting biogas plants, firstly the capacity of the plant should be determined. If only livestock waste is used in biogas plant, the quantity of daily manure production, feeding patterns of animal and the quantities of solid materials of manures should be determined. Daily manure production may be different amounts depending on the yields and types of animal waste.

In the calculation of manures; 10-20kg/d (wet) manures production or 5-6% of live weight for bovine livestock, 2kg/d (wet) manures production and 4-5% of live weight for sheep and goat and 0,08-0,1 kg/d (wet) manures production and 3-4% of live weight for poultry are accepted according to the studies.

The quantities of manures vary due to the types of animals. Accordingly;

- 3,6 ton/year wet manure is obtained from 1 unit of cattle (bovine livestock),
- 0,7 ton/year wet manure is obtained from 1 unit of sheep and goats,
- 0,022 ton/year wet manure is obtained from 1 unit of poultry.

Total cattle population of Turkey was determined as 89% of adult and 11% of young (depending on data base of TÜİK for Turkey) and manure production of young population was accepted half of the amount of adults according to Turkish-German Biogas Project. While 37,5 kg manure/animal.day was taken for adults of cattle, 9,4 kg manure/animal.day was taken for young. Different manure properties were accepted depending on the manure of young and adult cattle. Manure from broiler chicken and laying hens, also considered separately due to their different properties in the study. 0,19kg manure/animal*d was taken for broiler chicken and 0,13 kg manure/animal*d was chosen for laying hen.

The amount of wet manures in terms of ton/year is calculated due to the current animal potential of Turkey and is given in the following table.

Table 2.13. Biogas Amount Potential of Animal Waste in Turkey
(Koçer and et al., 2006).

Animal Species	Animal Numbers	Wet Manure Amount (ton/year)
Cattle	11.054.000	39.794.400
Sheep, Gout	38.030.000	26.621.000
Chicken, Turkey	243.511.000	5.357.242
Total	292.595.000	71.772.642

Animal fed on pasture or barn effects on daily manure production. Solid content of the mixture of manure-water should be 7-9% for optimum biogas production. Solid matter contents are 15-20% in cattle manure, 30% in chicken manure and nearly 40% in sheep manure.

2.3.2. Used Technologies in Biogas Production

Although biogas plants are generally same as its overall structure, they are very diverse in terms of size. The reason of this is that biogas technologies are based on bacteria transactions. Components and combination possibilities of biogas technology are virtually unlimited. Therefore, qualified personnel for the concrete application must inspect the suitability of mechanisms and systems. Biogas production takes place in different ways. Typical features are illustrated in the following table.

Table 2.14. Categorization of Biogas Production Methods Related to Different Criteria (German Biomass Research Center and et al., 2010)

Criteria	Specific Properties
Dry Matter Amounts of Materials	- Wet Fermentation - Dry fermentation
Feeding Type	- Discontinuous Feeding - Batch Feeding - Discontinuous Feeding
Numbers of Process	- One level - Two levels
Process Heat	- Physophilic - Mesophilic - Thermophilic

The content of materials depends on the solid matter content. This represents the fundamental separation of biogas technology named wet or dry fermentation. Pumpable materials (less solid material content) are used in wet fermentation system. Stackable materials that have high solid materials are used in dry fermentation systems. According to the comments of Federal Environment Ministry, dry matter content should be 30% for dry fermentation and 12% for wet fermentation.

The loading patterns of biogas plant largely depend on the availability of fresh materials for microorganisms and also, this has an effect on biogas production. Meet the need of material can be done in three different ways such as continuously feed discontinuous feed and non-continuous feed.

Process temperature varies depending on the anaerobic population that takes place in biogas production. Designated operating temperatures are given in the following table for working principles.

Table 2.15. Heat Ranges of Anaerobic Reactor Process

	Temperature range (°C)	Optimum Temperature (°C)
Physophilic	0 - 20	15
Mesophilic	15 - 45	35
Thermophilic	45 - 75	55

Biogas plant can contain many different combinations. But in general, the main components of a biogas plant are listed as follows:

1- Waste Pool/Tank
2- Reactor (Main Fermentation Tank)
3- Gas Dryer
4- Biogas Storage Tank
5- Gas Engine and Electric Generator
6- Separator

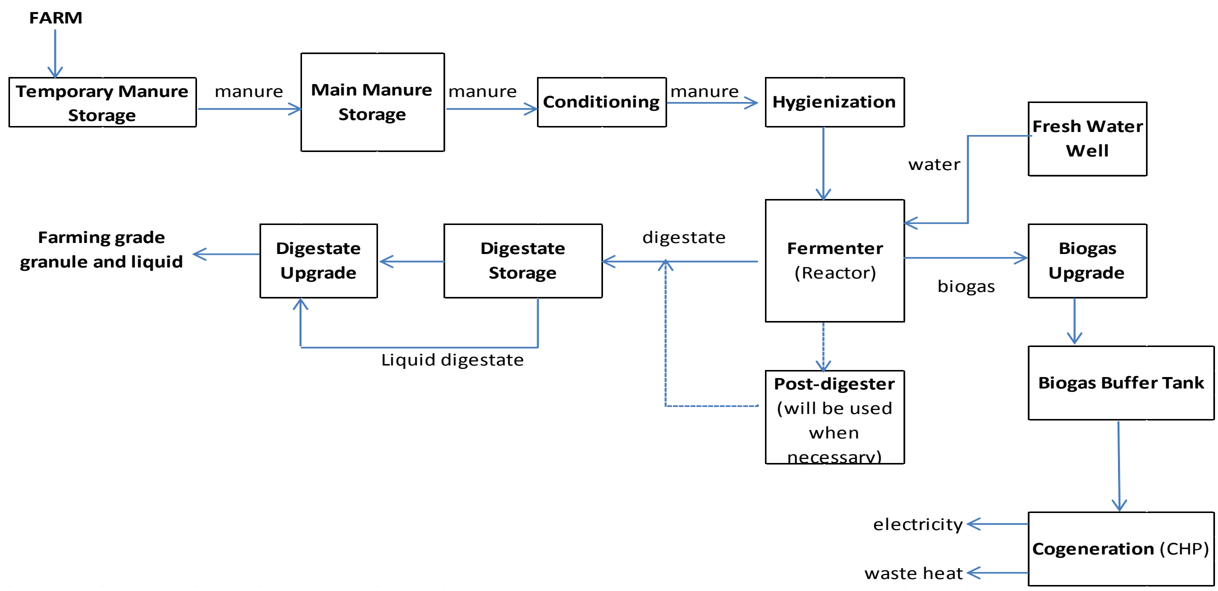


Figure 2.7. Main Components of Biogas Plant

Anaerobic digesters, which constitute the basic principle of biogas plants, are classified in three main groups according to feeding methods and operating temperatures. These are explained below.

Covered Lagoon Digesters

Produced biogas is collected with the help of sealed cover in these lagoons. Compared to other digesters, these are the least developed and least expensive methods based on technology. Lagoons require large residential areas and are preferred for the prevention of odor during manure storage. Covered lagoon digesters perform better in liquid manure applications that solid ratio is less than 2%.

Heating is not applied in covered lagoons. So these digesters are operated in physophilic and their biogas production rates are low compared to other digesters.

These systems are used in climate zones where temperature values are high and seasonal and daily differences are less.

Mixing Digesters (Agitators)

These digesters have the most advanced technology in other digesters. Better operating conditions are performed while using manures with 2-10% solid contents. In this system, there is a need for heated tank on the surface or in the ground. The solid particles are kept in the suspended form with continuous feeding of manure slurry. Complete mixing anaerobic digesters can be operated in mesophilic (32-35oC) or thermophilic (50-60oC) conditions, so the biogas production rate is high-speed. Enough operational experiences are available for both conditions. In a typical design, mechanical mixer can be used in the tank and circulating pump also can be used.

The application of these digesters in big farms and central facilities are more suitable because of their high-energy demand for manure mixing and high investment costs. Despite these reasons, they are preferred for advantages such as consistent performances and no risk for sand, gravel and other foreign material sedimentation.

Plug Flow Digesters

Plug flow digesters are common in cattle farms in U.S.A. A typical design consist a closed rectangular concrete tank containing 20 days manure. Fresh manures are fed to tank on a daily basis; on the other hand, equal volume of fermented manures is forced out of the tank. Coarse part of the solid material turns into a sticky viscous during digestion and inhibit the decomposition of solid mass and form a channel.

This configuration is the most basic and cheapest one in anaerobic digesters. Plug flow digesters are operated in mesophilic conditions with 20-30 days hydraulic retention times (HRT). Tank is covered with stable concrete or flexible hpalon or propylene. Biogas is collected in this covered area and orientated to discharge or generator. Temperature control is provided with the help of hot water distribution in the tank. Heat waste that occurs from generator can be used in the production of hot water.

The most important advantages of plug flow digesters are the simplicity and low price of the system organization and operation. However, such reactors are not efficient and consistent like mixing digesters. The use of these units are only limited to applications with low amounts of sand, soil, gravel. Collapsing and accumulation of solid substances need for cleaning effort in the tank. At the same time, solid surface (cake) forming on the surface may lead to difficulty during the cleaning of the hot water pipes. Therefore, the use of these systems is more suitable for cattle manures then poultry manure because of poultry manure's high dust content.

2.3.3. Biogas Production of Animal and Slaughterhouse Wastes

Environmental pollution caused by the use of conventional technologies becomes the most important problems of today and our society. Livestock wastes come into prominence in Turkey because of the quantity and harmful effects on environment.

The efficiency of methane production is highly depending on the many factors such as composition of substrate, the mixture ratio, biodegradability of biomass, solid and organic matter content of substrate and also the contribution of nutrients with each other. Also, other parameters such as temperature, hydraulic retention time, mixing frequency and loading patterns are important for methane production.

Important parameters should be studied and analyzed in laboratory and pilot plants before installing biogas plant. Analyzes must be done before and after digestion both in laboratory and pilot experiments. Laboratory analyzes that are suggested in biogas production studies are summarized below.

Table 2.16. Important Environmental Conditions for Biogas Plants

Temperature	Mainly, it is expected that high temperature fasten the chemical reactions. The optimum working temperature is determined according to certain technology and type of waste. Therefore the temperature of the system is protected.
pH	Microorganisms from various levels of decompositions need different pH values to grow up as optimum. Depending on using technology, pH values can be changed. But generally optimum pH value in the reactor is preferred between 7.0-7.5.
Alkalinity	Alkalinity is the parameter to determine the capacity of acid-neutralization.
Nutritional value	In anaerobic decomposition, microorganisms need vitamins and feeds according to their species. Concentration and availabilities of these components impact on the growth rate and activities of various populations. The methanogen archaeas need Cobalt (Co), Nickel (Ni), Molybdenum (Mo) and Selenium (Se). And sometimes they need partially element of Wolfram (w).
Harmful Materials	The harmful materials in the system can postpone the process progression and stop the decomposition in toxic concentrations. For this reason, determination of these substances before loading to reactor and decomposition of these are important.

Table 2.17. Operational Parameters for Biogas Facilities

Plant parameters	
The rate of Loading Raw	Organic mass in raw material is expected to decompose as total. While choosing the size of fermented, always minimum gas efficiency is aimed. If there is a demand about

material and Waiting time	total decomposition of organic mass in raw material, tank volume as suitable size and keeping the material inside the fermented for a long time should be provided. Therefore the performance of optimum decomposition should be provided by fungible economic prize.
Mixing	To obtain a high biogas production, bacteria and material should contact each other intensively. And generally it is obtained by mixing the fermentation tank. In unmixed fermentation tank, after a certain time a layer is obtained with segregation. It causes the density differences in the material existing in the tank and the decrease of gas production.
Dry Matter Amount (DM)	The dry matter and organic dry matter content of raw material which will be loaded in the reactor is important for the decomposition process working as successful. Determination of optimum dry matter ratios is necessary for conditions of plant.
Grain Dimension	The little dimensioned grains of raw materials which are loaded in reactor increases the microbiological connect and thereby it increases the decomposition rate.
Volatile fatty Acids (VFA)	The accumulation of volatile fatty acids during the decomposition process is possible. This situation depending on acidic medium prevents methane obtaining for required bacteria in methane production process due to the lack of optimum conditions.
Nutrition Content	●Total Nitrogen (N), Phosphorus (P), Potassium (K), Magnesium (Mg), Sulphur (S) ●NitrateNO_3), Ammonium Nitrogen (NH_4), Phosphate (P_2O_5), Potassium Oxide (K_2O)
C/N	Carbon and nitrogen values for metabolic activities of methanogen bacteria should be optimum as (C/N:8-20).
Heavy Metals	● Lead (Pb), Cadmium (Cd), Chromium (Cr), Cupper(Cu), Nickel (Ni), Zinc (Zn), Mercury(Hg)
Gas Composition and its Amounts	Daily amount of biogas which will be obtained and the composition of gas which is important to determinate the quality of gas (methane, carbon dioxide, water vapor, and traces gases) are related factors on plants' efficiency. The obtaining of unwanted ratios of the compositions shows that the presence problems and uncompleted decompositions in the reactor.

Biogas Potential of Livestock and Slaughterhouse Wastes

Generally, animal wastes are more preferred than other sources as substrate in biogas plants. Extraordinary biogas production potential occurs from cattle and pig raising farms based on the statistics of raising livestock in Germany. Alternative processing and evaluating methods must be researched for animal wastes because of the increase in number and capacity of farms and also number of wastes. In order to protect climate, animal wastes should be considered in energy production technologies by decreasing emissions.

The biogas efficiency of liquid cattle manure is less than liquid pig manure with its 20-30 Nm3 biogas per ton material. Moreover, gas obtained from liquid cattle manure has less methane content then gas that obtained from liquid pig manures. This difference depends on the different components of manures. Liquid cattle manure are highly formed of carbohydrates; however, liquid pig manure includes highly protein. ın first stage, biogas efficiency is mainly depending on the organic matter content. If liquid livestock wastes are diluted (for example; cleaning of barn), the real material values and biogas efficiency can show deviations in practice.

Biogas efficiency and methane values in biogas from different substrates are given in the following Table 2.18 in terms percent of waste.

Table 2.18. Biogas Efficiency could be obtained from Various Sources and Methane Amounts in Biogas (www.tarim.gov.tr).

Source	Biogas Efficiency (Liter/kg)	Methane rate (% Volume)
Cattle Manure	90-310	65
Poultry manure	310-620	60
Pig Manure	340-550	65-70
Wheat straw	200-300	50-60

Rye straw	200-300	59
Barleycorn straw	290-310	59
Vegetable wastes	330-360	Variable
Cultivation wastes	310-430	60-70
Grass	280-550	70
Spilled Tree Leaves	210-290	58
Mud of waste water	310-800	65-80

Studies were done to determine biogas production potential from livestock sector of Turkey in the concept of Turkish- Germany Biogas Project. So, waste quantity and methane and biogas content was determined depending on the TÜİK's data which included number and type of animals. The values related to this are given in the following table.

Table 2.19. Properties of Cattle and Poultry Manure (DBFZ, 2011)

Parameters	Cattle (aged)	Cattle (calf)	Chicken for meat	Chicken for egg
Kg Manure/animal*day	37,5	9,4	0,19	0,13
% rate of Dry Matter	14,5	14,5	-	-
M^3 CH_4/animal*day	0,9	0,2	0,013	0,009
M^3 CH_4/animal*year	323	80,8	4,9	3,1
Biogas Potential (TJ/animal*year)	0,0116	0,0029	0,00017	0,00011

Another study showed that fermentation the mixture of dairy cattle manure with barley straw and rice straw increase the amount of CH4 production. Maximum methane efficiency is observed in optimum C/N conditions which are between 25 and 32. If C/N ratio increases, methane production efficiency decreases.

Another important issue is optimum retention time of animal waste in different temperatures and the amount of biogas production. Ambient temperature is very important factor in biogas. The optimum temperature should be around 30-35oC. Biogas production can stop below 10oC. Biogas efficiencies of cattle and chicken manure in different temperatures were studied in variable studies and the results are given in the following table. If optimum temperature values are not stable, biogas production efficiency decreases.

Table 2.20. Biogas Efficiencies of Cattle and Chicken Manure at Different Temperatures (Kocer and et al., 2006).

Temperature (^oC)	Cattle Manure (L/m^3)	Chicken manure (L/m^3)
9	101,4	253,3
18	339,7	448,0
27	509,8	1008,9
36	686,0	1266,2

In addition to animal wastes, wastes from slaughterhouses can be used in biogas plants. Stomach, intestines, blood and oil form the slaughterhouse wastes that are possible to use. However, using of cattle blood and fat is forbidden in the German biogas plants. Only winged blood and oil can be used in Germany. All parts of animals can be used in Turkey. Required calculations for biogas plants can be done according to the amount and type of wastes. The same type of German waste is assumed for the calculation of the gross biogas potential for slaughterhouse wastes. The properties of slaughterhouse wastes that are related to cattle and winged animals are given in the following table.

Table 2.21. The Properties of Cattle and Poultry Body Parts (DBFZ, 2011).

Parameters	Substrate	Cattle	Poultry
DM (%)	Stomach/ Intestine (K3)	20	
	Content of Stomach/ Intestine (K2)	15	15
	Blood (Poultry) (K3)		18
ODM (%)	Stomach/ Intestine (K3)	90	
	Content of Stomach/ Intestine (K2)	84	85
	Blood (Poultry) (K3)		96
Biogas efficiency (m^3/t ODM)	Stomach/ Intestine (K3)	400	
	Content of Stomach/ Intestine (K2)	485	350
	Blood (Poultry) (K3)		343
Methane Content	Stomach/ Intestine (K3)	60	
	Content of Stomach/ Intestine (K2)	60	60
	Blood (Poultry) (K3)		70

2.3.4. Facility Examples in Turkey and The World

Although biogas plants are not very common in Turkey, the number of biogas plants and the application areas throughout the world increase each passing day in European Union and Japan. According to the studies, Turkey has potential to operate 2000 biogas plant only from livestock wastes. However, only 36 biogas plants in 85 are operated in current conditions. Most of these plants are being used by the municipalities and private companies, (wastewater treatment plants and landfill gas) and also they are located in the western part of Turkey (for example Istanbul and Kocaeli). The number of biogas plants that are used in agricultural activities could not be determined exactly. Information about the number and capacity of biogas plants operated in agricultural, municipality and industrial sector are given in the following table.

Table 2.22. Conditions, Installed Capacities and Distributions of Biogas Plants by the Sectors (DBFZ, 2011).

	Activated Plants	Capacity in Plant (MW)	Plants in plans	Plant Capacities in Plants (MW)	Total Biogas Plants	Total Capacity (MW)
Agriculture (animal wastes, agricultural plants)	2	0,68	12	11,99	14	12,58
Food Industry (waste water, organic waste)	17	13,68	2	3,88	19	17,56
Municipality (gas from thrash, waste water)	17	96,98	12	34,72	29	131,70
Municipality (gas from thrash)	13	93,04	9	32,03	22	125,08
Municipality (waste water)	4	3,94	3	2,69	7	6,62
Uncategorized	0	0	23	61,16	23	61,16
Total	**36**	**111,23**	**49**	**111,76**	**85**	**222,99**

Maps that show the distribution of biogas plants in operation and both in operation and planning in Turkey are given in the following.

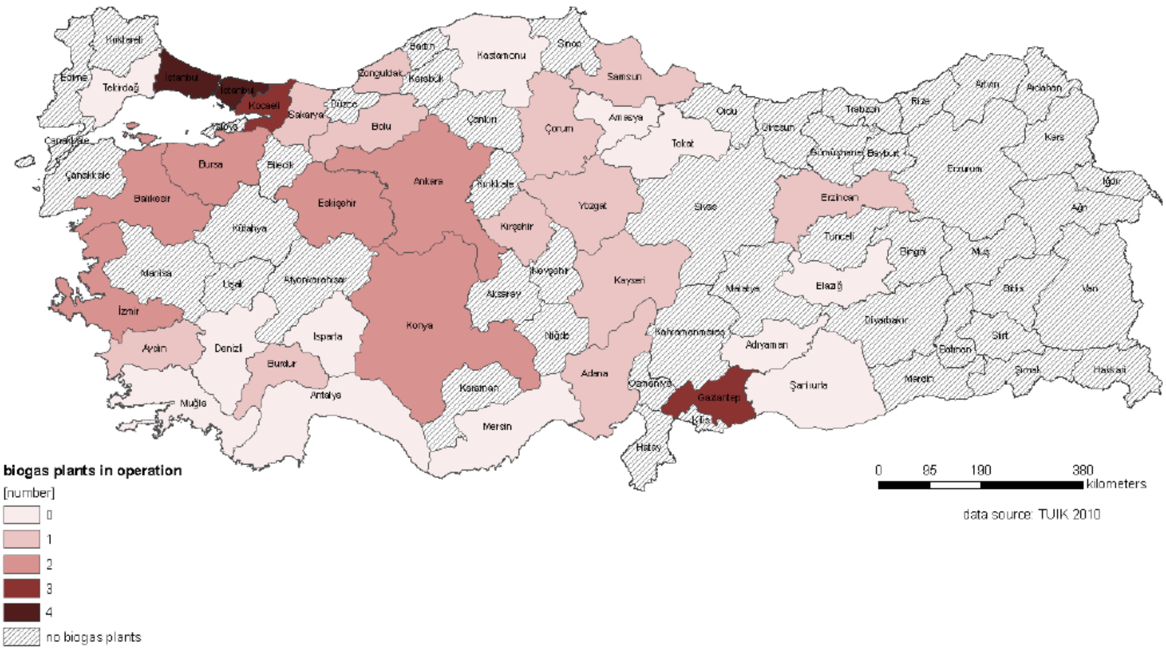


Figure 2.8. Distribution of Biogas Plants in Turkey (Operated Plant Numbers) (DBFZ,2011).

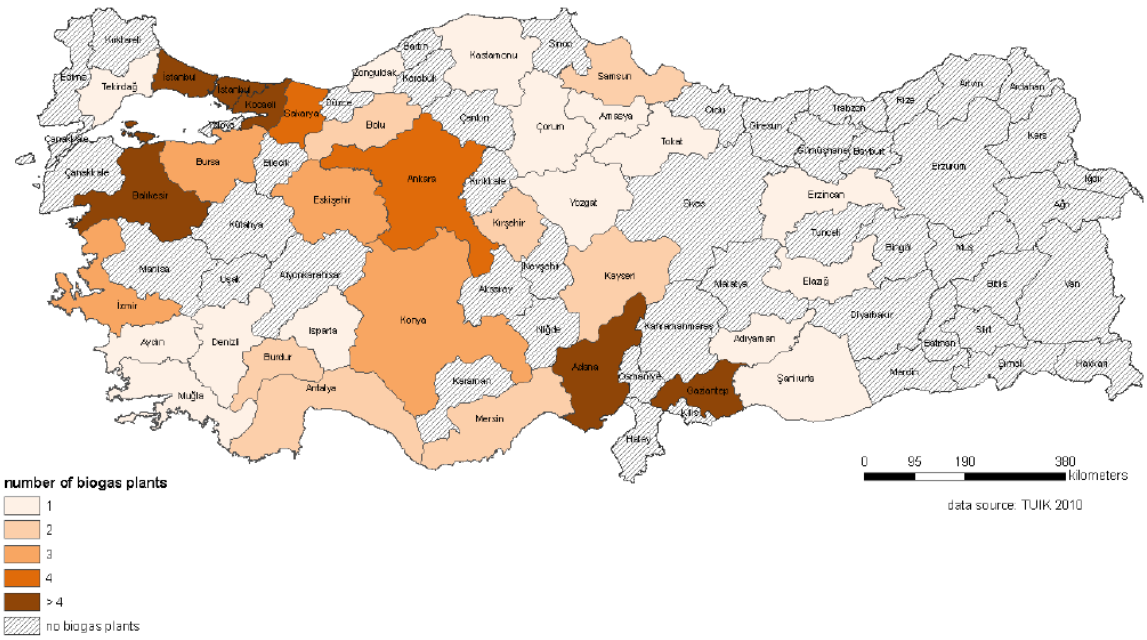


Figure 2.9. Biogas Plant Numbers in Turkey (operating and planning) (DBFZ, 2011).

There are deficiencies in the treatment and purification of biogas in Turkey. Produced biogas is only separated hydrogen sulphate and condensate in order to use in gas motors. While many biogas plants are waiting to get certificate/license from EPDK, only very few plants have been in operation.

Many of biogas plants located in Gaziantep, Istanbul and Kocaeli. In Turkey, especially municipalities are more related to install a high capacity biogas plants. Current situations are still unclear related to network connections (electricity, gas, and grid). There is not any regulation for properties and methods of using digestate constitute a problem.

One of the biogas plant is operated by ISTAÇ in order to produce energy from landfill gas. Energy from Landfill Gas projects have started to dispose and evaluate landfill gas in both European side (Odayeri-Eyüp) and Asia side (Kömürcüoda-Şile). Landfill gas production and energy production projection of Odayeri and Kömürcüoda Landfill was determined. Maximum installed capacity of Odayeri calculated as 25-20MW. So, nearly 2.203 GWh electricity production projections are given for 2007-2030. Maximum installed capacity for Kömürcüoda calculated between 10-15 MW and nearly 1.136 GWh electricity production potential was calculated for 2007-2030. Total installed capacity of both plants will be in the range of 35-45 MW and about 3339 GWh of electricity production targets were determined. This value meets the electricity demand of a city about 200.000 houses. Moreover, the methane content was measured nearly 50-60% for both plants. These projects also provide additional incomes depending on reducing in carbon emissions. Installed systems produce salability carbon credits because they turn carbon dioxide into methane by burning. These systems will be provided emission reductions which is corresponding approximately emissions emitted by the amount of 600.000 vehicles in traffic.

Figure 2.10. Energy production Plant from İSTAÇ Waste

Kocaeli Municipality started to the disposal of agricultural and animal wastes and the production of energy and plant construction was finished in 2010. The schematic presentation of plant is given in the following. Daily loading quantities of plant was determined as 19 - 20 ton/d of food waste from open markets and animal waste. Total solid content is 11 - 12 % and fermentation temperature is 35oC. Moisture content is 75 % and also the volume of fermentation is 1.650 m3. Biogas production is 2.095 m3 and total heat and electricity production is also 329,98 kW/d in plant.

Kupferzell Agricultural, which is in Germany, was taken in operation in 2011. Animal waste and rotten vegetables are used as substrate in the plant. Combined Heat and Power Plant (CHP) is used to produce heat and electricity from biogas in the plant. 1.500 MW electricity and 2.800 MW heat productions will be expected every year. Using biogas for electricity and heat generation, the emission reduction rate happens to be 500 - 1160 kg CO_2/MW-hour.

Soil and water digester of Cayuga in America was operated in 2012. Digester, which has the volume of 35.000 gallon, was designed in the concept of manure management in the area. Manure digested with the food waste based on the operation process. This project is supported to provide methane production by EPA AgSTAR program.

Mureck Biogas Plant was taken in operation in order to produce biodiesel and use biomass for heating in 2004. Plant has the volume of 3000m3 mixing unit and 230m3 hydrolysis tank. Also, it includes 4 pieces of 1000m3 volume of liquid tanks and 4 pieces of 1000m3 volume of digester tanks. Liquid manure and silage-corn-grain are mixed in the mixing tank and given into hydrolysis tank to accelerate fermentation process. Digestate can be sold for manure applications after solid separations.

Biogas that is obtained from plant is used in combined heat and power plant for heat and electricity production. Annually, 3.333.000 m3 gas production is performed depending on the amount of substrate. Annually electricity production is 999 kW and heat production is 1.165 kW from the plant.

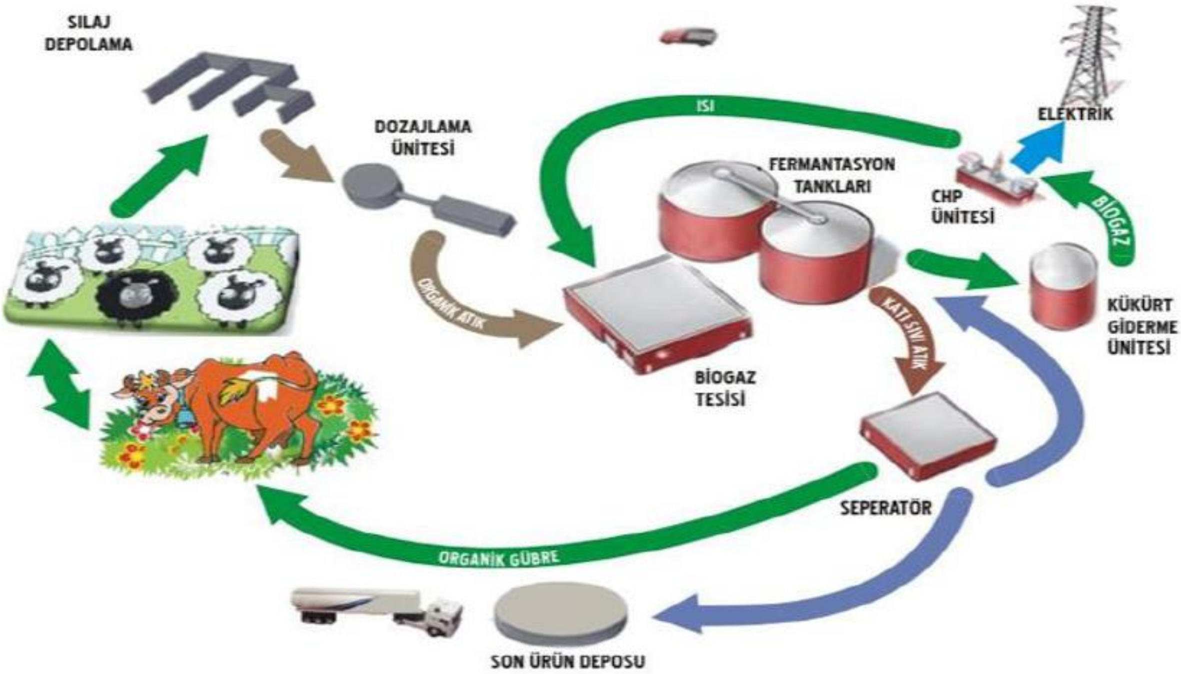


Figure 2.11. Biomethanization Plant in Municipality of Kocaeli
(Sayın and et al., 2011)

Figure 2.12. Mureck Biogas Plant (Puchas, K. and Sakulin, C., 2008).

2.3.5. Energy Production From Biogas

Biogas is a type of renewable energy. Gasholder must be capable of storage biogas for 24 hours because biogas can be used continuously. Biogas can be used directly for heating and electricity production and also for natural gas and vehicle fuel after the removal of CO2.

Use of biogas is based on the electricity production in Germany. For this purpose, mainly internal combustion generators are used for electricity production. Furthermore, biogas can also be used in micro gas turbines, fuel cells and stirling engines. Although other methods serve converting biogas into electricity, they were little or non-except generators. Another area of usage is to use in burners and heating boiler for thermal energy production.

Feeding into natural gas grid of biogas after preparation also becomes widely use option in recent years. There were 38 plants which feed produced biomethane into natural gas grid in Germany according to data in August 2010. A number of other projects will be carried out in future. Federal Government of Germany has an ambitious goal that six billion cubic meters of natural gas need is replaced by biogas until 2020. There is also an alternative method for using biomethane directly for fuel compared to feeding into network, but this takes place a very small proportion in applications around the world.

Direct use of raw biogas is actually impossible because of the presence of specific substances such as sulphur. Therefore, biogas goes through a variety of gas purification and gas preparation processes because of a precondition for using various combinations. These processes can be listed as desulphurization, drying separation of carbon dioxide, separation of oxygen and other trace gases and also turning into quality of natural gas.

2.4. Organic Fertilizer Production

Remaining solid products after biogas production are called as digestate. Nitrogen, phosphorus and potassium, which are the need of plants, are protected in remaining part of biogas plant. So this material can be used as agricultural fertilizer.

The most important ingredient used in the production of biogas plant is animal waste. Animal waste is described as liquid manure, manure slurry, farmyard manure, by-products of straw and similar agricultural production that are proposed materials for the implementation directly or indirectly on agricultural crops to support the growth of cultivated plants, increase efficiency and the quality according to the 1th item and 2nd paragraph of Fertilizer Law. Anaerobic fermentation is an advanced technology that is applied to animal waste. Fermentation of animal origin manure and plant materials sourced from agricultural production is also classified as farm wastes. Processed wastes that are obtained after anaerobic fermentation can be covered in the cope of Fertilizer Law. Therefore, farmers can produce fertilizer as an energy producer.

Digestate is in the form of solid and liquid. Separation of organic materials from liquid manure can be done by fermentation. Organic dry matter content of digestate can be reached to 40% in this way. Fermented liquid manure whose dried matter content is increased can be pumped and sprayed easily then raw manure. Because of these properties, it is more easy to use in agricultural activities. The advantages of fermented liquid manure and the disadvantages of raw manure are summarized in the following table.

Table 2.23. Comparison of Fermented Liquid Manure and Raw Liquid Manure (Köttner, 2011)

Fermented Liquid manure	Raw Liquid manure
ADVANTAGES	**DISADVANTAGES**
Separation organic materials (increasing the dry matter content)	Unpleasant odor during treatment and production

Decreasing smell	The spread of pathogenic bacteria
Cleaning	Damage of botanical formation and the formation of typical “Liquid Fertilizer Flora”
Elimination of weed seeds	Deterioration of soil properties
Development of fertilizer value (Short-time effect of N-Fertilizer)	Pollution of groundwater and surface water

Various legal arrangements should be considered depending on the uses substrate and the production and processing of fermented wastes in biogas production plants. These arrangements are applied in EU members. However, there is not any legislation related to the properties and the use of digestate sourced from biogas plant in Turkey. This situation poses a problem in terms of application in Turkey. So, applied Fertilizer Regulations in Germany should be organized for Turkey. The fundamentals of EU’s Fertilizer Regulations are considered in this project to give accurate information in respect to the application and enforcement because there is not any legislation related to this in Turkey.

Fertilizer Regulation in Germany

Marketing fermented manures in terms of important purposes of legislation is covered by provisions of Fertilizer Regulation (DüMV) and Fertilizer Practices Regulation (DUV). Because there is still an absence of legal regulations for fermented manure (digestate) in Turkey, compliance with U.S.A. regulations can be considered in current applications. .

Despite the lack of regulation related to the application of digestate in Turkey, relevant parameters of organic fertilizer should not exceed the values which are given in The Production, Importation and Placing on the Market of Agricultural Organic, Organomineral Fertilizers, Soil Regulators and Other Microbial Product with Enzyme Content Regulation. Relevant parameters are given in the following table.

Table 2.24. The Limit Values of Regulation (Ministry of Agricultural and Rural Affairs, 2011).

Limit values of Heavy Metals	Unit	Amount
Cadmium , (Cd)	(mg/kg or ppm)	: 3
Cupper, (Cu)	(mg/kg or ppm)	: 450
Nickel, (Ni)	(mg/kg or ppm)	: 120
Lead, (Pb)	(mg/kg orppm)	: 150
Zinc, (Zn)	(mg/kg orppm)	: 1100
Mercury, (Hg)	(mg/kg or ppm)	: 5
Chrome, (Cr)	(mg/kg or ppm)	: 270
Health Parameters	**Unit**	**Amount**
Manures Microbe	cell/g	: 1.0x103
Total bacteria (Anaerobe, Microaerophyl)	cell/g	: 1.0x103
Total anaerobic microorganisms	5cfu/ml	: -
Enterobactericea Bacteria Group	cfu/ml	: < 3
Total Lactose positive bacteria	cfu/ml	: < 1
Escherichia coli	-	: -
Clostridium spp	5cfu/ml	: <2
Salmonella spp	-	: -
Mycobacterium spp	-	: -
Staphylococcus aureus	-	: -
Bacillus anthracis	-	: -
Bacillus cereus	-	: -
Total flaman fungus and yeast	cfu/ml	: <3

Suitable criteria for the application of organic products, which are obtained from vegetable and animal wastes after physical and chemical processes in accordance with the Regulation, are given below.

Table 2.25. Organic Fertilizer Sourced from Animal and Plant (Ministry of Agricultural and Rural Affairs, 2011).

Specie Name of Organic Production	The obtaining way of organic product and information about main components	Nutritious Matter Content and other criteria needed to be in product contents, amounts and raw materials
Solid Organic Fertilizer	Obtained products as a result of physical and chemical processing of animal derived materials	Organic matter at least : % 30 Organic nitrogen at least: % 2 Total (N + P_2O_5 + K_2O) at least : % 6 Maximum moisture: % 20 The used raw materials should be specified. 90% of the products pass in 10mm sieve
Liquid Organic Fertilizer	Obtained products in the form of solution or suspension as a result of physical and chemical processing of animal derived materials	Organic matter at least: % 25 Total (N + P_2O_5 + K_2O) at least: % 3 The used raw materials should be specified.
Solid Organic Fertilizer	Obtained products as a result of physical and chemical processing of vegetable or animal derived materials	Organic matter at least: % 30 Organic nitrogen at least: % 2 Total (N + P_2O_5 + K_2O) at least : % 6 Maximum moisture: % 20 The used raw materials should be specified. 90% of the products pass in 10mm sieve.
Liquid Organic Fertilizer	Obtained products in the form of solution or suspension as a result of physical and chemical processing of the mixture of vegetable and animal derived materials	Organic matter at least: % 25 Total (N + P_2O_5 + K_2O) at least : % 3 The used raw materials should be specified

Sealed storage tanks should be designed for fertilizers and fermented wastes in order to prevent any leakage to surface and groundwater. Ammonium nitrogen losses occur during storage of the fertilizer after the anaerobic treatment. Nitrogen loses can be classified in the form of gas (ammonia) and minerals (nitrate) during the soil implementation. Nutrient content of fertilizer is important in order to increase the quality of the soil. Various amounts of the nutrients found in total solid manure are given in the table below.

Table 2.26. The Amount of Nutrients in Animal waste

Animal Species	N	P_2O_5	K_2O	CaO	MgO
Cattle Manure	2,3-4,7	0,9-2,1	4,2-7,6	1,0-4,2	0,6-1,1
Chicken Manure	4,3-9,5	2,8-8,1	2,1-5,3	7,3-13,2	1,1-1,6

Scratchy hose tractor and fertilizer distribution tractor can be used for soil applications. First one of these reactors causes 41% less emissions than other. The other one causes strong odor and ammonia emissions. The pictures of these reactors are given in below, respectively.

Figure 2.13. Soil Practice Methods (Köttner, 2011).

Change the application from the use of animal wastes to the use of digestate provides economic and environmental benefits in the concept of biogas production from animal waste. Minimizing the negative effects on soil, water and air pollution is most important one depending on the change in current waste management. So, environmentally friendly approaches are adopted from the local area where biogas plant is installed. Agricultural efficiency increases and the intensity of odor decreases depending on the change in fermented fertilizer (digestate) in Aydın. Moreover, cost caused from the application of chemical fertilizer decreases due to the use of digestate. Environmental benefits from the use of digestate are summarized in the following table.

Table 2.27. Environmental Benefits of Fermented Manure

Environmental Benefits of Using Fermented Biogas Waste	
Advanced use of fertilizers	- Prevent the loss of nutrients - Decrease the severe impact on plants - Improve the flow properties - Increase the adequacy of plant - Increase the plant health - Reduce weed seed germination
The use for environmental health	- Decrease the intensity of odor - Decrease air pollution sourced by methane and ammonium - Reduce the depression of nitrate - Clean the liquid fertilizer - Recover the organic remains - Reduce the connection costs with a central sewer system

3. LEGISLATION

In this section, as a part of this work, information about the existing legal legislation of animal waste regarding to utilization of renewable energy resources for the purpose of generating electrical energy and information about animal waste management will be given. There are plenty of existing regulation and directive in waste management. Waste producers have to obey the legal liabilities related to legislation. As part of project, legal legislation regarding to products from animal source sector has to be considered because the mentioned wastes are animal wastes.

Besides, except waste regulation, the project including the use of renewable energy sources and legal framework about obtaining energy have an importance. The regulations about the use and practice of the products will be gained and as a result of the use as renewable energy resources of animal wastes can be summarized as below:

- The Renewable Energy Law
- Animal Side Products Unused for Human Consumption Regulation
- The Protection of Waters Against Pollution Caused by Nitrates from Agricultural Sources
- The Solid Waste Control Regulation
- General Rules For The Regulation of Waste Management
- Environmental Law
- The Production, Importation and Placing on the Market of Agricultural Organic, Organomineral Fertilizers, Soil Regulators and Other Microbial Product with Enzyme Content Regulation
- Control Regulation of Emissions Cause Odor

In this section, particularly important points of waste producers' responsibilities and liabilities will be summarized rather than giving all the texts related to regulations.

3.1. Waste Regulations

Inadmissible plants due to disposing their wastes to environments directly or indirectly as a result of production, consumption and services have to treat and dispose their wastes or make them dispose and get necessary licenses regarding to the standards and methods of regulations. Legislation related to Waste Management is considered as a part of Environmental Law.

Besides, waste producers have to take measures to decrease their wastes to the minimum by using suitable methods and technologies. Preventing or decreasing waste production and waste harms by waste recovery and collecting recovered wastes one by one at waste source are fundamentals. Ministry arranges the fundamentals about waste management plans. Natural and/ or artificial person who demands to establish and manage waste recovery, recycling and disposal plants obliged to obtain license from Ministry and obtain permission about production standard, the suitability or products for sale and inspection in the markets from foundations regarding to determined fundamentals of regulations.

People who pollute and harm the environment are charge of the harms without seeking failure condition due to decomposition and pollution they cause. The compensation responsibilities of people who pollute the environment are hidden due to occurred harms regarding to general rules. Proceedings about preventing environmental pollution and recovering it are availed of incentive scheme. For this purpose, at the beginning of every year new fundamentals can be introduced by Undersecretaries of Treasury providing that consulting to the Ministry.

According to European Union Waste Directive, European Union members will be prohibited to send their organic wastes to the waste storage fields as from 2020. For this reason, plenty of large biogas plants are built to be suitable method for organic waste recovery in European Union countries. Depending on the work, which was done in Turkey in 2005, annual goals to decrease organic waste amounts are set. But, the goals cannot be practiced in determined years. From now on, the new goals about organic waste amounts will be stored by coming into force the regulation about regular waste storing are shown in the below table. The regulation of general rules about waste management is announced in the official newspaper dated on 5 July 2008.

Table 3.1. Annual Targets Related To the Amount of Landfilled Organic Waste (Regulation on Landfill of Waste, 2010)

Goals of Organic Waste Quantity To Be Landfilled	
Target time	**Total organic Waste Amount** (as weight) (in 2005 the produced total organic waste amount as weight)
Within 5 years	% 75
Within 8 years	%50
Within 15 years	%35

The main purpose of the law is to be protected against harmful effects of wastes throughout the process from waste production to disposal time. Regulations related to biomass are not included. With respect 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 re-cleaning.
- 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, activities related to all kinds of waste and residues, which could result in the detriment of the environment, are prohibited.

Organic content of animal wastes and their recoveries, biomass and renewable energy recovery by aerobic and anaerobic composting related to animal waste management have to be considered as sustainable option. The strategy of waste management represents biogas plants for in particular organic fraction as an important alternative. For this reason, it is important due to bio-methane and compost recovery by anaerobic digestion of animal wastes, channeling of these kinds of wastes to the new fields except regular storage fields, protection of water waste and gas emissions of animal wastes.

3.2. Energy Regulations

Ministry of Energy and Natural Resources is the main foundation, which is charge of Energy policy of Turkey. Besides, there are plenty affiliated foundations with Ministry of Energy and Natural Resources. These are listed in the below table.

Table 3.2. The Main State Institutions and Organizations Responsible for Energy Policies in Turkey (Budak, 2009).

Foundation Name	Related to Governmental Foundation
(SPO), State Planning Organization	Premiership

TUBITAK, The Scientific and Technological Research Council of Turkey	Premiership
Research, Planning and Coordination Council	T.C. Ministry of Energy and Natural Resources
Directorate General for Energy	T.C. Ministry of Energy and Natural Resources
Directorate General of Mines Safety	
Directorate General of petroleum concessions	T.C. Ministry of Energy and Natural Resources
Turkish *Electricity* Generation *Company*	T.C. Ministry of Energy and Natural Resources
Turkish Electricity Transmission Company	T.C. Ministry of Energy and Natural Resources
Turkish Electricity Distribution Company	T.C. Ministry of Energy and Natural Resources
Turkish Electricity Trading and Contracting Company	T.C. Ministry of Energy and Natural Resources
The State Water Supply Administration the State Water Supply Administration	T.C. Ministry of Energy and Natural Resources
The Turkish Petroleum Corporation (TPAO)	T.C. Ministry of Energy and Natural Resources
Directorate General of Renewable Energy	T.C. Ministry of Energy and Natural Resources
Petroleum Pipeline Corporation	T.C. Ministry of Energy and Natural Resources
Plants of Turkish Coal	T.C. Ministry of Energy and Natural Resources
Council of Turkish Anthracite	T.C. Ministry of Energy and Natural Resources

But, until now, any foundation has been established to support the use of biogas by policies and to be charge of biomass. 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 law provisions of "Utilization of Renewable Energy Resources for the Purpose of Generating Electrical Energy" have to be taken into consideration in the use of electrical energy production including animal wastes (biomass) of renewable resources. The aim of this law is to increase the use of renewable energy sources for generation of electrical energy, to gain the resources to the economy as reliable, economical and good-qualified, to diversify energy resources, reduce greenhouse gas emissions, assess waste products, protect the environment, and develop the necessary manufacturing sector for realizing these objectives. Besides, this law includes the protection of renewable energy resource fields, documentation of electrical energy gaining from the resources and the guidelines and rules about the use of the resources. As a part of this law, animal wastes are called as biomass with together the other renewable energy resources.

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".

For following and determination of source type of producing electrical energy from renewable energy resources at purchase and sale produced among national markets and international markets, (RES document) "Renewable Energy Source Document" is given to partial person who got the production license by EPDK. The guidelines and rules about RES document are arranged by regulation. Existing prices on the List-1 are practiced for 10 years for the owners of production license who have RES support mechanism for operating or being operated facilities between the year of 18/5/2005 and 31/05/2015 related to application of Law. The price for production plants based on biomass is indicated as 13,3 US¢/kWh (The Law related to Utilization of Renewable Energy Resources for the Purpose of Generating Electrical Energy, 2005). This price in Turkey according to Renewable Energy Law is listed to the determined grid. Besides, according to related regulations' List-2, local additions are done to the plants, which use local produced equipment based on biomass energy (Table 3.3)

Table 3.3. Additions of Local Contribution

Plant Type	Local Production	Addition of Additives (US¢/kWh)
Manufacturing Plant Based on Biomass Energy	1-Fluidized bed steam boiler	0,8
	2- Liquid or gas fired steam boiler	0,4
	3- Gasification and gas cleaning group	0,6
	4- Steam and gas turbines	2,0
	5- Internal combustion engine or a stirling engine	0,9
	6- Generator and power electronics	0,5
	7- Cogeneration system	0,4

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 waste 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. If the manure fulfills the limitations it can be used as fertilizer directly.

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 Ministry of Food, Agriculture and Livestock are executing the provision of this regulation. The purpose of this regulation is to derivative and determines 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 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 or digestive residues that arise during the conversion of biogas and compost may be offered to the market as organic fertilizer and soil enhancer. 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.

3.5. Protection of Water Against Pollution Caused By Nitrates From Agricultural Sources Regulations

Last amendment of water pollution control regulation was announced in the official gazette on 13/02/2008. 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 newspaper. 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 groundwater, 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 seawaters are eutrophic and also whether these waters could be eutrophic.

Besides, In Turkey, Waste Pollution Control Regulation of discharge limits of livestock wastes is shown on Table 5.15. Discharged livestock wastes to the environment are treated by biological and/or by physicochemical processes after the dilution of waste with water. According to related discharged limits, the average for 24 hours should be as COD$\leq$ 400 mg/l, TSS $\leq$ 150 mg/l, NH_4-N $\leq$ 15 mg/l, PO_4-P $\leq$ 2 mg/l and pH=6–9. The use of expensive advanced waste treatment technologies like

Nanofiltration should be required to reach these limits after biological nitrogen and phosphorus removal in Membrane Bioreactor.

Biogas can be an option to solve the problem by using the manure in combination with a good fertilizer management. Programs shall be developed in required areas to train and inform farmers and to promote the implementation of good agricultural practices. The Ministry of Agriculture and Rural Affairs shall determine the amount of livestock manure for vulnerable zones, with respect to region, soil, climatic conditions and specific agricultural activities to be implemented.

- 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.

3.6. Regulation on Control of Emissions Causing Odor

The goal of this regulation is to arrange the technical and governmental guidelines and rules related to the decrease and control of emissions causing odor. Its content includes the sanctions and processes related to solutions and determination of odor problems coming from proceedings with odor complaints. This regulation was arranged based on the annex 9th part of Environmental Law, which is dated on 9/8/1983 and numbered as 2872. Proceeding performers causing the odor emissions, while establishing and processing these proceedings:

- They obey the technical requirements of regulation to decrease the harms of plants to the public and environment and have suitable technological levels
- They make the level of odor in the environment and odor emissions measure according to the essences determinate in 7th and 8th parts (topic 14-1, 15-1)
- They never pass over the measurements of emission and environment odor according to the determinate levels in regulation
- As a part of the regulation of Environmental Effect Evaluation was announced in the official newspaper dated on 17th July, 2008 and numbered as 26939, they approve to establish the plants according to the below technical requirements: Estimating the plants by this regulations as well during the process of estimation according to the regulation of Environmental Effect Evaluation, Choosing the suitable land to establish the plant, The distance among habitable fields and the protection band around these places, The use of Raw Material and production methods, Decreasing odor emissions or preventing to exist odor emissions in the environment by using waste treatment technology
- They obtain their permissions as a part of Environmental Regulations.

As a part of Regulation, the odor level values can be categorized as the odor level values in the environment and emission level values. Whether Total Ordered Hour Percentage does not pass over %15 in the settlements and %20 in the industrial fields, it is accepted that the odor limit values are approved in the environment. As a part of the regulation, the values about emission in 8th numbered have to be taken into consideration. As a part of odor protection and odor treatment, the numbered laws of regulation that is given below have to be taken into consideration.

- LAW 14-(1) the information in the Odor Protection and Control Methods Guideline is used for plants causing odor emission due to using process and proceedings. As well as, the odor concentration value is decreased below the level value of 8th law.
- LAW 15-(1) The provisions in the added 5th law of the regulation of Control of Air Pollution based on Industry was announced in the official newspaper dated on 3rd July, 2009 and numbered as 27277 are valid to protect smell problem of proceedings of fertilizer during plants, slaughters, barns and coops, plants which works on animal wastes such as animal fats.

3.7. Concurrency With European Union Legislations

When concurrency between legislations of Turkey and European Union Legislations is considered, it is observed that some regulations are concurrent with Turkey and EU countries. Although some regulations of Turkey are concurrent with EU regulations, some regulations, which are active in EU countries, have not legislated in Turkey yet. This situation determinate that some points about animal waste management has not come up with regulations and certain rules. The deficiencies due to animal waste management are obtained as Energy loss of Turkey and waste disposition burden of Turkey.

As a part of Dry Waste Management, the determined goals in EU regulations about preventing / decreasing to send the organic wastes to the settled storage fields is considered as the goals of Turkey among the works of Turkey regulations .

According to Energy White Paper Regulation (EWP, 2006), decreasing greenhouse emissions at the rate of %60 until 2050,and processing some precautions to decrease the emissions until 2020 is determined. The Methane and organic manure recovery from animal wastes are used to decrease greenhouse gas emissions as energy production from methane obtaining from the wastes and as organic manure recovery.

According to EU Animal Side Products Legislation (AbPR, 2003), animal side products (household wastes as well) are required to recover as compost by practicing aerobic and anaerobic biochemical treatment processes. The main goal of this legislation is to protect distributions of pathogen microorganisms obtaining from animal side products to the environment by biological treatment processes. When anaerobic biotechnology is used, practice of pasteurization (1 hour at 70°C) with together high-leveled technological execution is approved. When the beneficial product recovery is efficient in the strategy of EU Waste Reduction and in the Thematic Strategy of Waste Recovery, recovery about more sustainable waste management strategy is considered. Biomethane and organic manure recovery from animal wastes are concurrent with the mentioned above proper strategy.

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

- Manure management regulation
- Energy targets regarding the biogas within an energy action plan
- Favorable feed in tariffs (FiT) for biogas
- Biowaste management with targets and/or with given utilization pathways.

4. SITE and INVENTORY SURVEY

The data of current livestock population and slaughterhouses for Aydın and its 16 districts were collected during the site survey stage of this study. During the study, some livestock farms were visited and the current conditions regarding the farming style, manure management and environmental conditions were investigated.

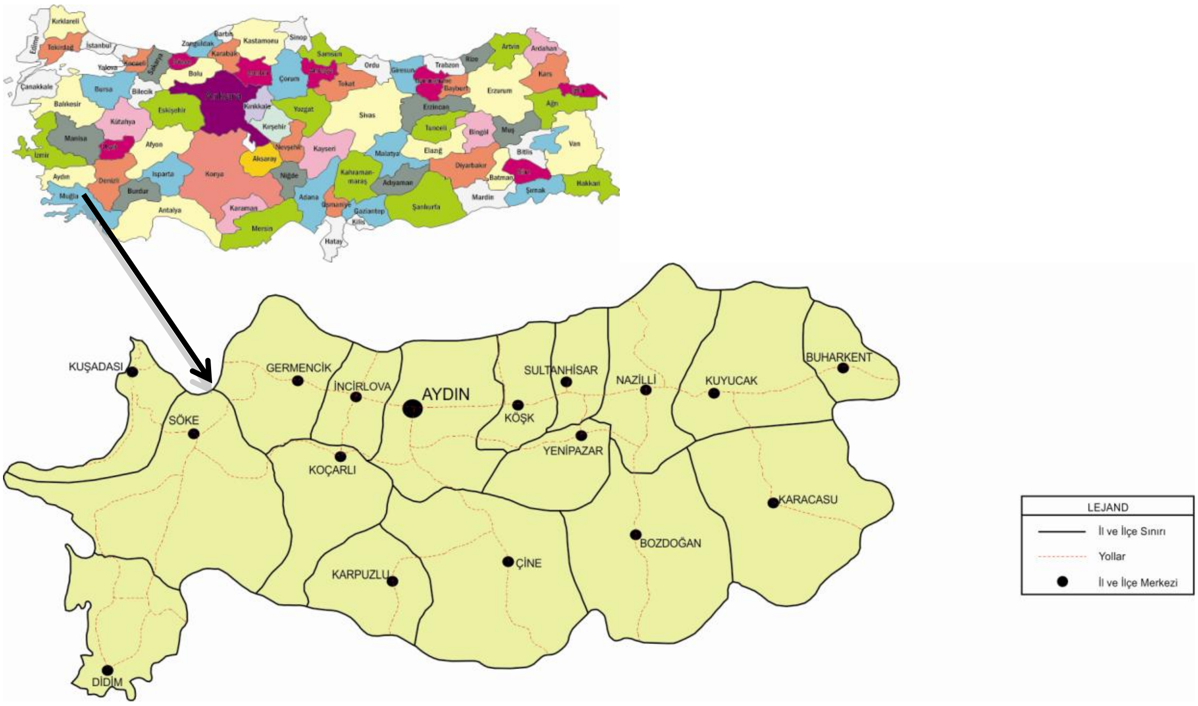


Figure 4.1. Provincial and District Boundaries and District Centers of Aydın

The changes of the number of cattle and cows in Aydın are given in the table below between 2008,2009, 2010 and 2011 by taking into consideration the average numbers of them in Turkey. While the average amount of them is under the average value of Turkey in 2008, this value shows above the average value of Turkey in the following three years.

Table 4.1. Average Amount of Cattle and Cow Per Enterprises That is Recorded to Herd Book in Aydın and Turkey (E-ıslah system, 2011)

Years	Amount of Cattle (head)		Amount of Cow (head)	
	Aydın	Türkiye	Aydın	Türkiye
2008	27,7	29,4	11,0	13,3
2009	28,1	25,3	11,9	11,1
2010	28,5	25,8	12,3	11,5
2011	31,2	26,5	13,2	12,0

Aydın has an important place in the field of livestock in the Aegean Region as in Turkey. In Aegean Region, Aydın is second in-line after İzmir with the number of 66.128 cow and 157.789 cattle according to records of 2011 in the E-ıslah system. According to the research, every one of 6 cattle and cows (17%) that is grown in the Aegean Region is grown in Aydın.

The number of Union members has increased over the years. The number of members increased approximately 7-times from 2002 to 2011 and it reached from 750 to 5.064. In addition, the registered number of cattle increased approximately 14.000 through 158.000. These show that not only the number of registered union members, but also the average number of cattle per farm over the years has increased.

- ***Agricultural Activities in Aydın***

The size of land used for agricultural production has been shown difference among different size classes according to the studies in the concept of Consulting Systems and Dairy Cattle Enterprises Management in Turkey and AB carried out by ADSYB. However, there are fewer farms which has any area for crop production or grazing animals or not use its area (4,8%). 77%of farms that are participated in the study has a small amount of irrigated or non-irrigated arable land.

The majority of cattle farms in Aydın have 10-49 acres available agricultural land (KTA) with an average of 27 acres of land and 15 head of female-cattle. Moreover, the rate of enterprises, that has KTA more than 50 acres including seven farms that have 500 acres for agricultural land, is very high (50%).

4.1. Site Investigation

Aydın is a large region with 17 districts, including the central district. In the context of this study, several locations have been visited in order to identify the waste generation and current waste management techniques in Aydın.

The following information regarding the following topics were collected and discussed

i. Current waste management system
    a. Storage area and used techniques
    b. Waste disposal
ii. Environmental and social concerns
    a. Environmental problems
    b. Social complaints
iii. Precautions to be taken

Bovine Livestock Farm

The facilities that have more than 30 (approx.) are very clean and in order. The cattle are very healthy and they are in good condition. Most of the farms are semi-open facilities.

The following photographs are from bovine livestock farms, which has both cows for milk production and cattle for meat production. Generally, the farms, which look like those, have cattle populations between 50 and 250, including the calves.

Figure 4.2. Bovine Livestock Farms

Manure Management

- ***Manual Manure Collection***

The general situation is that the farms are not using automatic manure collection systems widely. Some of the farms even don't have electricity and generating electricity by diesel generators, when it is necessary.

2 farms that we have visited are using manual manure collection. In manual manure collection, a tractor is pulling a stripper on the ground and taking the manure to the storage pit, where it will be waiting for 6 months. The farms are stripping the manure 2 or 3 times in a month. The following photographs are showing the manual stripping system's corridor in those farms.

Figure 4.3. Manual Stripping System

After the stripping of the manure in the corridor, where the cattle are feeding and living, the manure is stored in a land at the end of the farm. The land is a couple of meters deeper than the concrete waste corridor of the farm. The manure is stored there 6 to 8 months in order to get dry and be usable at the farmlands, where it will be taken in the spring and summer time. The followings are the photographs of the storage area.

Figure 4.4. Areas That Manures Spilled

- ***Automatic Manure Collection***

The farms, which have the automatic collection system, are in better shape. The cattle are cleaner than the others and that is much more hygienic than the manual collection system. The automatic collection system is a two-way stripper. It goes from one side to another and strips the manure to an underground storage, and then it goes to the other side and strips the leftovers to the other underground storage. The stripper has sensors on it to detect the cattle, which are on their way, and to stop when necessary. The following photographs are from the farm where it has an automatic manure stripper system.

Figure 4.5. Automatic Manure Stripper System

This stripping system is working 2 times a day and therefore the ground where the cattle are standing is much more cleaner than the farms which are using manual system. The following photograph shows the situation in the automatic stripping (left) and manual stripping system (right).

Figure 4.6. Automatic Stripping (left) and Manual Stripping System (right)

The automatic manure stripper system collects the manure and pulls it to the underground storage, where it will be waiting for 1 month. During that period, a pump is mixing the manure with water, in order to make it pumpable. By that way, they are pumping the manure to the farmlands without carrying by trucks and tractor loaders. The farms are generally using their manure in their own farmlands.

Figure 4.7. Pumping System

Risks and Precautions

There are a couple of risks foreseen during our site survey. Those are listed below;

Risk-1: The manure collection system is very important for hygiene.

Precaution-1: All the farms should have automatic manure collection system.

Risk-2: The manure storage areas are very near to the farm. Also, the manure is staying on the land for more than 6 months and greenhouse gas emissions generates during that stage. The rain also makes the manure decompose over the land and its aqueous emissions are contaminating the ground water. This is not hygienic and very harmful for the environment, as well as the employee working in the farm.

Precaution-2: The manure could be collected in a pool, where an impermeable layer is put between the soil and manure. An impermeable material could cover the pool in order to stop the greenhouse gas emissions escape to the atmosphere.

Risk-3: The manure is being used as a fertilizer at the moment. This is not healthy and has some serious risk. The pathogens could easily be transferred to the soil and to the crops being cultivated in those lands. Also, the manures harm the farmland, by ruining the soil and its agricultural properties.

Precaution-3: The manure should decompose before being used as a fertilizer in farmlands. In order to decompose the manure, it should be either sent to a biogas facility or to a composting facility. Another option is to decompose it on an impermeable material, and letting it dry by mixing it periodically. But this method should be well managed on the land before taking it as a decomposing method for animal manure.

Risk-4: The underground storage tank for manure is a very good application. But to mix it with water and send it to the farmlands, without letting the manure to finish its biological decomposition, includes the risks foreseen above. The pathogens could be transferred to the soil and to the crops. Also, the manures harm the farmland, by ruining the soil and its agricultural properties. Also the liquid manure could leak to the ground from the underground storage. The underground storage should be made of an impermeable material like polyethylene, polycarbonate or reinforced concrete.

Precaution-4: The facilities, which have underground storages, could change these underground storages to basic biogas units. The performance for generating biogas and the quality of the biogas won’t be good enough to generate electricity, but they could use that biogas in basic burners to cook or boil water.

Slaughterhouses

Currently, there is no regular waste collection system in Aydın for the slaughterhouse wastes. The slaughterhouses generally have the number of animals they are slaughtering, but they don't know the amount of waste they are generating and sending for disposal. In developed countries, such wastes are collected by licensed companies and sent to special disposal units.

There are a couple of wastes that the slaughterhouses are generating;

- Manure; which is generated by the animals before slaughtering
- Internal organs; which are not usable as offal.
- Blood; which is currently being sent to the municipality wastewater treatment facility.
- Bones; which are being taken by some companies periodically.

Figure 4.8. Manure in slaughterhouse

Figure 4.9. Internal organ residues (not offal)

Figure 4.10. Bones (covered by lime)

Slaughterhouse wastes are generally sellable, but the intestines are useless and left as a final waste to be disposed. The small slaughterhouses are sending their waste to the municipality landfills, while the big slaughterhouses are burying the waste to excavated pits in ground with 1,5 to 2m depths.

Those wastes have no more financial value but have value as biomass. They have to be studied very well, before taking them to a biogas process as they could cause real problems for the microorganism, which are active in biogas process.

4.2. Inventory Survey

4.2.1. Livestock Enterprises In The Region

The data related to the livestock farms and slaughterhouses were collected and interpreted according to the number of districts. The stock farm data belongs to year 2012, while the data for poultry and ovine belong to year 2010.

The stock farms are classified in to two as; herd book and pre-herd book. Herd book farms are the ones that are registered to the ADSYB and pre-herd books are the farms that are not registered to the association. The poultry farms are grouped into two as commercial and breeding farms. The populations of livestock in those farms are given in the table below.

Çine is the densest district for the amount of farms with 6582 farms, while central district, Nazilli, Bozdoğan, Söke and Karpuzlu districts are following them. The number of farms registered for pre-herd books herd books is variable. As it could be seen on the table, there are a lot of unregistered farms in the region. The correlation chart for the registered and unregistered farms is given below.

The ovine farms are grouped into commercial and breeding farms and the number of farms is given in table below. As it could be seen on the table, Kuyucak is the densest district for ovine farms with 657 facilities, while Buharkent and Karacasu are following with 473 and 447 farms respectively.

Table 4.2. The number of animal farm enterprises in the province of Aydın

Districts	The Number of Bovine Enterprises 2012			The Number of Ovine Enterprises 2010	The Number of Winged Enterprises 2010
	Pre-herd Book Enterprises	Herd Book Enterprises	Total	Total	Total
Merkez	3872	746	4618	174	1
Bozdoğan	3449	454	3903	225	2
Buharkent	254	38	292	473	24
Çine	5494	1088	6582	160	2
Didim	406	36	442	50	13
Germencik	1131	237	1368	203	10
İncirliova	968	158	1126	89	4
Karacasu	1055	273	1328	447	1
Karpuzlu	2187	268	2455	191	5
Koçarlı	2200	206	2406	139	1
Köşk	1428	180	1608	37	0
Kuşadası	78	8	86	50	2
Kuyucak	1383	464	1847	657	6
Nazilli	3455	523	3978	337	5
Söke	2529	171	2700	199	10
Sultanhisar	771	88	859	62	1
Yenipazar	1399	270	1669	90	0
TOTAL	**32059**	**5208**	**37267**	**3583**	**87**

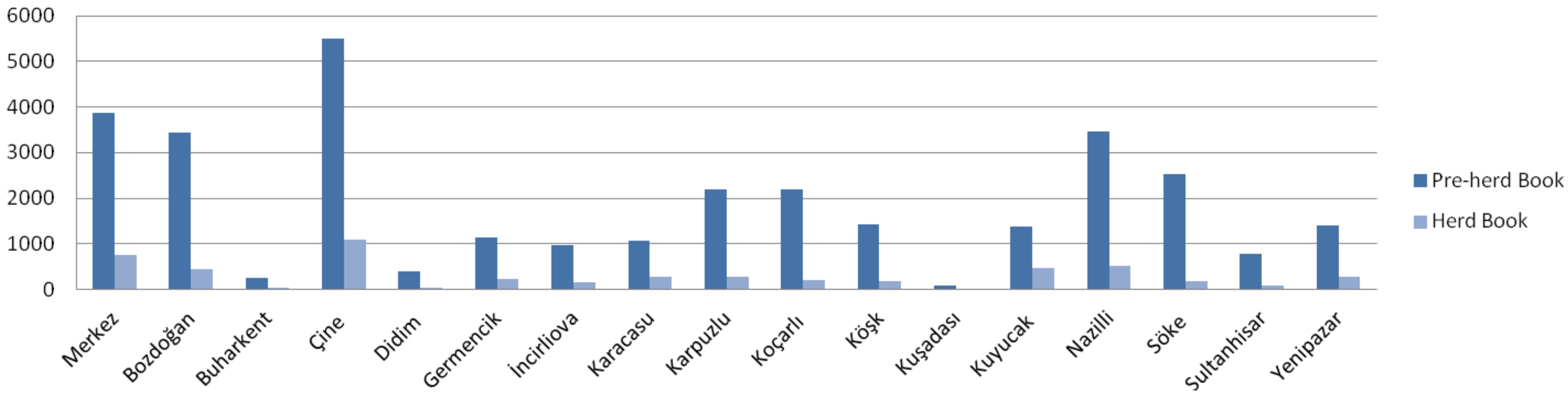


Figure 4.11. Comparison of the numbers for bovine livestock enterprises based on pre-herd book and herd book in the districts

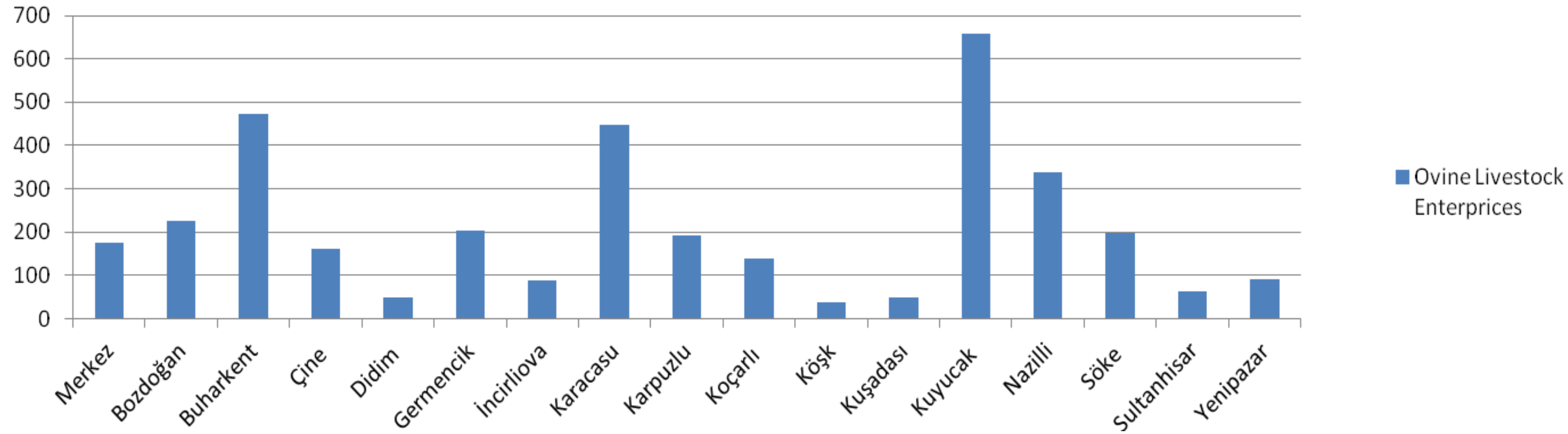


Figure 4.12. Comparison the numbers of ovine livestock enterprises in the districts

The data regarding the poultry farms are for Aydın central district and 16 districts as grouped into commercial and breeding farms. According to year 2010 data, the densest districts for the poultry farms are Buharkent, Didim, Germencik and Söke with the numbers 24, 13, 10 and 10 respectively. Köşk and Yenipazar are the districts where there are no poultry farms in the region.

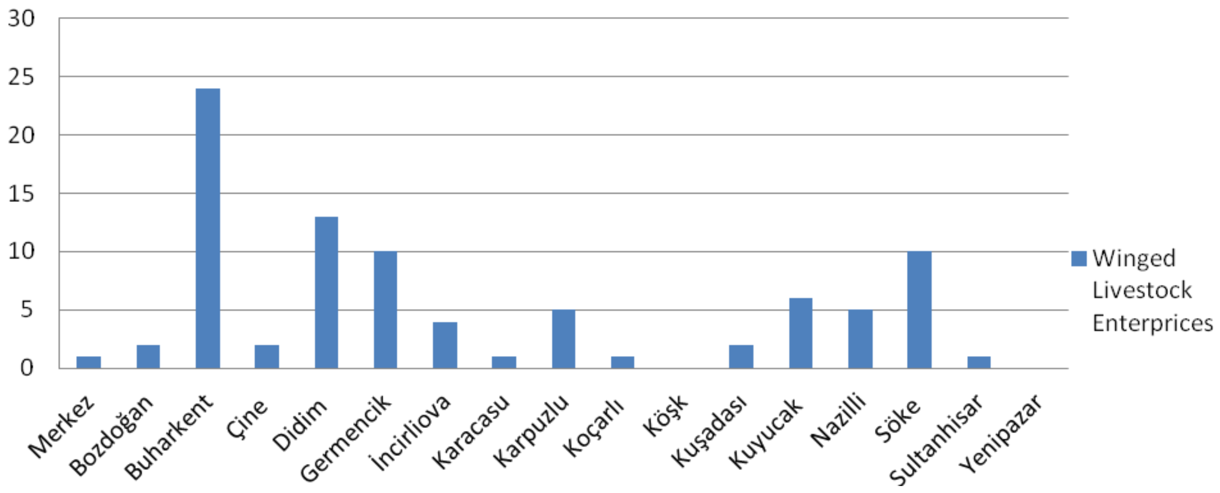


Figure 4.13. The distribution of Poultry Farming Plants Among Counties

The registered slaughterhouses in Aydın, their locations and the related data are given in the table below. Those slaughterhouses given in the table are slaughtering cattle, sheeps or goats according to the regions and type of livestock farms within the district they belong to. The classified slaughterhouses could do the slaughtering of the specified type of animals according to their class. The classification details and limits of slaughtering numbers are given in the related section (slaughterhouses).

Increasing the hygiene at the slaughterhouses by the announcement of the new food regulation is for the compliance studies of Turkish standards with the EU standards. Small slaughterhouses are going to be closed due to hygiene problems, as they are major points for their operational costs to the municipalities.

Table 4.3. Licensed Slaughterhouses

Name	Provinces
COMBINES	
Ege Et	ÇİNE
Paşa Can Et ve Et Ürünleri	Savrandere Köyü-MERKEZ
CLASS 1 SLAUGHTERHOUSES	
Akçaova Belediye Mezbahası	Akçaova-ÇİNE
Öznaz Ltd.Şti.	NAZİLLLİ
Aydın Belediye Mezbahaları	AYDIN-MERKEZ
CLASS 3 SLAUGHTERHOUSES	
Karpuzlu Belediye Mezbahası	KARPUZLU
İncirliova Belediye Mezbahası	İNCİRLİOVA
Germencik Belediye Mezbahası	GERMENCİK
Bozdoğan Belediye Mezbahası	BOZDOĞAN
Kuyucak Belediye Mezbahası	KUYUCAK
Yenipazar Belediye Mezbahası	YENİPAZAR
Köşk Belediye Mezbahası	KÖŞK
Sultanhisar Belediye Mezbahası	SULTANHİSAR
Atça Belediye Mezbahası	Atça-SULTANHİSAR

Davutlar Belediye Mezbahası	Davutlar-KUŞADASI
Bıyıklı Belediye Mezbahası	Bıyıklı-KOÇARLI
Bağarası Belediye Mezbahası	Bağarası-SÖKE
Ortaklar Belediye Mezbahası	Ortaklar-GERMENCİK
Didim Belediye Mezbahası	DİDİM
Karacasu Belediye Mezbahası	KARACASU
Umurlu Belediye Mezbahası	UMURLU
Dalama Belediye Mezbahası	DALAMA
EgeAy Ltd.Şti.	KUŞADASI
Boran Gıda	Pamukören-Kuyucak
Çamlıdere Köy Muhtarlığı Mezbahası	Çamlıdere Köyü-Bozdoğan

4.2.2. The population of livestocks in the region

The bovine livestock in Aydın has developed in bovine livestock, ovine farming and poultry farming. Cow, heifer, male and female calf, young bull and bulls are breeded in bovine livestock, sheep and goats breeded in ovine farming, egg and meat chickens, turkeys and ducks breeded in poultry farming. District based actual data is given in the table below.

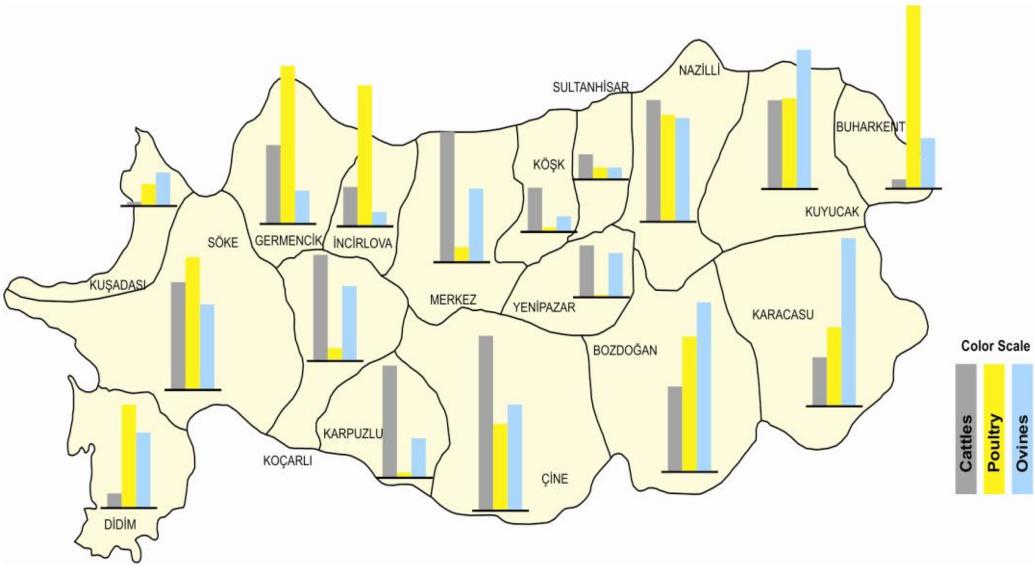


Figure 4.14. The distribution of the number of animals

As it could be seen in the figure 4.15., total cattle population in Aydın is 350.797 according to the year 2012 data. The highest population is in Çine and central district with 74.677 and 44.444 number of animals respectively. Bozdoğan, Nazilli, Karpuzlu, Söke, Koçarlı, Kuyucak, Germencik, Yenipazar, Karacasu, Köşk, İncirliova, Sultanhisar, Didim, Buharkent and Kuşadası follows those 2 districts in descending order.

Table 4.4. Animal Numbers in Farms Located in Aydın Merkez and Other Districts

County	BOVINE - 2012				POULTRY (WINGED)-2010						OVINE- 2012		
	Herd and Pre-herd Book Together				Chicken -Union		The part except the Union			Total	Sheep	Goat	Total
	Cow	Young**	Bull	Total	Egg	Broiler	Egg	Broiler	Others*				
Merkez	18.132	26.311	1	**44.444**	0	30.000	20.000	34.000	30.000	**114.000**	19.843	6.028	**25.871**
Bozdoğan	11.773	18.025	0	**29.798**	0	79.000	25.000	79.000	503.420	**686.420**	17.121	35.285	**52.406**
Buharkent	825	1.196	0	**2.021**	360.420	143.000	301.646	81.098	393.500	**1.279.664**	8.508	2.511	**11.019**
Çine	28.909	45.767	1	**74.677**	0	110.000	26.000	77.000	327.060	**540.060**	19.362	9.972	**29.334**
Didim	1.260	2.150	0	**3.410**	0	393.500	12.800	396.000	0	**802.300**	14.528	7.746	**22.274**
Germencik	6.904	11.094	2	**18.000**	0	600.000	0	443.000	0	**1.043.000**	5.577	1.595	**7.172**
İncirliova	3.741	5.385	0	**9.126**	162.060	165.000	182.206	170.000	222.500	**901.766**	2.808	280	**3.088**
Karacasu	4.525	6.650	0	**11.175**	0	40.000	17.364	0	343.000	**400.364**	25.441	29.751	**55.192**
Karpuzlu	9.979	16.272	2	**26.253**	0	0	2.221	0	0	**2.221**	7.910	695	**8.605**
Koçarlı	8.126	16.802	0	**24.928**	0	35.000	0	30.000	0	**65.000**	15.500	1.116	**16.616**
Köşk	3.887	6.224	0	**10.111**	0	0	9.205	0	0	**9.205**	3.094	193	**3.287**
Kuşadası	325	364	0	**689**	0	45.000	15.700	48.000	0	**108.700**	3.446	3.991	**7.437**
Kuyucak	8.721	11.725	0	**20.446**	0	222.500	17.800	220.000	0	**460.300**	24.360	14.318	**38.678**
Nazilli	11.663	16.709	0	**28.372**	0	304.000	37.500	205.000	0	**546.500**	18.215	4.945	**23.160**
Söke	8.188	17.171	1	**25.360**	0	343.000	0	337.000	0	**680.000**	12.733	6.032	**18.765**
Sultanhisar	2.187	3.480	0	**5.667**	0	25.000	5.450	25.000	0	**55.450**	2.294	156	**2.450**
Yenipazar	6.357	9.963	0	**16.320**	0	0	750	0	25	**775**	6.392	3.361	**9.753**
TOTAL	**135.502**	**215.288**	**7**	**350.797**	**522.480**	**2.535.000**	**673.642**	**2.145.098**	**1.819.505**	**7.695.725**	**207.132**	**127.975**	**335.107**

*Other; Total numbers of turkey, goose and duck in plants
** Under young cattle includes of number of heifer, female/male calf, bullock.

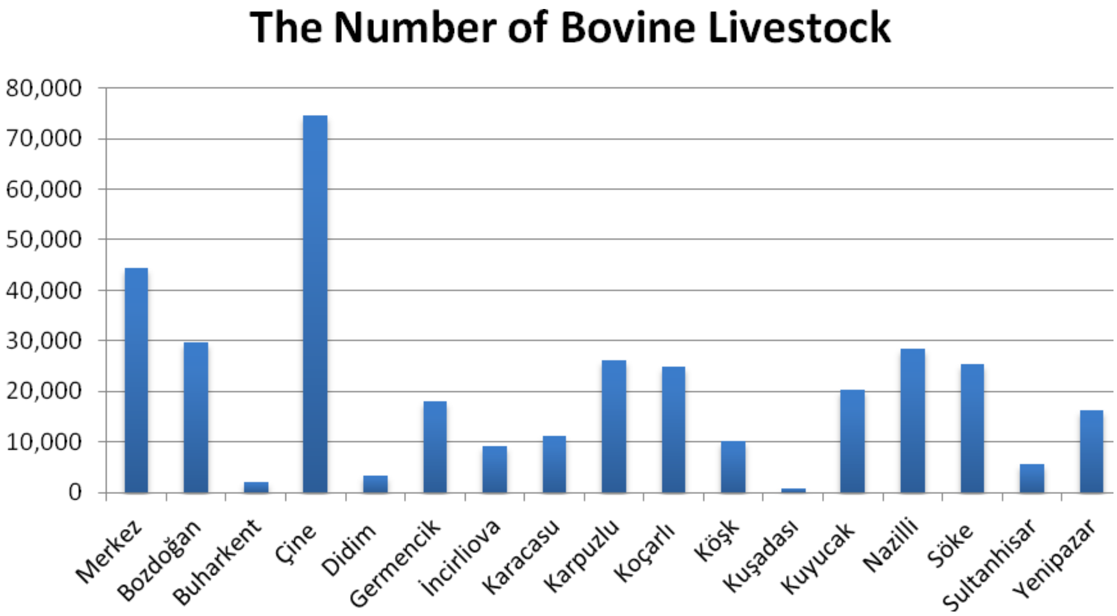


Figure 4.15. The Distribution of Bovine Livestock Based on County

As it could be seen in the figure above, total ovine population in Aydın is 335.107 according to the year 2010 data. The ratio of sheeps in total is 62%, with a population of 207.132, while the population of goats is 127.975 with a ratio of 38% in total. The highest population is in Karacasu and Bozdoğan with 55.192 and 52.406 number of animals respectively, while the lowest populations are in Sultanhisar, İncirliova and Köşk district with 2.450, 3.088 and 3.287 number of animals respectively.

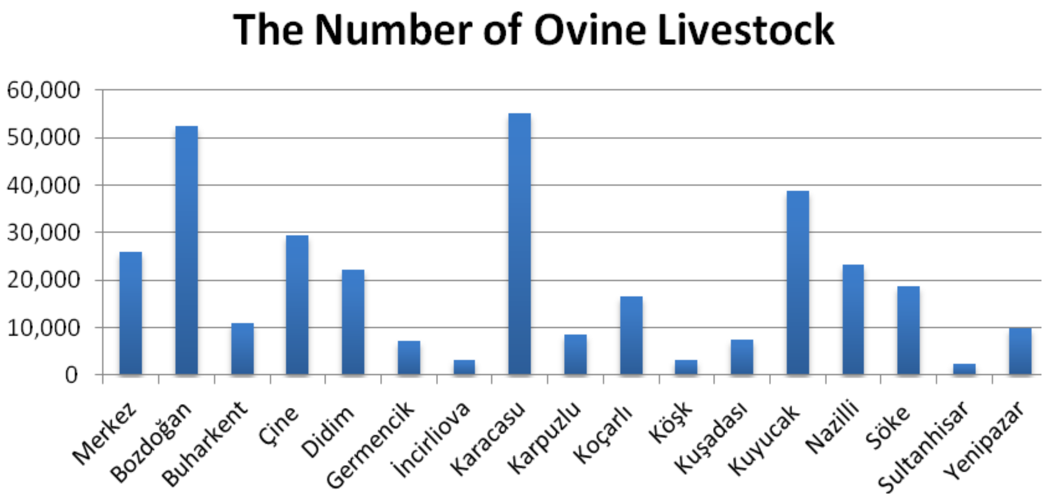


Figure 4.16. The Distribution of Ovine Livestock Based on County

As it could be seen in the table above, total poultry population in Aydın is 7.695.725 according to the year 2010 data. The highest population is in Buharkent, Germencik and İncirliova with 1.279.664, 1.043.000 and 901.766 number of animals respectively, while the lowest populations are in Yenipazar, Karpuzlu and Köşk districts with 775, 2.221 and 9.205 number of animals respectively.

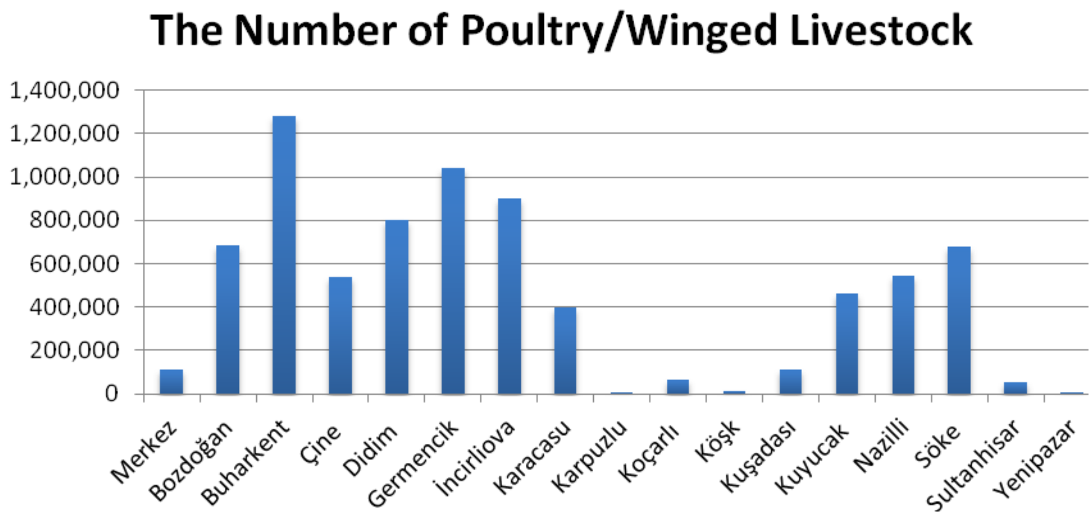


Figure 4.17. The Distribution of Poultry Numbers Based on County

4.2.3. The Numbers Of Slaughterhouses In The Region

The information regarding the slaughterhouses in the region is given in Section 4.2.1. There are 20 class-3, 3 class-1 and 2 combine facilities, with a number of 25 in total. The district-based distribution of the slaughterhouses is given below.

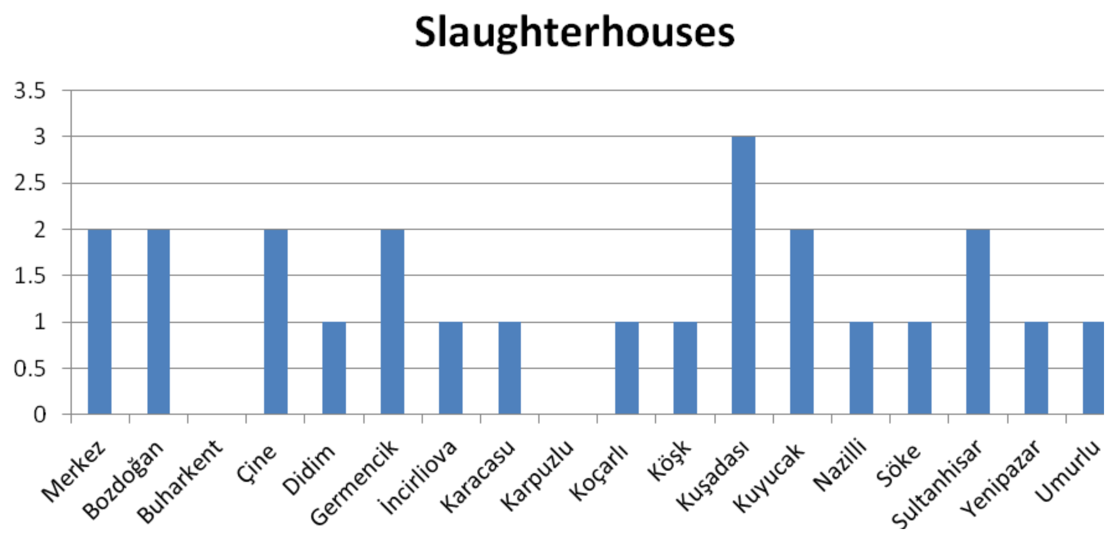


Figure 4.18. The Distribution of the Number of Slaughterhouses Based on County

5. QUANTIFICATION OF REGIONAL WASTES

In order to operate a successful biogas facility, to guarantee the sustainability of the waste input (raw material) is the key point. After the startup of the facility, fluctuations in the raw material amount could stop the process, which will be a total system failure. Therefore, within the context of this study, the most recent livestock and related waste data has been considered.

The Amount of Wastes in Animal Farms

The data of manure generation per unit animal and the characterization of the manure are not available for the Aydın region. Therefore, general data for the manure generation and specifications are assumed during this study. The manure generation according to different types of animals is given in the table below.

Table 5.1. Assumptions for Daily Waste Generation

Animal Specie	Waste Amounts kg manure/animal*day	Sources
Bovine		
Cow and Bull	37,5	www.biyogaz.web.tr
Calf	9,4	www.biyogaz.web.tr
Ovine		
Sheep and Gout	2	Berkes and Kışlalıoğlu, 1993
Poultry		
Broiler Chicken	0,19	www.biyogaz.web.tr
Egg Chicken	0,13	www.biyogaz.web.tr
Turkey-Goose-Duck	0,07	Koçer and et al., 2006

According to the assumptions, the annual amount of manure is calculated in tons according to the amount of animals given in Table 4.4. The calculated manures generation results are given in the table below.

Table 5.2. The Amount of Animal Waste (Manures)

County	The Amount of Animal Waste			
	Quantity of Bovine Manures (ton/year)	**Quantity of Poultry Manures** (ton/year)	**Quantity of Ovine Manures** (ton/year)	**Total Quantity of Manures** (ton/year)
Merkez	338.468	6.154	18.886	363.508
Bozdoğan	222.987	25.006	38.256	286.249
Buharkent	15.396	57.010	8.044	80.450
Çine	552.732	22.559	21.414	596.705
Didim	24.623	55.359	16.260	96.242
Germencik	132.589	72.332	5.236	210.157
İncirliova	69.681	45.253	2.254	117.188
Karacasu	84.752	12.362	40.290	137.404
Karpuzlu	192.444	105	6.282	198.831
Koçarlı	168.872	4.508	12.130	185.510
Köşk	74.558	437	2.400	77.394
Kuşadası	5.697	7.195	5.429	18.321
Kuyucak	159.597	31.532	28.235	219.364
Nazilli	216.966	37.079	16.907	270.951
Söke	171.001	47.158	13.698	231.857
Sultanhisar	41.874	3.726	1.789	47.389

Yenipazar	121.194	36	7.120	128.350
TOTAL	**2.593.433**	**427.809**	**244.628**	**3.265.870**

Cattle manure amount is the dominant type comparison to the other type of animal waste. Annual manure generation according to the type of animals is listed as follows; cattle 2.354.879 tons.manure/year, poultry 427.809 tons.manure/year and ovine 244.628 tons.manure/year. Even the manure generation of ovine per unit animal is higher than the poultry, the number of poultry is much more higher than the others and therefore the annual manure generation of poultry is higher than the manure generation of ovine. The pie charts of manure generation according to types of animals are given below.

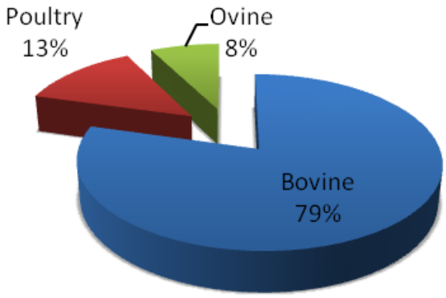
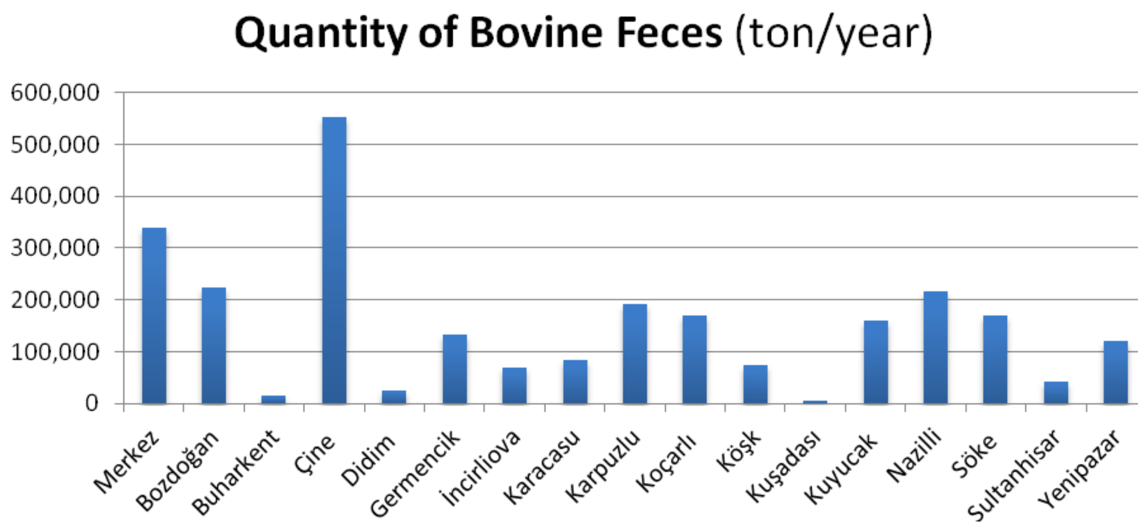


Figure 5.1. The Distribution of Waste By Source

The stock farms generate 79% of the total manure generation in the region. The highest generation is in Çine, which also has the highest cattle population in the region. The annual manure generation in Çine is calculated as 552.732 tons. Central district, Bozdoğan and Nazilli districts follow Çine with the annual manure generation amounts of 338.468 tons, 222.987 tons and 216.966 tons respectively. The distribution of manure generation in bovine livestock regarding the districts is given below.



Şekil 5.2. The Quantity of Bovine Livestock Wastes

The highest annual manure generation from the ovine farms is found to be in Karacasu and Bozdoğan districts with amounts of 40.290 tons and 38.256 tons respectively. Those districts also have the highest population for sheeps and goats. Kuyucak, Çine, central district, Nazilli and Didim districts follows those 2 districts for annual manure generation with the amounts of 28.235 tons, 21.414 tons, 18.886 tons, 16.907 tons and 16.260 tons respectively. The distribution of manure generation in ovine farming regarding the districts is given below.

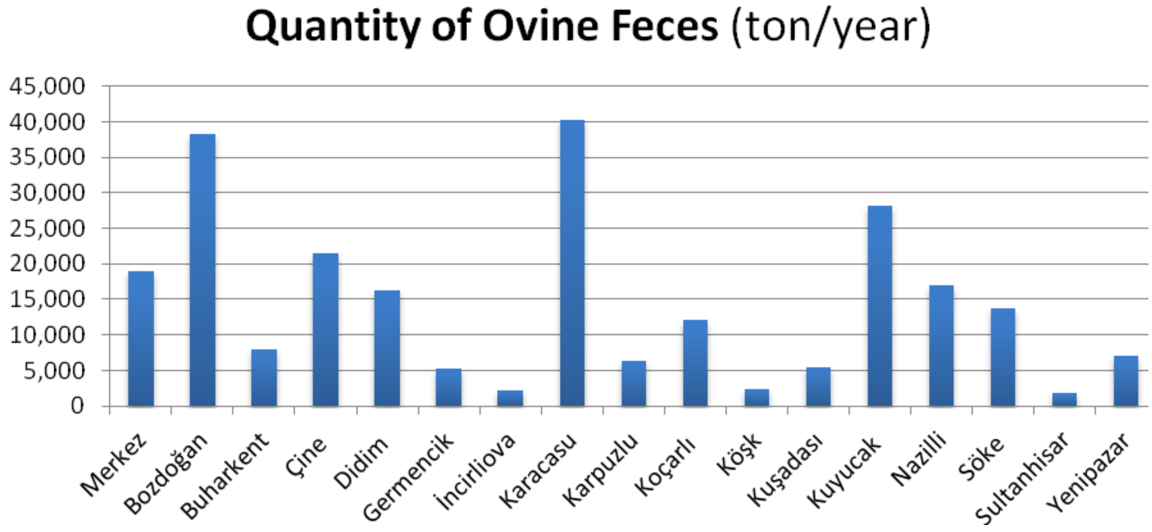


Figure 5.3. The Quantity of Ovine Livestock Waste

Even though the highest poultry population is in Buharkent, the highest manure generation is happened to be in Germencik district. The reason is that, the turkey and duck population is higher in Buharkent than Germencik, but the unit manure generation of chickens is higher than those animals. Therefore, the highest annual manure generation is in Germencik with an amount of 72.332 tons, where also the meat and egg chickens have the highest population as well. Buharkent, Didim, Söke and İncirliova follows this district with the amounts of 57.010 tons, 55.359 tons, 47.158 tons and 45.253 tons respectively. Rest of the districts have manure generation under 40.000 tons annually. The distribution of manure generation in poultry farming regarding the districts is given below.

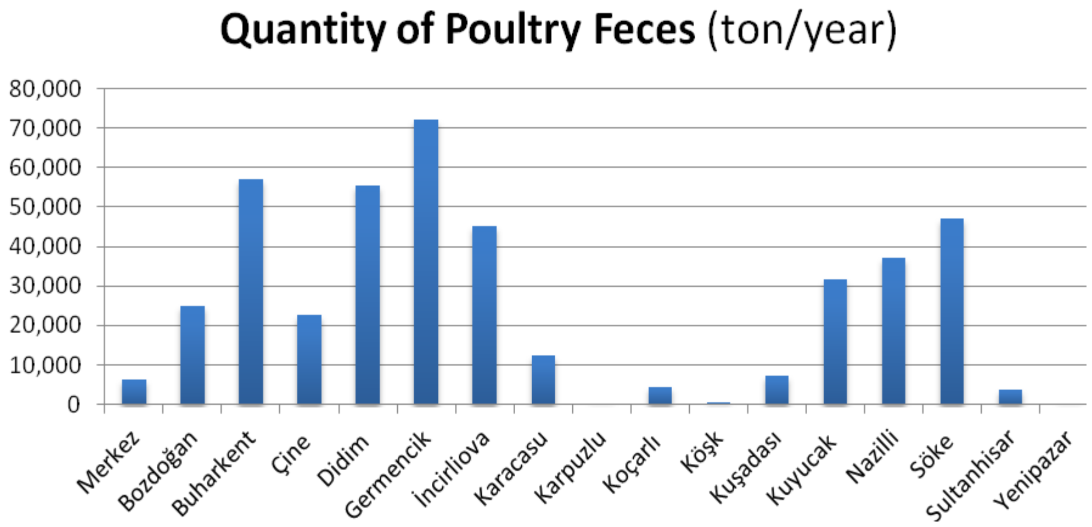


Figure 5.4. The Quantity of Poultry Livestock Waste

The annual manure generation from bovine livestock is calculated as 3.027.317 tons. Regarding the distribution based on districts, Çine is the highest manure-generating district in the region. The main reason for that is, Çine has the biggest bovine livestock capacity in Aydın region. After Çine, central district, Bozdoğan, Nazilli, Söke, Kuyucak and Germencik follows Çine in order, with the annual manure generation amounts of 363.508 tons, 286.249 tons, 270.951 tons, 231.857 tons, 219.364 tons and 210.157 tons respectively. The distribution of manure generation in bovine livestock in the whole region is given below.

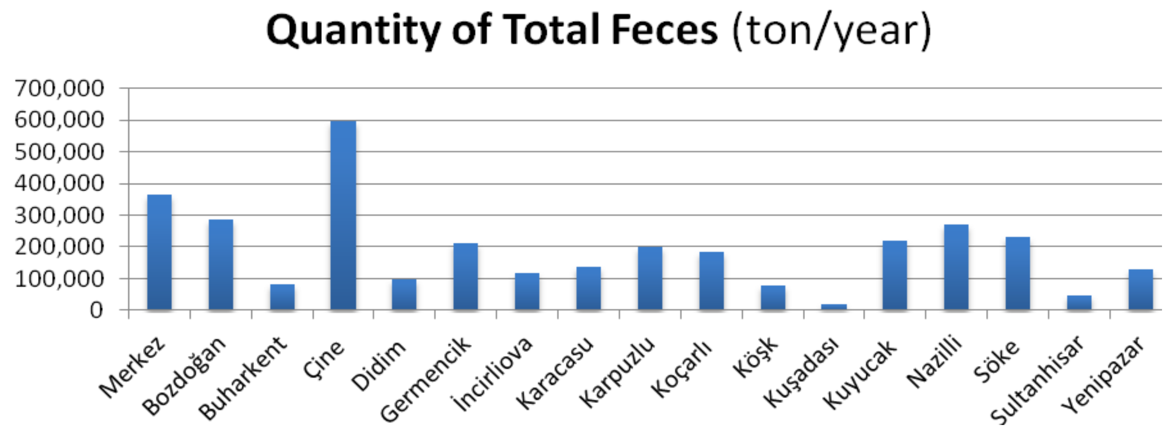


Figure 5.5. The Distribution of Total Wastes Based on County

Slaughterhouse Wastes

The amount of wastes generated by those 25 slaughterhouses is not certain. There are only assumed information regarding the amount of waste generated daily and annually by the slaughterhouse owners or managers. The data given in the study is collected by the interviews with the slaughterhouse workers and managers.

According to those data, combine facilities slaughter the highest number of animals among all slaughterhouses. Therefore, the amount of waste generated by the combine facilities is the highest among all. The daily waste generation in the combine facilities varies between 1 to 3 tons, according to the number of animals slaughtered daily. The daily waste generation in the class 1 slaughterhouses is 0,5 tons, which is 2 tons per week approximately. Generally 10 cattle and 20 ovine are slaughtered daily in those class-1 slaughterhouses. Class-3 slaughterhouses are the small facilities and have a daily slaughtering of 10 animals in the busiest day. Therefore, their monthly waste generation is 1 ton, which makes 50 kg waste daily, approximately.

The variations in the amount of wastes are because of the variations in the amount of animals slaughtered in the facilities. It is also hard to determine the amount of wastes from the slaughterhouses due to the methods used, such as disposing wastes in the landfills and burial of the wastes in the excavated pits. If we do a general approach to the slaughterhouses in the region, approximately 2000 tons of waste is being generated by those facilities annually.

Environmental problems arise due to the burial of those wastes in the ground, such as soil pollution, groundwater pollution and destruction of the agricultural lands by those wastes. Therefore the disposal method of those wastes is important in terms of managing a waste management plan in the region. It is obvious that, a biogas facility could be non-feasible if it was built just for those wastes, as their amount is too low and not certain at the moment. It is logical to use those wastes as an input to the biogas facilities built for the disposal of livestock manures. It would be misleading if those wastes are considered within the facilities mentioned in this study before the exact amounts and side effects of those slaughterhouse wastes to the livestock manures in the biogas process is precisely considered. Therefore, just the biogas and energy capacities of those wastes are calculated separately and they are not considered as an input to the facilities mentioned in this study.

6. WASTE-TO-ENERGY POTENTIAL IN AYDIN

The energy potential of the manures generated by the livestocks has been studied within the context of this study. The energy potential of each manure type varies according to the physical and chemical properties of those wastes. The manure generation calculations are given in the Section 6. Accepted values of dry matter and organic dry matter content and also biogas production potential of different animal wastes are summarized in the following table.

Table 6.1. Accepted Properties of Animal Wastes

Waste Type	**DM** (Dry Matter)	**ODM** (Organic Dry Matter)	**Biogas Potential** (m^3/ton ODM)
Biovine Waste	14,5%	77,5%	250
Winged Animal Waste	28,0%	80,0%	400
Ovine Waste	30,0%	80,0%	200

Moreover, cost of coal, natural gas and electricity, the efficiency of cogeneration and calorific values of coal and natural gas that are used in feasibility calculation are given in the following table.

Table 6.2. Assumptions for Feasibility Calculations

PARAMETER	VALUE	UNIT
1 m^3 biogas	0,65	m^3 methane
1 m^3 methane	9,97	kW enegy
Calorific value of natural gas	8.250	kcal/Sm^3
Calorific value of coal	3.000	kcal/kg
Electricity production efficiency of cogeneration	42%	Percent
Thermal efficiency of cogeneration	46%	Percent
The unit price of natural gas	0,60	TL/m^3 natural gas
The unit price of coal	150	TL/ton coal
The unit price of electricity	0,24	TL/kWh electricity

6.1. Biogas Production Potential

The biogas potential of the wastes that are available in Aydın region is calculated by considering the livestock living in the farms and their annual waste generation potential based in the districts of Aydın.

Table 6.3. Total Biogas Production Potential of Aydın

County	**Quantity of Bovine Manures** (ton/year)	**Quantity of Poultry Manures** (ton/year)	**Quantity of Ovine Manures** (ton/year)	**Biogas Potential** (m^3/year)	**Methane Potential** (m^3/year)	**Electricity Production** (kWh_e/year)	**Heat Production** (kcal/year)	**Installed Power** (kW_e)
Merkez	338.468	6.154	18.886	10.966.758	7.128.393	27.461.477	28.115.322.008	3.407
Bozdoğan	222.987	25.006	38.256	10.341.371	6.721.891	25.895.466	26.512.024.990	3.213
Buharkent	15.396	57.010	8.044	5.926.737	3.852.379	14.840.937	15.194.292.488	1.841
Çine	552.732	22.559	21.414	18.577.428	12.075.328	46.519.092	47.626.688.920	5.772
Didim	24.623	55.359	16.260	6.432.414	4.181.069	16.107.183	16.490.687.234	1.999
Germencik	132.589	72.332	5.236	10.457.192	6.797.175	26.185.490	26.808.953.888	3.249
İncirliova	69.681	45.253	2.254	6.120.429	3.978.279	15.325.953	15.690.856.189	1.902
Karacasu	84.752	12.362	40.290	5.422.528	3.524.644	13.578.365	13.901.659.242	1.685
Karpuzlu	192.444	105	6.282	5.717.440	3.716.336	14.316.843	14.657.720.286	1.776
Koçarlı	168.872	4.508	12.130	5.730.375	3.724.744	14.349.232	14.690.880.639	1.780
Köşk	74.558	437	2.400	2.248.922	1.461.799	5.631.446	5.765.528.122	699
Kuşadası	5.697	7.195	5.429	1.065.280	692.432	2.667.531	2.731.043.593	331
Kuyucak	159.597	31.532	28.235	8.664.226	5.631.747	21.695.786	22.212.352.549	2.692
Nazilli	216.966	37.079	16.907	10.229.148	6.648.946	25.614.453	26.224.320.844	3.178
Söke	171.001	47.158	13.698	9.686.932	6.296.506	24.256.708	24.834.248.957	3.010
Sultanhisar	41.874	3.726	1.789	1.596.117	1.037.476	3.996.781	4.091.942.239	496
Yenipazar	121.194	36	7.120	3.749.799	2.437.369	9.389.740	9.613.305.704	1.165
TOTAL	**2.593.433**	**427.809**	**244.628**	**122.933.094**	**79.906.511**	**307.832.483**	**315.161.827.892**	**38.196**

The map of biogas, electricity and heat generation is given below, according to the data mentioned in Table 6.3.

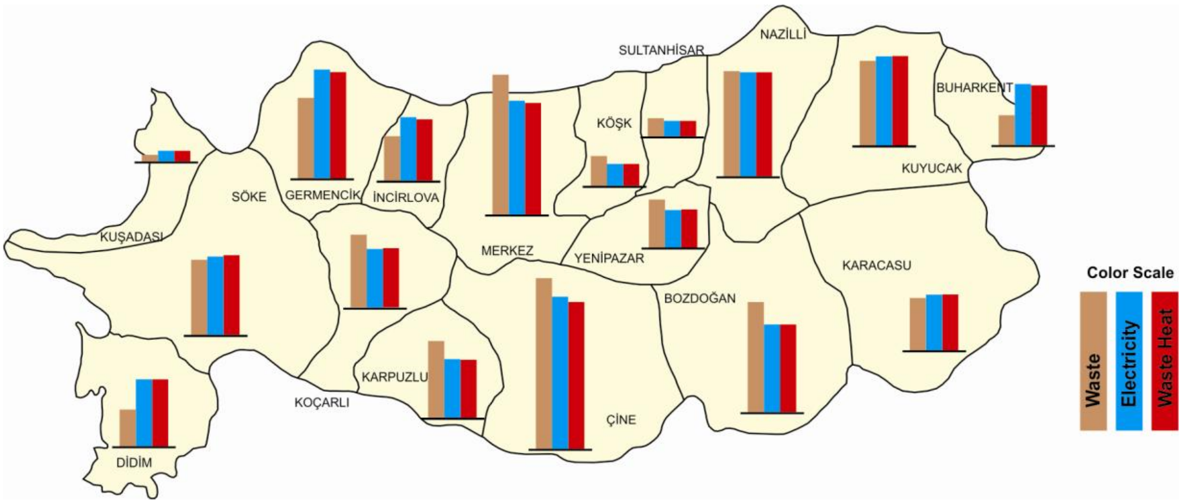


Figure 6.1. Total Waste Quantity and Electricity and Heat Production Potential of Biogas Plant in Aydın

The total biogas potential of Aydın is calculated as 122.933.094 m3 annually. The highest potential is in Çine with 18.577.428 m3 biogas generation annually. Central district, Germencik, Bozdoğan and Nazilli districts follows Çine in descending order. The biogas potential based on districts is given in the graphic below. The methane content of the biogas shows its purity in terms of producing energy out of it. As a general assumption, a healthy biogas facility operates and produces a biogas with methane content of 65% in normal operating conditions. Therefore, we have assumed that 65% methane production is obtained in this project and we calculated that the total methane potential of the Aydın region is 79.906.511 m3 annually.

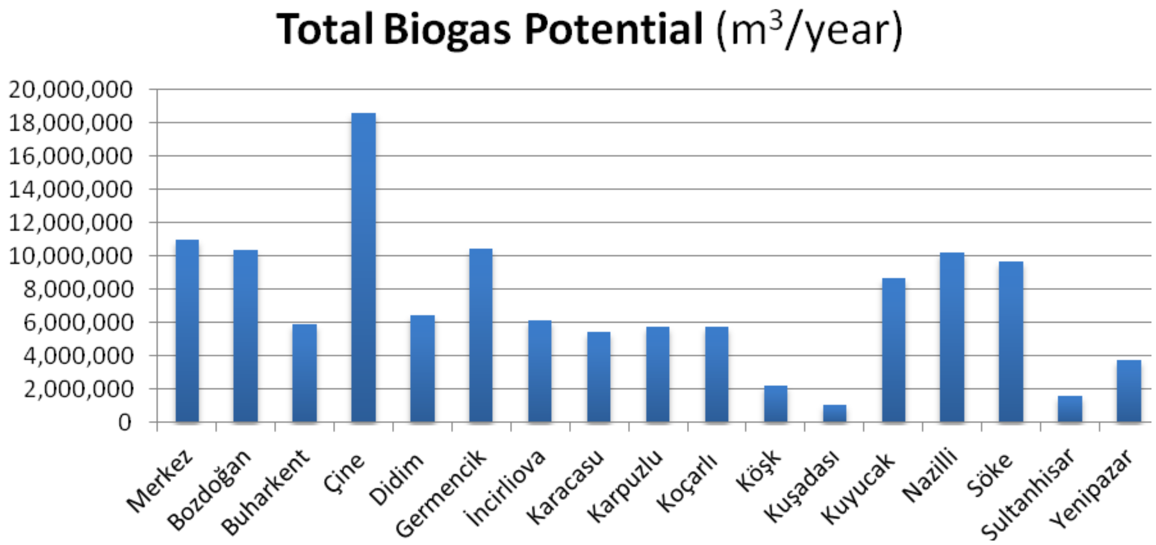


Figure 6.2. The Distribution of Total Biogas Potential Based on County in Aydın

The total electricity generation potential of the biogas generated is calculated as 307.832.483 kWhe annually. Çine has the highest potential for electricity generation amongst all districts. The electricity generation based on the districts is given below.

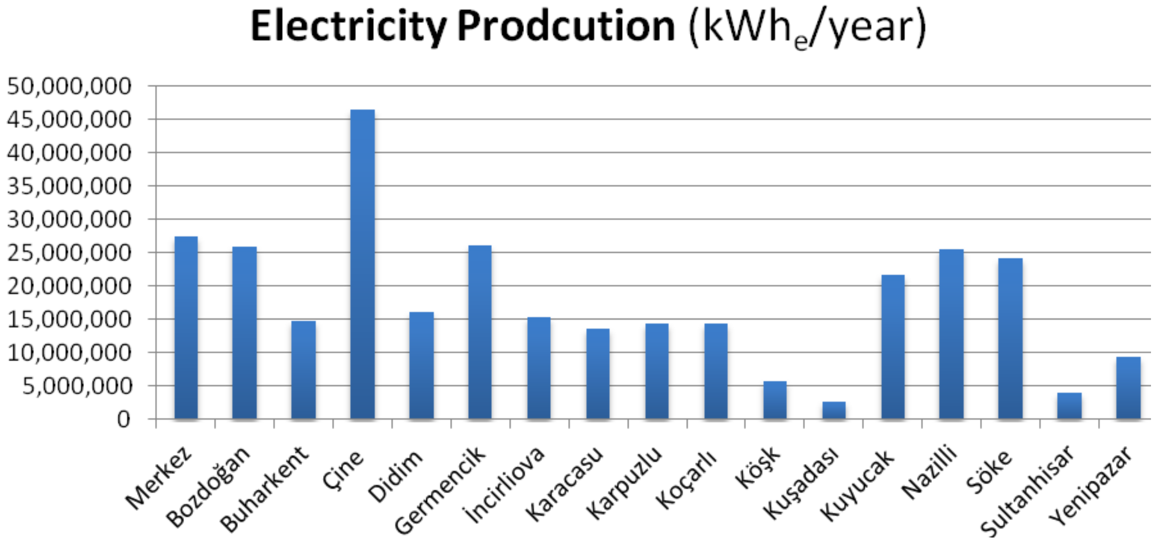


Figure 6.3. The Distribution of Electricity Production Based on County in Aydın

The total waste heat generation potential of the biogas generated is calculated as 315.161.827.892 kcal annually. The districts are in the same order for generating waste heat as they are in generating electricity. If we make a rough estimation, by the utilization of waste heat 5 million m2 could be heated. The waste heat generation based on the districts is given below.

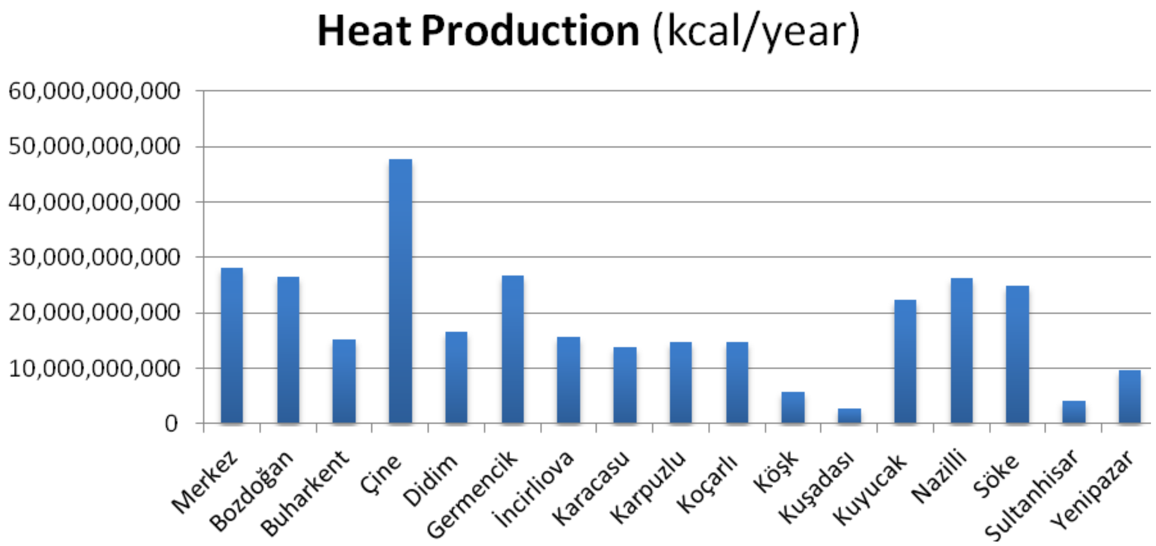


Figure 6.4. The Distribution of Heat Production Based on County in Aydın

The district based map of biogas generation and installed capacity of the facilities in Aydın region is given below.

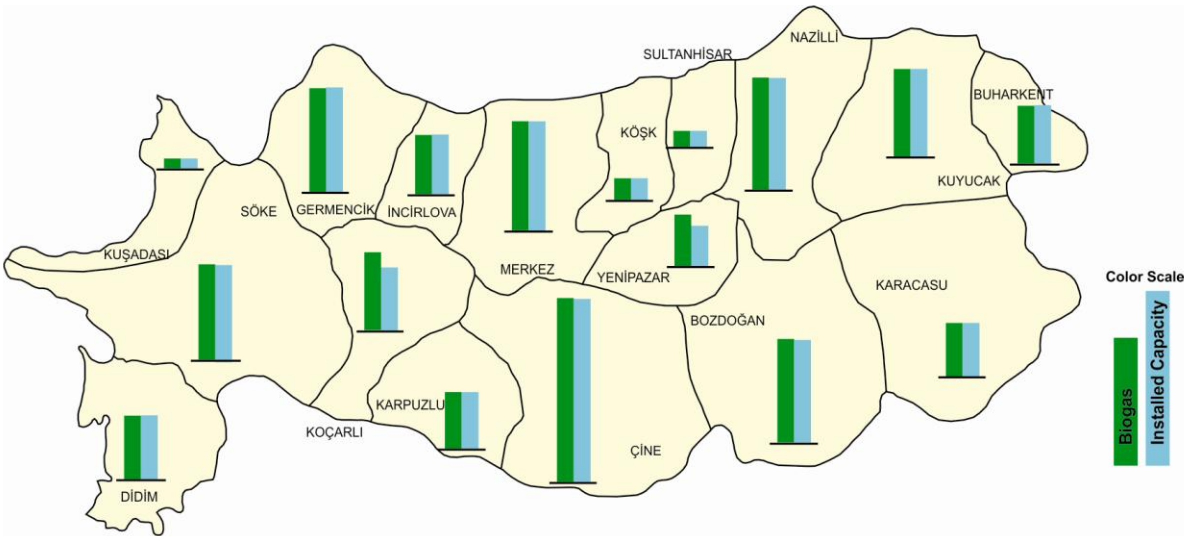


Figure 6.5. The Distribution of County-Based Biogas Production on Map

6.2. Income and Benefit Calculations

The income and benefit calculations out of the electricity and waste heat generation in the biogas facilities that will use the manure generated in the livestock farms, is given in the table below.

Table 6.4. Obtaining Benefits from The Use of Animal Wastes in Biogas Plants

BENEFIT	Electricity		Waste Heat			
			Natural Gas Equivalent		Coal Equivalent	
COUNTY	**Production** (kWh_e/year)	**Benefit** (TL/year)	**Quantity** (m^3/year)	**Benefit** (TL/year)	**Quantity** (ton/year)	**Benefit** (TL/year)
Merkez	27.461.477	6.683.849	3.407.918	2.044.751	9.372	1.405.766
Bozdoğan	25.895.466	6.302.698	3.213.579	1.928.147	8.837	1.325.601
Buharkent	14.840.937	3.612.136	1.841.732	1.105.039	5.065	759.715
Çine	46.519.092	11.322.282	5.772.932	3.463.759	15.876	2.381.334
Didim	16.107.183	3.920.327	1.998.871	1.199.323	5.497	824.534
Germencik	26.185.490	6.373.286	3.249.570	1.949.742	8.936	1.340.448
İncirliova	15.325.953	3.730.184	1.901.922	1.141.153	5.230	784.543
Karacasu	13.578.365	3.304.838	1.685.050	1.011.030	4.634	695.083
Karpuzlu	14.316.843	3.484.576	1.776.693	1.066.016	4.886	732.886
Koçarlı	14.349.232	3.492.460	1.780.713	1.068.428	4.897	734.544
Köşk	5.631.446	1.370.638	698.852	419.311	1.922	288.276
Kuşadası	2.667.531	649.250	331.036	198.621	910	136.552
Kuyucak	21.695.786	5.280.537	2.692.406	1.615.444	7.404	1.110.618
Nazilli	25.614.453	6.234.302	3.178.706	1.907.223	8.741	1.311.216
Söke	24.256.708	5.903.840	3.010.212	1.806.127	8.278	1.241.712
Sultanhisar	3.996.781	972.776	495.993	297.596	1.364	204.597
Yenipazar	9.389.740	2.285.369	1.165.249	699.150	3.204	480.665
TOTAL	**307.832.483**	**74.923.348**	**38.201.434**	**22.920.860**	**105.054**	**15.758.091**

The total electricity income out of the biogas generated from the livestock manure in Aydın region is 74.923.348 TL annually. The benefit from the waste heat could be calculated as an equivalent to natural gas or coal, depending on the regions conditions for using those fuels. If we assume that the waste heat will be replacing the natural gas and will generate benefit according to natural gas amount and unit price, then the benefit will be 22.920.860 TL annually. If we do the same assumption regarding the coal, then the benefit will be 15.758.091 TL annually, as it is cheaper than the natural gas.

7. FACILITY SCENARIOS

In the context of the feasibility studies, the district based energy production potentials have been calculated. As the values for the districts are low to install biogas facility in each of them, big central facility scenarios have been proposed and studied. During the estimations, the distances between the districts were studied and nearby districts are grouped in order to make the transportation of the wastes and the production of the energy feasible.

Methane is one of the most important greenhouse gases, with a GWP value of 21. Using livestock manures in the biogas facilities will reduce the methane and therefore greenhouse gas emissions caused by these wastes. Additionally, the digestate, which is another end product of biogas process, could be utilized as a soil amendment material or organic fertilizer and has a market in the agricultural sector. The emission reduction and digestate calculations are also done and given in the scenarios.

The distances between the districts are grouped into 4 critical stages. Within these distance groups, 20 to 25 km is the optimum distance to make the transportation feasible for centralized biogas facilities. Therefore, the distance groups are identified and the table of calculations is given below.

Table 7.1. Distances

Legend	Levels	Distances (km)
	1.level	0-20
	2.level	21-40
	3.level	41-50
	4.level	41-55

After the consideration of the distances and the road network, 3 biogas facility senarios are proposed. The feasibilities based on the district groups has been prepared in the context of this study. Those scenarios are;

- West Aydın Energy Plant Project
- Middle Aydın Energy Plant Project
- East Aydın Energy Plant Project

Table 7.2. Distances between the Districts of Aydın

	Merkez	Bozdoğan	Buharkent	Çine	Didim	Germencik	İncirliova	Karacasu	Karpuzlu	Koçarlı	Köşk	Kuşadası	Kuyucak	Nazilli	Söke	Sultanhisa
Merkez	0	69	84	37	99	22	12	85	56	22	19	60	57	45	49	30
Bozdoğan	69	0	68	89	171	90	80	69	112	80	50	132	41	29	121	40
Buharkent	84	68	0	120	183	106	95	43	138	106	65	144	28	40	132	56
Çine	37	89	120	0	136	69	50	120	32	43	54	97	93	80	86	65
Didim	99	171	183	136	0	76	87	183	94	85	117	77	156	143	52	128
Germencik	22	90	106	69	76	0	11	107	88	22	41	34	79	66	25	51
İncirliova	12	80	95	50	87	11	0	96	70	10	30	45	68	56	36	41
Karacasu	85	69	43	120	183	107	96	0	139	106	66	144	28	41	133	56
Karpuzlu	56	112	138	32	94	88	70	139	0	61	73	115	111	98	66	83
Koçarlı	22	80	106	43	85	22	10	106	61	0	40	56	79	66	33	51
Köşk	19	50	65	54	117	41	30	66	73	40	0	78	39	26	67	11
Kuşadası	60	132	144	97	77	34	45	144	115	56	78	0	116	104	22	89
Kuyucak	57	41	28	93	156	79	68	28	111	79	39	116	0	13	106	29
Nazilli	45	29	40	80	143	66	56	41	98	66	26	104	13	0	93	16
Söke	49	121	132	86	52	25	36	133	66	33	67	22	106	93	0	77
Sultanhisar	30	40	56	65	128	51	41	56	83	51	11	89	29	16	77	0
Yenipazar	39	30	59	65	137	60	49	60	83	52	20	97	33	20	86	10

Table 7.3. Counties for Energy Plant Projects

Energy Plant Project	Counties
West Aydın Energy Plant Project	Kuşadası, Söke, Didim and Germencik
Middle Aydın Energy Plant Project	Merkez, Çine, İncirliova, Karpuzlu, Koçarlı, Köşk, Sultanhisar and Yenipazar
East Aydın Energy Plant Project	Karacasu, Bozdoğan, Buharkent, Kuyucak and Nazilli

7.1. West Aydın Energy Plant Project

The districts that are chosen for the west section, the biogas, methane, electricity and waste heat generation values are given in the table below.

Table 7.4. Total Biogas Feasibility Study in West Aydın Energy Plant Project

Waste and Biogas Production

Explanation	*Amount*	*Unit*
Bovine Waste	333.910	ton/year
Winged Waste	182.044	ton/year
Ovine Waste	40.623	ton/year
Biogas Production	27.641.817	m^3/year
Methane Production	17.967.181	m^3/year

Electricity and Heat Production

Explanation	*Amount*	*Unit*
Electricity Production	69.216.912	kWh_e/year
Heat Production	70.864.933.672	kcal/year
Installed Power	8.589	kW_e

Revenue and Expenses

Explanation	*Amount*	*Unit*
Revenue of Electricity	16.846.704	TL/year
Thermal Benefit (natural gas equivalent)	5.153.813	TL/year
Total Revenue	22.000.518	TL/year
Total Expenses	6.600.155	TL/year
Net Income	15.400.362	TL/year

Investment

Explanation	*Amount*	*Unit*
Investment	44.445.791	TL
Pay Back Time	2,9	year
Investment Rate	5.175	TL/kW_e

Within the scenario, west section has an annual biogas generation of 27.641.817 m3. The annual electricity and waste heat generations in this section are 69.216.912 kWhe and 70.864.933.672kcal respectively.

The investment cost of the biogas facility is calculated as 44.445.791TL. During the calculations, 2000 Euro/kWe installed capacity investment ratio has been used. This value is general for the facilities that were built in the EU and in most of the developed countries.

The emission reduction and digestate calculation results are given in the table below.

Table 7.5. Benefits from West Aydın Energy Plant Project

Emission Reduction

Explanation	*Amount*	*Unit*
From Electricity Production	35.993	ton/year
From Methane Production	189.372	ton/year
Total	225.365	ton/year

Carbon Revenue

Explanation	*Amount*	*Unit*
The Unit Price of Carbon Credit	13,8	TL/CO_{2e}
Carbon Revenue	3.110.038	kWh_{th}/year

Digestate Production

Explanation	*Amount*	*Unit*
Digestate	83.487	ton/year

According to the table above, middle Aydın section has a potential in GHGs emission reduction of 225.365 tons.CO2e annually.

7.2. Middle Aydın Biogas Facility

The districts that are chosen for the middle section, the biogas, methane, electricity and waste heat generation values are given in the table below.

Table 7.6. Total Biogas Feasibility Study in Middle Aydın Energy Plant Project

Waste and Biogas Production

Explanation	*Amount*	*Unit*
Bovine Waste	1.559.825	ton/year
Winged Waste	82.777	ton/year
Ovine Waste	72.273	ton/year
Biogas Production	54.707.267	m^3/year
Methane Production	35.559.724	m^3/year

Electricity and Heat Production

Explanation	*Amount*	*Unit*
Electricity Production	107.315.379	kWh_e/year
Heat Production	140.252.244.107	kcal/year
Installed Power	16.998	kW_e

Revenue and Expenses

Explanation	*Amount*	*Unit*
Revenue of Electricity	33.342.133	TL/year
Thermal Benefit (natural gas equivalent)	10.200.163	TL/year
Total Revenue	43.542.297	TL/year
Total Expenses	13.062.689	TL/year
Net Income	30.479.608	TL/year

Investment

Explanation	*Amount*	*Unit*
Investment	78.190.961	TL
Pay Back Time	2,6	year
Investment Rate	4.600	TL/kW_e

Within the scenario, middle section has the highest biogas, electricity and waste heat generation potential with 54.707.267 m3.biogas/year, 107.315.379 kWh electricity/year and 140.252.244.107 kcal waste heat/year.

The investment cost of the biogas facility is calculated as 78.190.961TL. During the calculations, 2000 Euro/kWe installed capacity investment ratio has been used. This value is general for the facilities that were built in the EU and in most of the developed countries.

The emission reduction and digestate calculation results are given in the table below.

Table 7.7. Benefits from Middle Aydın Energy Plant Project

Emission Reduction

Explanation	*Amount*	*Unit*
From Electricity Production	55.804	ton/year
From Methane Production	374.796	ton/year
Total	430.600	ton/year

Carbon Revenue

Explanation	*Amount*	*Unit*
The Unit Price of Carbon Credit	13,8	TL/CO_{2e}
Carbon Revenue	5.942.279	kWh_{th}/year

Digestate Production

Explanation	*Amount*	*Unit*
Digestate	257.231	ton/year

According to the table above, middle Aydın section has an annual potential in GHGs emission reduction of 430.600 t CO2e approximately. The amount of fertilizer that will be obtained from this plant is calculated as 257.231 ton/year.

7.3. East Aydın Biogas Facility

The districts that are chosen for the eastern section, the biogas, methane, electricity and waste heat generation values are given in the table below.

Table 7.8. Total Biogas Feasibility Study in East Aydın Energy Plant Project

Waste and Biogas Production

Explanation	*Amount*	*Unit*
Bovine Waste	699.698	ton/year
Winged Waste	162.988	ton/year
Ovine Waste	131.732	ton/year
Biogas Production	40.584.010	m^3/year
Methane Production	26.379.606	m^3/year

Electricity and Heat Production

Explanation	*Amount*	*Unit*
Electricity Production	101.625.007	kWh_e/year
Heat Production	104.044.650.113	kcal/year
Installed Power	12.610	kW_e

Revenue and Expenses

Explanation	*Amount*	*Unit*
Revenue of Electricity	24.734.510	TL/year
Thermal Benefit (natural gas equivalent)	7.566.884	TL/year
Total Revenue	32.301.394	TL/year
Total Expenses	9.690.418	TL/year
Net Income	22.610.976	TL/year

Investment

Explanation	*Amount*	*Unit*
Investment	58.005.141	TL
Pay Back Time	2,6	year
Investment Rate	4.600	TL/kW_e

Within the scenario, eastern section has an annual biogas generation of 40.584.010 m3. The annual electricity and waste heat generations in this section are 101.625.007 kWhe and 104.044.650.113 kcal respectively. The payback period of the facility will be 2,57 years.

The emission reduction and digestate calculation results are given in the table below.

Table 7.9. Benefits from East Aydın Energy Plant Project

Emission Reduction

Explanation	*Amount*	*Unit*
From Electricity Production	52.845	ton/year

From Methane Production	278.038	ton/year
Total	330.883	ton/year

Carbon Revenue

Explanation	*Amount*	*Unit*
The Unit Price of Carbon Credit	13,8	TL/CO_{2e}
Carbon Revenue	4.566.191	kWh_{th}/year

Digestate Production

Explanation	*Amount*	*Unit*
Digestate	149.163	ton/year

According to the table above, middle Aydın section has an annual potential in GHGs emission reduction of 330.883 tons.CO2e approximately. Also, benefit form carbon reduction is 330.883 ton/year in total. Carbon income is calculated as 4.556.191 kWh/year. The amount of fertilizer production is also given as 149.163 ton/year.

8. ENVIRONMENTAL BENEFITS OF WASTE MANAGEMENTS

Nowadays, biogas technology, which enables the wastes that cause environmental problems to be processed, disarmed and to be in use of energy obtaining, is an important consideration in terms of renewable energy production. Biogas which known as an energy production method in society, cannot be utilized as it should be in our country, although there is an organic waste potential (renewable wastes, animal waste, etc.) that can be utilized. In case of evaluation of these sources, it is possible to be provided a large input from economic and environmental aspects.

8.1. Environmental Benefits of Biogas Production in Aydin

It is clear that in overcoming the energy requirements and solution of energy problems of Turkey; agricultural, livestock and household wastes should be evaluated with anaerobic processes. For this purpose, the evaluation of the production potential of wastes, determination of the anaerobic decomposition conditions and definition of the proper generator type, development of the anaerobic digestion technologies by supporting the relevant topics is necessary.

As a part of this, present livestock industry of Aydin Merkez and its 16 counties and the growth in this industry depending on years will cause the increase of the present waste amount of this area. Besides, the unprocessed farm fertilizers that currently kept in open fields or spread out on soil, ammonia (NH3) emissions and odors are released to atmosphere along with the gas emissions that evolving climate such as methane (CH4) and nitrogen oxide (N2O). The release of these emissions effects on climate changes due to global warming. At the same time, these emissions cause negative living conditions based on air pollution and the odor obtaining from manure in the area. Moreover, unprocessed manure that spread out on fertilizable lands causes soil pollution, and therefore it causes to decrease of agricultural efficiency.

Thanks to energy production with biogas technology from wastes from livestock farms, it will be provided environmental and socioeconomic advantages for the local community. By the recovery of the animal wastes in the area in the biogas plants, the gas emissions that cause air pollution will be prevented, thus the air quality of the area will be recovered. Depending on the qualifications of the digester waste that will be obtained from the plant, the use of chemical fertilizer will be decreased and the organic content fertilizer use will be increased. This situation will cause the decrease of costs of the farmers in the local area that obtaining from chemical fertilizer uses and the increase efficiency of crops because of the use of fertilizers with high organic content.

By the development of the use of biogas production technologies in this area, employment opportunities will arise and increase due to establishing new plants, it will provide development in this area. Furthermore, depending on the plants that use biogas technology and areas, whereas the costs from fertilizer management are decreasing, the use of biogas side products like electricity and heat will provide to progress utilities for the plants.

The benefits that will be obtained depending on the use of biogas technology have been summarized for public people and for farmers one by one at the table below.

Table 8.1. Advantages for Local People and Farmers (Al Seadi ve diğ., 2008)

For People	For Farmers
i) Increase the use of renewable energy sources **ii)** Decrease the spread of greenhouse gases **iii)** Reduce the dependency on imported energy sources **iv)** Harmonization to energy and environmental goals of European Union **v)** Reduce the amount of disposal waste **vi)** İncrease job opportunities **vii)** Wide range for using biogas by-products **viii)** Less water need	**i)** Additional income for livestock sector **ii)** Using digestate as a fertilizer and increasing harvest yields depending on this **iii)** Evaluation of livestock manures **iv)** Reduce the formation of odors and flies

8.2. Impacts of The Greenhouse Gas Reduction on The Environment

The energy generation from the wastes is an environmental protection method by reducing the greenhouse gas emissions caused by the fossil fuels. The greenhouse gases that are causing climate change and global warming are; Carbon dioxide (CO2), Methane (CH4), Nitrous Oxide (N2O) and other gases (Hidrofluorocarbons, HFC; Perflorocarbons, PFC; SF6 gases). The GWP (global warming potential) of those gases are given according to the equivalency of CO2. CH4 is 21 times, N2O is 310 times, and the other gases are 600 to 23.900 times of CO2 in terms of being greenhouse gas.

Total greenhouse gas emissions were predicted as 401,9 million tons CO2 equivalent in 2010. The portions of greenhouse gas emissions were 71% for energy sector, 13% for industrial processes, 9% for wastes and 7% for agricultural wastes as CO2 equivalent in 2010.

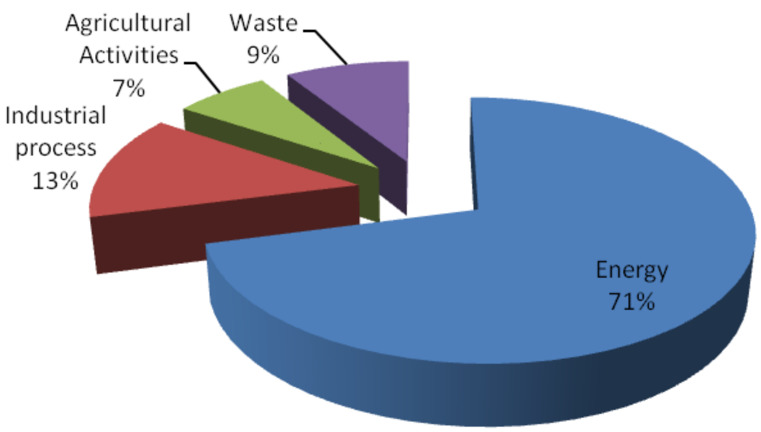


Figure 8.1 The Sectorial Distribution of Carbon Emissions-2010 (www.tuik.gov.tr)

CO2 emissions per person increased in 2010. The total greenhouse gas emissions increased 115% as CO2 equivalent, from 1990 to 2010. Although the emissions per person were 3,39 ton CO2/person in 1990, it was calculated as 5,51 ton/person in 2010.

Emissions from energy had the biggest portion of CO2 emissions in 2010. Total CO2 emissions were released highly from energy sector and industrial processes, respectively 85% and 15%. Released CH4 emissions were caused from waste, industrial activities and energy. Their percentage rates were given as 59%, 30% and 10%, respectively. N2O emissions were caused from agricultural activities as 74%, waste as 14% and energy as 12%. When CO2 emission from energy source was investigated in 2010, it was seen that the portions of total CO2 emissions were 20% for industry, 16% for transportation and 23% for other sectors.

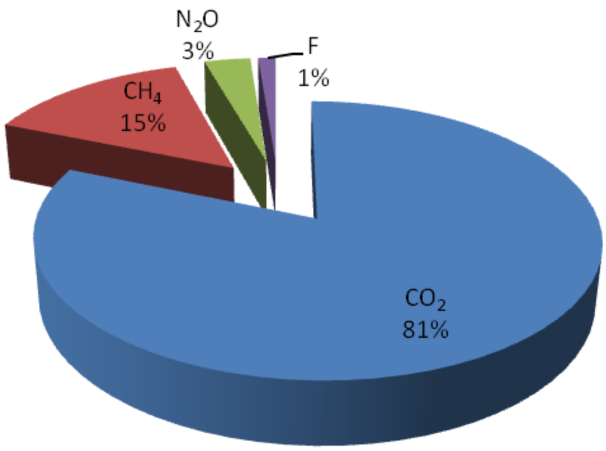


Figure 8.2 Total Greenhouse Gas Emissions (million tons CO_2 equivalent) (www.tuik.gov.tr)

In the context of this study, it was found out that, the method that has been proposed could generate electricity and waste heat and at the same time could reduce the greenhouse gas emissions by using the animal wastes in the Aydın region. This emission reduction will help to increase the air quality in Aydın and will protect the environment from global warming and climate change. The emission reduction calculation results for the proposed facility in Aydın are summarized in the table below.

Table 8.2. Total Reduction in Carbon Emissions

Regions	Emission Reduction (ton CO_2/year)
West Aydın	225.365
Middle Aydın	480.600
East Aydın	330.883
TOTAL	**986.848**

As it could be seen in the table above, the implementation of the projects will have significant impacts for the reduction of greenhouse gas emissions.

9. CONCLUSIONS

Within the context of this study called "The Atlas of Aydın from Livestock Manure to Clean Energy”, the disposal method of livestock manures in Aydın, which are currently being dumped to the municipality landfills or spread to the farmlands without pre-processing, were evaluated with an understanding of integrated waste management. The current disposal methods are completely not appropriate regarding the environment and public health. The leachates of those wastes and the by-products formed by chemical and biological mechanisms within soil and groundwater could arise problems for environmental safety and public health. Spreading the manure to the farmlands appears to be another problem, which reduces the farmland harvest efficiency, pollutes soil and groundwater. The dispose of livestock manure instead of using them as an energy source appears to be a loss for our national sources.

The aim of this study was to show the overall energy potential of the livestock manures in Aydın region. By doing that, biogas technology showed its potential for being the most important disposal method for the livestock manures available in the region. During the study, the data of livestock population was collected from the site, the related local institutions and governmental departments. Within the context of this study, the livestock manure caused by the farms has been identified and the biogas potential of the wastes in the Aydın region was calculated. According to the biogas potential, the energy potential of the livestock manure was calculated.

The calculation results of the biogas and energy generation values are promising for Aydın. This region has the potential for installing several biogas plants. Within the study, 3 central biogas facilities were proposed. But it is possible to install several biogas plants apart from this proposal. Today it is feasible to install biogas facilities for minimum 1.500 bovine or 500.000 poultry populations. Such an investment could easily pays the investment back in lest than 5 years. Above those population values, the payback period of the investment decreases and the investment becomes more feasible.

The Aydın region has an electrical installed capacity of 39 MW in total. Of course this installed capacity is calculated according to ideal conditions and estimations such as; the manure collection will be 100% successful, all of the manures have biodegradable content, the manures have equal biodegradable content. It is very important to adjust the collection methods and transportation methods and routes of the manures before a centralized biogas facility. The biogas potential of the manure depends on the availability of the degradable organic materials in the manure. If the manure is not collected properly, or kept waiting too long, then the biogas potential will be lower than ideal conditions.

Moreover, the release gases from the livestock wastes cause greenhouse effect that leads to global warming as well. Climate changes due to global warming are occurred all around the world. So it is very important to prevent the escape of the release gases to the atmosphere from wastes. As a part of this project, use of the suggested biogas technology leads to decrease the carbon emission, based on the electricity generation and methane reduction. When the energy production is obtained from biomass, energy production from fossil fuels will be decreased. This situation and the greenhouse effect potentials of decomposable organic wastes in the environment are discussed in this study. The practices proposed in the study, will decrease the greenhouse emissions and within the context of voluntary carbon certificate, a financial income, which could reduce the payback period of the investment could be generated. The carbon reduction calculation results were given in the study.

The amount of manure generated by the livestock farms is defined as 3.027.317 tons annually. Within years, the manure generation will increase with the developing sectorial dynamics. The problems (odor, low air quality due to emissions, hygiene problems, available land problem for dumping the waste) will arise in the future and cause financial problems, because of the lack of a sustainable waste management system.

As a result, the end results of the study are promising. The total capacity of livestock farms, their manure potential, the biogas and energy capacity of those manures and the potential of Aydın as a growing county with population, economy and livestock farming is the most important facts for investing in the region. The biomass and biogas technologies are very suitable for this region and companies should make further investigations in the region in order to identify the best locations for installing biogas facilities. Even if the first financial investment seems like an important burden, the plants will earn their re-payments in short term by evaluating the sources with high energy production potentials. A sustainable energy management will be provided thanks to energy recovery from livestock wastes. Therefore environmental and financial problems related to dispose of livestock wastes would be eliminated. Livestock wastes will be evaluated as energy source, as well.

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