Palestine Polytechnic University

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Biogas stations Design in West Bank and GAZA city

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Submitted to the Collage of Engineering

In fulfillment of the requirements for the degree of

Bachelor degree in Electrical Power Technology Engineering

May 2019

الإهداء:

لا بد لنا ونحن نخطو خطواتنا الاخيرة في الحياة الجامعية من وقفة نعود الى اعوام قضيناها في رحاب الجامعه مع اساتذتنا الكرام الذين قدموا لنا الكثير باذلين بذلك جهودا كبيرة في بناء جيل الغد

وقبل ان نمضي نتقدم بأسمى ايات الشكر والامتنان والتقدير والمحبة الى أولى منارات العلم والمعرفة آباءنا وامهاتنا

ثم نتقدم بازهى باقة حب وتقدير الى اساتذتنا الذين حملوا اقدس رسالة في الحياة..الى الذين مهدوا لنا طريق المعرفة, وسهلوا علينا امورنا...

Abstract:

Recently, an increase in electricity consumption was observed in West Bank and Gaza Strip, and because of the limitation of supplied power electricity to these areas, and because of the increasing numbers of animals in West bank and Gaza strip, we found that we can use the waste of these animals in order to produce biogas. biogas considered as a clean source of electricity production.it consist of methane (60%) and carbon dioxide (about 35-40 %).This project illustrate the amount of production biogas from animals manure in West bank and Gaza trip ,which is estimated about 155.77 million meter^3/year),and design biogas stations in west bank cities and Gaza city, in which it is possible to produce the electrical power for about 520 MWh, which in turn helps to cover the shortage of electricity.

الملخص:

نظرا لزيادة استهلاك الطاقة الكهربائية في مناطق الضفة الغربية وقطاع غزة، ولمحدودية الطاقة الكهربائية المزودة لهذه المناطق، ونظرا لزيادة اعداد الحيوانات في الضفة الغربية وقطاع غزة، يمكن الاستفادة من سماد هذه الحيوانات في انتاج الغاز الحيوي. يعتبر الغاز الحيوي الناتج من سماد الحيوانات والذي يتكون من غاز الميثان بنسبة 60% وغاز أكسيد الكربون بنسبة تتراوح بين (35-40) % مصدرا نظيفا لإنتاج الطاقة الكهربائية. هذا المشروع يوضح كمية الغاز الحيوي التي يمكن استخراجها من سماد الحيوانات في الضفة الغربية وقطاع غزة، والتي تقدر بحدود 155.77 (مليون $م^3$/عام)، وتصميم محطات غاز حيوي في مدن الضفة الغربية ومدينة غزة، والتي يمكن من خلالها انتاج طاقة كهربائية بمقدار 520(ميجا واط ساعة)، والتي بدورها تساعد في تغطية النقص في الكهرباء.

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Chapter 1:

1.2 Introduction:

Nowadays, energy can be obtained from a variety of sources. Because of the rapid development of technology and the growing demand for electricity, we must cover this growing demand in ways that are possible.

Recycling is one of these ways that it is possible to work on it to produce electricity. Recycle is the process of collecting and processing materials that would otherwise be throw away as trash and turning them into new product. We can represent the recycling in three steps:

1) Collecting and processing.
2) Manufacturing.
3) Purchasing new products made from recycled materials.

There are several ways to collect the material, and then, recyclable are send to a recovery facility to be sort, cleaned and processed into materials that can used in manufacturing.

Manufacturing is the process of converting raw materials into finished goods that allow using it in several work.

Purchasing new products made from recycled materials is final step of recycling this stage, offer a human to sell a new material and use it.

Biogas is one of the methods that fall under the list of recycling for the production of electric power. Biogas can be produce from raw materials such as agricultural waste, manure, municipal waste, plant material, sewage, green waste or food waste. Biogas is an environmentally advantage energy source, which is mostly combine of methane (60%), and carbon dioxide (35-40%). Moreover, biogas contains a low quantity of other gases, such as Ammonia (NH_3), hydrogen sulfide (H_2S), hydrogen (H_2), oxygen (O_2), Nitrogen (N_2), and carbon monoxide (CO) [1].

Electricity can be produce by using biogas growth in biogas stations. Biogas is produce by anaerobic digestion of organic waste materials from animal waste into renewable energy[2].

The manure and waste are mix in the plant's receiving tank before being heated to 38-52 c◦ and pumped into the digester in which the biogas is produced. The biomass stays in the digester for 2-3 weeks and the fermented slurry can subsequently be use as crop fertilizer has improved qualities such as less odor inconveniences when spreading the slurry and significant reduction of greenhouse gasses[2].

In this project, we aim to design and configure a biogas stations that will convert the manure waste obtained from farms animal to electrical power. Many parameters will be discussed in this project, such as the amount of farm animal waste, the amount of biogas production and the amount of electricity generated.

1.3 Objectives:

1. Design biogas plants in west bank and Gaza strip.
2. Production of electric power from biogas system.
3. Disposal of animal manure waste.
4. Cover the shortage of electricity in Palestinian cities.

1.4 Main topic:

Work on designing biogas stations in West Bank and Gaza strip, which in turn produces electricity in those areas.

1.5 Background:

1) A study[1] , presents biogas potential from the organic waste obtained from the farm animals and slaughterhouses in Malaysia. The findings of this study indicated that biogas potential of 4589.49 millionm3year−1 could be produce from animal waste in Malaysia in 2012, which could provide an electricity generation of 8.27×109kWhyear−1.

2) In study [3] tests were conducted on several types of cows in different age, weight, system of digestion. The amount of the methane from these cows was identified, the methane yield was found to be highest in the manure of fresh cows (216 L CH_4/kg VS), followed by Young-1 (208 L CH_4/kg VS), high (196 L CH_4/kg VS), dry (160 L CH_4/kg VS), and Young-2 (148 L CH_4/kg VS) cow manures.
3) A study[4] for the feasibility of poultry waste for energy generation in Pakistan was performed, to find a renewable energy sources making it important to achieve energy security. Large number of poultry farms are operating to fulfill the population protein demand and because of that, there will be a huge amount of waste, so the produced waste is estimated and then it will be converted into biogas by technology of conversion, then the electricity will be generated from that estimated waste. As a result, for that a 280 MWh/day of electricity can be generated from the biogas that is produced from poultry waste and this adaptation would be a valuable addition of renewable energy in country existing energy system.
4) In study [5], the amount of organic waste that can be treated by anaerobic digestion and the possibilities of waste collection was estimated in Uruguay. because of that, the potential for methane generation from solid and liquid wastes was calculated, the results indicate that, in the current situation, energy generation equivalent to 1.3–2.1% of total primary energy could be achieved Despite its low incidence in the energy generation, biogas generation from wastes must be viewed from the standpoint of sustainable development, Achieving this leads to waste treatment and minimizes environmental impacts.
5) A study in Poland—Current state[6], the waste collection is made up of municipal waste (82, 000, 000m ^ 3) and cattle dung (551, 000, 000m ^ 3) and from weeds (254, 000, 000m ^ 3) the amount of energy in the size of PJ 39.44 of biogas and thus have biogas shares of 7.5% of the total energy in Poland compared to coal energy and In recent years, attention has been given to the development of plans for the establishment of biogas production projects and their use as energy, despite the difficulty of the mission.

1.6 Methodology:

1) Collecting data about animal manure from the Palestinian central bureau of statistics.
2) Analyzing the information and results while doing this project and calculations for several required requirements, like the amount of produced biogas and the generated electricity from biogas stations.

3) Design the biogas stations with taking into consideration all steps required for the safety and excellent design, taking into account the selection of the appropriate location for the establishment of the station.
4) Simulate the project, using E-TAP program to make sure that the project going well and to simulate the work principle for the biogas stations.

Chapter 2:

2.1 Design of biogas system

2.1.1 Components of biogas production unit:

1) The digester.
2) Biodegradable gas tank (container).
3) Feeding mixing chamber.
4) Exit room and storage area and drying fermented emulsifier.
5) Gas delivery network and equipment use.
6) In addition to the barn and water cycle.

Briefly, the biogas plant has three interconnected chambers:

1) Digester chamber.
2) Hydraulic chamber.
3) Slurry pit.

2.1.2 Working mechanism of the digester:

The organic material is placed in a container called the digestion in which the oxygen is not allowed to enter where the waste is located.

The bacteria analyze the waste in a free of oxygen weather. This process results a combustible mixture of methane and carbon dioxide (called biogas). It also produces liquid medicated fertilizer.

The resulting gas is collected in reservoirs where the resulting gas volume is about 1.5-2.5 of the volume of the same digester.

If we assume that the volume of the digestion is 1,000 liters, the resulting gas volume is about 1500 to 2500 liters of gas.

The methane ratio in the resulting gas varies depending on the type of waste used. The total residue is between 60-70% and the residues that remain after the production of gas are nitrogen, which is needed by the plants.

Therefore, the residues of the anaerobic digestion process are used to fertilize the plants in the farms. In this way, the waste can be used as a source of energy and fertilizer source at the same time, Cows are considered to be preferred animals in the field of gas production from waste.

Figure 1 shows the general design for the biogas plant:

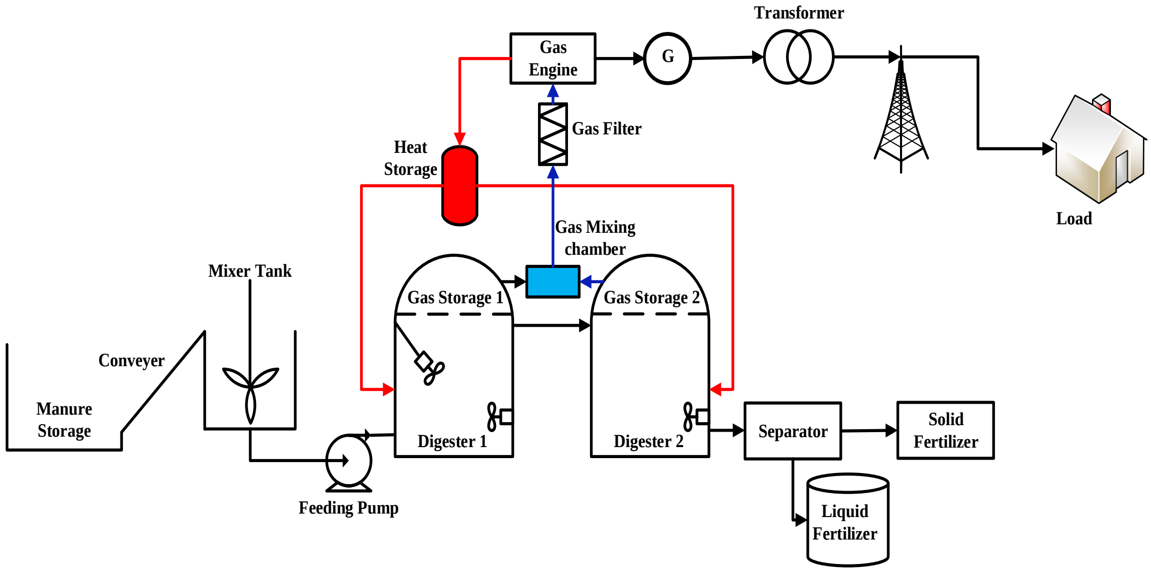

Fig.1: General Design for the biogas plant

2.1.3 Size of the digester:

After the calculation of total manure discharge, digester size can be considered based on solid discharge per day and the retention time (HRT).

To evaluate the digester size, the total influent (Q) shall be calculated according to equation(1):

$$Q=\frac{Total\ discharge}{TS\%}. \quad (1)$$

The required quantity of water to add with the total solid discharge can be calculated according to equation (2):

$$Water = Q - Total\ discharge. \quad (2)$$

All these calculated values shall be substitute in equation (3):

$$V = Q \times HRT \times Total\ discharge \quad (3)$$

To obtain the digester working volume which then can be used to calculate the digester size according to equation (4):

$$V = Vgs + Vf. \quad (4)$$

Where Vgs, Vf, are the volumes of gas collecting chamber, fermentation chamber.[7]

After evaluating the digesters volume, we need to calculate the methane content in the biogas, but to find the methane content, we have to calculate the biogas potential, by the equation (5):

$$Total\ of\ biogas(L/day) = Total\ manure(Kg/day) * Biogas(L/day) \quad (5)$$

From this equation, we will be able to find the amount of methane content, by equation (6):

$$Methane\left(\frac{m^3}{day}\right) = Total\ of\ biogas\ \left(\frac{L}{day}\right) * Methane\ \% \quad (6)$$

The electricity generations will be considered as the total generation from different digesters. Every 1 m3 of Methane can give 1 kVA [4]. To choose the capacity of selected generator is very important to know that 65% of energy lost as Heat & other mechanical losses as utilized by electrical generators[7].

2.2 Process of biogas system

Biogas can be produced from different feedstock. The main principal is that if the material contains biodegradable organic matter, under given conditions it shall be microbiologically transformed into biogas and mineralized compost.

Biogas is a mixture of carbon dioxide and methane. It is formed when bacteria break down organic material in the absence of oxygen, also called anaerobic digestion, for example in the digestive system of cattle. The possible uses of biogas are diverse. Cogeneration unit converts energetically rich biogas to electric current and heat. While the produced electric power is fed into the public network, the produced heat can be used for example for the heating of stables, residential buildings or industrial companies[2].

An interesting alternative for biogas production is the conditioning of raw materials to natural gas quality and then feeding it into the public gas grid. With this method, the gas can be transported over long distances and used as needed. Suitable starting substrates for biogas production are among other things renewable resources like maize, grass or rye. In addition, other plants such as sunflowers or sugar beets can be used. Biogas can also be gained from solid and liquid manure. Even organic waste, for which there is otherwise no use, may be utilized[2].

The reception of the waste materials is the first operational part of the whole biogas plant. In this process the materials (both liquid and solid) are poured into a tank that takes materials into its depths and supplies the biogas plant following processes without critical interruptions.

In the reception tank, the materials are mixed and unwanted obstacles are left in the tank. The odour treatment systems applied contains different units, such as bio-chemical scrubber and activated carbon filter. The system is low-cost in its operational terms and produces removal efficiency of more than 95 % from odour concentrations.

The three-phase heat exchanger systems are one of the key-elements of the Water biogas plant. This operation regulates the temperature of the waste materials simultaneously to 70 ˚C and then back to mesophilic temperature range.

The system operates in three phases:

1) In the first phase, the input flow is preheated by recirculated heat energy from outflow of the hygienisation units.
2) On the second phase, the sludge is heated up to 70ºC by hot water from the CHP unit (or other external heat source) in sludge – water heat exchanger.
3) Then the sludge is cooled to 35-38ºC prior entering into a digester.

Hygienization ensures the complete elimination of pathogenic bacteria and improves also the biogas production due to particle hydrolysis – this feature can have more than 20 % added total energy efficiency.

The heart of the biogas plant is its digestion process which can be divided into four separate steps: hydrolysis, acidification, acetogenesis and methanogenesis [2].

2.3 Potential of biogas and electricity generation

2.3.1 Overview:

In order to calculate the quantities of biogas and electricity generation that could be produced, information was collected from the Palestinian central bureau of statistics (PCBS) for the number of animals in west bank and Gaza strip farms, the data including the following animals: Cattles, Sheep, Goats, Broilers, Layers and Turkey. The amount of waste produced by animals was calculated based on body weight. The biogas generation was calculated based on the amount of animal waste produced per annum.

2.3.2 Animals population:

According to information obtained from the Palestinian central bureau of statistics (PCBS), the number of animals in the Palestinian authority were as follows: Cattles: 33,980, Sheep: 730,894, Goats: 215,335, Broilers: 31,515,383, Layers: 1,776,778 and Turkey: 546,413.

2.3.3 Animals waste:

Animal waste is composed of the organic matter that can be treated as the potential raw substance for the production of bioenergy [1].The amount of the farm animal waste is varied depending on the type of animal, feeding methods, the size of animal body, the type of breeding, and keeping time at day or night[8]. For the calculation of the quantity of animal and poultry waste, the amount of manure produced by farm animals was calculated. The amount of the manure produced from animals was estimated based on body weight. Generally, the daily manure can vary based on the type of animal, age, weight and system of digestion [3]. The amount of the manure, for instance, has been estimated as 10–25 kg/day for cattle, 2 kg/day for sheep and goat, and 0.08– 0.1 kg/day for chicken.[9]. In this project, the average amount of the manure was calculated based on 22.5 kg/day for the cattles, 1.6 kg/day for the sheep and goats and 0.045 kg/day for Broilers, Layers and Turkey[9].

2.3.4 Biogas production from the animal farms waste:

The cumulative biogas produced from the livestock waste is affected by the different factors such as feeding regime, animal type, body weight, the proportion of total solids and the waste availability[8]. The total solids of the waste is an important factor for the production of biogas from the animal's waste [1]. For the calculation of biogas, production from the animal manure the availability coefficient was taken into account when the cumulative biogas volume was calculated. The theoretical potential of biogas (TPB) generation from the manure was calculated as shown in Eq. (7) [1].

$$TPB = M * TS * AC * EBTS \ [1] \tag{7}$$

M is the total amount of the manure produced for each region (kg/year), TS represents the ratio of the total solids of the animal manure, AC denotes the availability coefficient and EB_{TS} is the quantity of estimated biogas produced per kilogram of the total solids (m^3/kg TS). In this project, TS value was considered as 25% for the cattles, sheep and goats, and 29% for Broilers, Layers and Turkey with the

EB_{TS} value of 0.6 (m^3/kg TS) for cattles, 0.4 (m^3/kg TS) for sheep and goats, and 0.8 (m^3/kg TS) for Broilers, Layers and Turkey. The availability coefficient was considered as 50% for cattles, 13% for sheep and goats and 99% for Broilers, Layers and Turkey. [2, 4]

2.3.5 Calculation of methane (CH4) content of biogas and the potential of electric power generation from biogas:

The percentage of methane present in animal manure varies from one species to another. It has been found that the biogas obtained from the cow manure is composed of 50–70% of methane [1]. Furthermore, it has been estimated that the methane content of the biogas generated from the sheep manure is ranging from 40% to 50% [4]. While the biogas production using chicken manure may contain methane content in the range of 50 – 70% [1]. In this project, methane was selected as 60% for cattles, 45% for sheep and goats, and 60% for Broilers, Layers and Turkey. The Theoretical Potential of CH4 was calculated according to Eq. (8):

$$Theoretical\ Potential\ of\ CH4 = TPB * CH4\% \ [1] \qquad (8)$$

For the calculation of heating value of the methane generated, it was assumed that 85% of the methane evolved could be converted to heat in the boiler by considering a calorific value of 36 MJ per cubic meter of methane (36 MJ/m3) [1].For the calculation of the colorific value (Heating value) of methane (MJ), we use equation (9):

$$Colorific\ value\ (Heating\ value)\ of\ methane = Heating\ converging\ efficiency * colorific\ value\ of\ methane [1] \qquad (9)$$

The potential of electricity generation (kWh/yr.) was calculated according to Eq. (10):

$$Potential\ of\ electricity\ generation = Methane \left(\frac{m3}{day}\right) * Production\ factor \qquad (10)$$

For methane gas each m^3 produce 2.09KWh of electricity power [1].

Chapter 3:

3.1 Collecting data:

Information was collected from the Palestinian central bureau of statistics (PCBS) regarding the number of animals in the west bank and Gaza strip, this statistic is for the year 2013, the statistics included the following animals: cattle, sheep, goats, broilers, layers, turkey. The distribution of animals in the west bank and Gaza strip is shown in table 3.1 below:

Table 3.1: Livestock Population in Palestine

Livestock Population in Palestine							
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Palestine	**33,980**	**730,894**	**215,335**	**31,515,383**	**1,776,778**	**546,413**	**34,818,783**
West Bank	**25,612**	**670,332**	**204,937**	**23,297,203**	**1,425,579**	**538,320**	**26,161,983**
Jenin	5,269	81,189	19,692	5,307,620	99,357	88,341	5,601,468
Tubas	3,208	61,525	12,256	832,563	0	800	910,352
Tulkarm	1,258	20,641	2,818	2,527,963	464,114	276,667	3,293,461
Nablus	5,063	99,236	17,430	3,524,829	117,069	853	3,764,480
Qalqiliya	2,916	25,790	2,666	2,569,336	101,833	122,667	2,825,208
Salfit	466	11,404	4,619	416,839	24,166	0	457,494
Ramallah & Al-Bireh	490	39,229	26,561	1,995,021	471,506	0	2,532,807
Jericho & Al- Aghwa	709	42,846	28,765	180,848	0	0	253,168
Jerusalem	265	29,709	17,028	52,300	11,700	46,550	157,552
Bethlehem	716	74,236	27,963	1,069,617	20,443	0	1,192,975
Hebron	5,252	184,527	45,139	4,820,267	115,391	2,442	5,173,018
Gaza Strip	**8,368**	**60,562**	**10,398**	**8,218,180**	**351,199**	**8,093**	**8,656,800**
North Gaza	2,564	16,565	2,424	2,965,084	134,571	2,750	3,123,958
Gaza	1,266	12,326	2,318	310,699	96,950	0	423,559
Deir Al-Balah	1,546	8,679	1,827	3,367,157	88,029	5,343	3,472,581
Khan Yunis	883	17,175	2,739	613,627	31,649	0	666,073
Rafah	2,109	5,817	1,090	961,613	0	0	970,629

Figure 2 shows the distribution of animal density in west bank and Gaza strip cities.

Figure 2: livestock population in Palestine.

3.2 calculation of the potential of biogas, Potential of methane (CH4), the colorific value (Heating value) of methane and The potential of electricity generation in each city in west bank and Gaza strip.

Here the calculation is depend on what was mentioned in chapter 2, specifically 2.3.

Table 3.2.1 and 3.2.2 shows the data that was relied upon in the calculation:

Table 3.2.1: calculations data.

	Manure (Kg/day)	**TS%**	**Biogas(m^3kg^{-TS})**	**AC%**	**CH4%**
Cattles	22.5	0.25	0.6	0.5	0.6
Sheep	1.6	0.25	0.4	0.13	0.45
Goats	1.6	0.25	0.4	0.13	0.45
Broilers	0.045	0.29	0.8	0.99	0.6
Layers	0.045	0.29	0.8	0.99	0.6
Turkey	0.045	0.29	0.8	0.99	0.6

Table 3.2.2: calculations data.

The colorific value of methane	36 MJ/M^3
Heating converging efficiency	0.85

The equations that were used are:

- $TPB = M * TS * AC * EBTS$
- $Theoretical\ Potential\ of\ CH4 = TPB * CH4\%$
- $Colorific\ value\ (Heating\ value)\ of\ methane = Heating\ converging\ efficiency * colorific\ value\ of\ methane$
- $Potential\ of\ electricity\ generation = Methane\left(\frac{m3}{day}\right) * Production\ factor$

1. Jenin city:

The number of animal in Jenin city is shown in table 3.2.3 below:

Table 3.2.3: number of animal in Jenin city.

Governate	Cattles	Sheep	Goats	Broilers	Layers	Turkey	Total
Jenin	5,269	81,189	19,692	5,307,620	99,357	88,341	5,601,468

The biogas production in Jenin city is shown in table 3.2.4 below:

Table 3.2.4: biogas production in Jenin city.

Theoretical Potential of Biogas TPB (Million m3 /year)							
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Jenin	3.245	0.616	0.149	20.022	0.374	0.333	24.742

The Potential of methane (CH4) in Jenin city is shown in table 3.2.5 below:

Table 3.2.5: Potential of methane (CH4) in Jenin city.

Theoretical Potential of CH4 (Million m3 /year)							
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Jenin	1.947	0.277	0.067	12.013	0.224	0.199	14.730

The colorific value (Heating value) of methane in Jenin city is shown in table 3.2.6 below:

Table 3.2.6: colorific value (Heating value) of methane in Jenin city.

The colorific value (Heating value) of methane (MJ)							
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Jenin	$5.96*10^7$	$8.49*10^6$	$2.06*10^6$	$3.68*10^8$	$6.88*10^6$	$6.12*10^6$	$4.51*10^8$

The potential of electricity generation in Jenin city is shown in table 3.2.7 below:

Table 3.2.7: potential of electricity generation in Jenin city

The potential of electricity generation (MWh)							
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Jenin	11.15	1.6	0.4	68.8	1.3	1.14	82.3

2. Tubas city:

The number of animal in Tubas city is shown in table 3.2.8 below:

Table 3.2.8: number of animal in Tubas city.

Governate	Cattles	Sheep	Goats	Broilers	Layers	Turkey	Total
Tubas	3,208	61,525	12,256	832,563	0	800	910,352

The biogas production in Tubas city is shown in table 3.2.14 below:

Table 3.2.9: biogas production in Tubas city.

Theoretical Potential of Biogas TPB (Million m3 /year)							
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Tubas	1.975	0.467	0.093	3.140	0	0.003	5.679

The Potential of methane (CH4) in Tubas city is shown in table 3.2.15 below:

Table 3.2.10: Potential of methane (CH4) in Tubas city.

Theoretical Potential of CH4 (Million m3 /year)							
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Tubas	1.185	0.210	0.041	1.884	0	0.001	3.323

The colorific value (Heating value) of methane in Tubas city is shown in table 3.2.16 below:

Table 3.2.11: colorific value (Heating value) of methane.

The colorific value (Heating value) of methane (MJ)							
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Tubas	$3.63*10^7$	$6.43*10^6$	$1.28*10^6$	$5.77*10^7$	0	$5.54*10^4$	$1.02*10^8$

The potential of electricity generation in Tubas city is shown in table 3.2.17 below:

Table 3.2.12: potential of electricity generation in Tubas city.

The potential of electricity generation (MWh)							
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Tubas	6.8	1.2	0.23	10.8	0	0.0057	19

3. Tulkarm city:

The number of animal in Tulkarm city is shown in table 3.2.13 below:

Table 3.2.13: number of animal in Tulkarm city.

Governate	Cattles	Sheep	Goats	Broilers	Layers	Turkey	Total
Tulkarm	1,258	20,641	2,818	2,527,963	464,114	276,667	3,293,461

The biogas production in Tulkarm city is shown in table 3.2.14 below:

Table 3.2.14: biogas production in Tulkarm city.

Theoretical Potential of Biogas TPB (Million m3 /year)							
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Tulkarm	0.774	0.156	0.0215	9.536	1.750	1.043	13.284

The Potential of methane (CH4) in Tulkarm city is shown in table 3.2.15 below:

Table 3.2.15: Potential of methane (CH4) in Tulkarm city.

Theoretical Potential of CH4 (Million m3 /year)							
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Tulkarm	0.464	0.070	0.009	5.722	1.050	0.626	7.943

The colorific value (Heating value) of methane in Tulkarm city is shown in table 3.2.16 below:

Table 3.2.16: colorific value (Heating value) of methane in Tulkarm city.

The colorific value (Heating value) of methane (MJ)							
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Tulkarm	$1.42*10^{7}$	$2.16*10^{6}$	$2.95*10^{5}$	$1.75*10^{8}$	$3.21*10^{7}$	$1.92*10^{7}$	$2.43*10^{7}$

The potential of electricity generation in Tulkarm city is shown in table 3.2.17 below:

Table 3.2.17: potential of electricity generation in Tulkarm city.

The potential of electricity generation (MWh)							
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Tulkarm	2.7	0.4	0.05	32.7	6.01	3.6	45.46

4. Nablus city:

The number of animal in Nablus city is shown in table 3.2.18 below:

Table 3.2.18: number of animal in Nablus city.

Governate	Cattles	Sheep	Goats	Broilers	Layers	Turkey	Total
Nablus	5,063	99,236	17,430	3,524,829	117,069	853	3,764,480

The biogas production in Nablus city is shown in table 3.2.19 below:

Table 3.2.19: biogas production in Nablus city.

Theoretical Potential of Biogas TPB (Million m3 /year)							
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Nablus	3.118	0.753	0.132	13.297	0.441	0.003	17.7464

The Potential of methane (CH4) in Nablus city is shown in table 3.2.20 below:

Table 3.2.20: Potential of methane (CH4) in Nablus city.

Theoretical Potential of CH4 (Million m3 /year)							
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Nablus	1.871	0.339	0.059	7.978	0.264	0.002	10.515

The colorific value (Heating value) of methane in Nablus city is shown in table 3.2.21 below:

Table 3.2.21: colorific value (Heating value) of methane in Nablus city.

The colorific value (Heating value) of methane (MJ)							
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Nablus	$5.73*10^7$	$1.04*10^7$	$1.82*10^6$	$2.44*10^8$	$8.11*10^6$	$5.91*10^4$	$3.22*10^8$

The potential of electricity generation in Nablus city is shown in table 3.2.22 below:

Table 3.2.22: potential of electricity generation in Nablus city.

The potential of electricity generation (MWh)							
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Nablus	10.7	1.9	0.3	45.6	1.5	0.01	60.2

5. Qalqiliya city:

The number of animal in Qalqiliya city is shown in table 3.2.23 below:

Table 3.2.23: number of animal in Qalqiliya city

Governate	Cattles	Sheep	Goats	Broilers	Layers	Turkey	Total
Qalqiliya	2,916	25,790	2,666	2,569,336	101,833	122,667	2,825,208

The biogas production in Qalqiliya city is shown in table 3.2.24 below:

Table 3.2.24: biogas production in Qalqiliya city.

Theoretical Potential of Biogas TPB (Million m3 /year)							
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Qalqiliya	1.796	0.195	0.020	9.692	0.384	0.462	12.551

The Potential of methane (CH4) in Qalqiliya city is shown in table 3.2.25 below:

Table 3.2.25:potential of methane (CH4) in Qalqiliya city.

Theoretical Potential of CH4 (Million m3 /year)							
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Qalqiliya	1.077	0.088	0.009	5.815	0.230	0.277	7.498

The colorific value (Heating value) of methane in Qalqiliya city is shown in table 3.2.26 below:

Table 3.2.26: Colorific value (Heating value) of methane in Qalqiliya city.

The colorific value (Heating value) of methane (MJ)							
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Qalqiliya	$3.30*10^{7}$	$2.70*10^{6}$	$2.79*10^{5}$	$1.78*10^{8}$	$7.05*10^{6}$	$8.50*10^{6}$	$2.29*10^{8}$

The potential of electricity generation in Qalqiliya city is shown in table 3.2.27 below:

Table 3.2.27: potential of electricity generation in Qalqiliya city.

The potential of electricity generation (MWh)							
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Qalqiliya	6.1	0.5	0.05	33.3	1.3	1.3	42.9

6. Salfit city:

The number of animal in Salfit city is shown in table 3.2.28 below:

Table 3.2.28: number of animal in Salfit city.

Governate	Cattles	Sheep	Goats	Broilers	Layers	Turkey	Total
Salfit	466	11,404	4,619	416,839	24,166	0	457,494

The biogas production in Salfit city is shown in table 3.2.29 below:

Table 3.2.29: biogas production in Salfit city.

	Theoretical Potential of Biogas TPB (Million m3 /year)						
Governate	Cattles	Sheep	Goats	Broilers	Layers	Turkey	Total
Salfit	0.287	0.086	0.035	1.572	0.091	0	2.072

The Potential of methane (CH4) in Salfit city is shown in table 3.2.30 below:

Table 3.2.30: Potential of methane (CH4) in Salfit city.

	Theoretical Potential of CH4 (Million m3 /year)						
Governate	Cattles	Sheep	Goats	Broilers	Layers	Turkey	Total
Salfit	0.172	0.038	0.015	0.943	0.054	0	1.225

The colorific value (Heating value) of methane in Salfit city is shown in table 3.2.31 below:

Table 3.2.31: colorific value (Heating value) of methane in Salfit city.

	The colorific value (Heating value) of methane (MJ)						
Governate	Cattles	Sheep	Goats	Broilers	Layers	Turkey	Total
Salfit	$5.27*10^6$	$1.19*10^6$	$4.83*10^5$	$2.89*10^7$	$1.67*10^6$	0	$3.75*10^7$

The potential of electricity generation in Salfit city is shown in table 3.2.32 below:

Table 3.2.32: potential of electricity generation in Salfit city.

	The potential of electricity generation (MWh)						
Governate	Cattles	Sheep	Goats	Broilers	Layers	Turkey	Total
Salfit	0.98	0.2	0.09	5.4	0.3	0	6.8

7. Ramallah and al-Bireh city:

The number of animal in Ramallah and al-Bireh city is shown in table 3.2.33 below:

Table 3.2.33: number of animal in Ramallah and al-Bireh city.

Governate	Cattles	Sheep	Goats	Broilers	Layers	Turkey	Total
Ramallah & Al-Bireh	490	39,229	26,561	1,995,021	471,506	0	2,532,807

The biogas production in Ramallah and al-Bireh city is shown in table 3.2.34 below:

Table 3.2.34: biogas production in Ramallah and al-Bireh city.

	Theoretical Potential of Biogas TPB (Million m3 /year)						
Governate	Cattles	Sheep	Goats	Broilers	Layers	Turkey	Total
Ramallah & Al-Bireh	0.301	0.297	0.201	7.526	1.778	0	10.106

The Potential of methane (CH4) in Ramallah and al-Bireh city is shown in table 3.2.35 below:

Table 3.2.35: Potential of methane (CH4) in Ramallah and al-Bireh city.

	Theoretical Potential of CH4 (Million m3 /year)						
Governate	Cattles	Sheep	Goats	Broilers	Layers	Turkey	Total
Ramallah & Al-Bireh	0.181	0.134	0.090	4.515	1.067	0	5.988

The colorific value (Heating value) of methane in Ramallah and al-Bireh city is shown in table 3.2.36 below:

Table 3.2.36: colorific value (Heating value) of methane in Ramallah and al-Bireh city.

	The colorific value (Heating value) of methane (MJ)						
Governate	Cattles	Sheep	Goats	Broilers	Layers	Turkey	Total
Ramallah & Al-Bireh	$5.54*10^6$	$4.10*10^6$	$2.78*10^6$	$1.38*10^8$	$3.27*10^7$	0	$1.83*10^8$

The potential of electricity generation in Ramallah and al-Bireh city is shown in table 3.2.37 below:

Table 3.2.37: potential of electricity generation in Ramallah and al-Bireh city.

	The potential of electricity generation (MWh)						
Governate	Cattles	Sheep	Goats	Broilers	Layers	Turkey	Total
Ramallah & AL-Al-Bireh	1.03	0.8	0.5	25.9	6.1	0	34.2

8. Jericho & Al- Aghwar:

The number of animals in Jericho & Al- Aghwar is shown in table 3.2.38 below:

Table 3.2.38: number of animals in Jericho & Al- Aghwar.

Governate	Cattles	Sheep	Goats	Broilers	Layers	Turkey	Total
Jericho & Al- Aghwar	709	42,846	28,765	180,848	0	0	253,168

The biogas production in Jericho & Al- Aghwar is shown in table 3.2.39 below:

Table 3.2.39: biogas production in Jericho & Al- Aghwar.

	Theoretical Potential of Biogas TPB (Million m3 /year)						
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Jericho & Al- Aghwar	0.436	0.325	0.218	0.682	0	0	1.662

The Potential of methane (CH4) in Jericho & Al- Aghwar is shown in table 3.2.40 below:

Table 3.2.40: Potential of methane (CH4) in Jericho & Al- Aghwar.

	Theoretical Potential of CH4 (Million m3 /year)						
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Jericho & Al- Aghwar	0.262	0.146	0.098	0.409	0	0	0.916

The colorific value (Heating value) of methane in Jericho & Al- Aghwar is shown in table 3.2.41 below:

Table 3.2.41: colorific value (Heating value) of methane in Jericho & Al- Aghwar.

	The colorific value (Heating value) of methane (MJ)						
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Jericho & Al- Aghwar	$8.02*10^6$	$4.48*10^6$	$3.01*10^6$	$1.2*10^7$	0	0	$2.80*10^7$

The potential of electricity generation in Jericho & Al- Aghwar is shown in table 3.2.42 below:

Table 3.2.42: potential of electricity generation in Jericho & Al- Aghwar.

	The potential of electricity generation (MWh)						
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Jericho & Al- Aghwar	1.5	0.8	0.6	2.3	0	0	5.2

9. Jerusalem city:

The number of animals in Jerusalem city is shown in table 3.2.43 below:

Table 3.2.43: number of animals in Jerusalem city.

Governate	Cattles	Sheep	Goats	Broilers	Layers	Turkey	Total
Jerusalem	265	29,709	17,028	52,300	11,700	46,550	157,552

The biogas production in Jerusalem city is shown in table 3.2.44 below:

Table 3.2.44: biogas production in Jerusalem city.

	Theoretical Potential of Biogas TPB (Million m3 /year)						
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Jerusalem	0.163	0.225	0.129	0.197	0.044	0.175	0.935

The Potential of methane (CH4) in Jerusalem city is shown in table 3.2.45 below:

Table 3.2.45: Potential of methane (CH4) in Jerusalem city.

	Theoretical Potential of CH4 (Million m3 /year)						
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Jerusalem	0.097	0.101	0.058	0.118	0.026	0.105	0.507

The colorific value (Heating value) of methane in Jerusalem city is shown in table 3.2.46 below:

Table 3.2.46: colorific value (Heating value) of methane in Jerusalem city.

	The colorific value (Heating value) of methane (MJ)						
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Jerusalem	$3.00*10^6$	$3.11*10^6$	$1.78*10^6$	$3.62*10^6$	$8.10*10^5$	$3.22*10^6$	$1.55*10^7$

The potential of electricity generation in Jerusalem city is shown in table 3.2.47 below:

Table 3.2.47: potential of electricity generation in Jerusalem city.

	The potential of electricity generation (MWh)						
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Jerusalem	0.5	0.58	0.33	0.68	0.15	0.6	2.9

10. Bethlehem:

The number of animals in Bethlehem city is shown in table 3.2.48 below:

Table 3.2.48: number of animals in Bethlehem city.

Governate	Cattles	Sheep	Goats	Broilers	Layers	Turkey	Total
Bethlehem	716	74,236	27,963	1,069,617	20,443	0	1,192,975

The biogas production in Bethlehem city is shown in table 3.2.49 below:

Table 3.2.49: biogas production in Bethlehem city.

	Theoretical Potential of Biogas TPB (Million m3 /year)						
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Bethlehem	0.441	0.563	0.212	4.035	0.077	0	5.329

The Potential of methane (CH4) in Bethlehem city is shown in table 3.2.50 below:

Table 3.2.50: Potential of methane (CH4) in Bethlehem city.

	Theoretical Potential of CH4 (Million m3 /year)						
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Bethlehem	0.264	0.253	0.095	2.421	0.046	0	3.081

The colorific value (Heating value) of methane in Bethlehem city is shown in table 3.2.51 below:

Table 3.2.51: colorific value (Heating value) of methane in Bethlehem city.

	The colorific value (Heating value) of methane (MJ)						
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Bethlehem	$8.10*10^6$	$7.76*10^6$	$2.92*10^6$	$7.41*10^7$	$1.42*10^6$	0	$9.43*10^7$

The potential of electricity generation in Bethlehem city is shown in table 3.2.52 below:

Table 3.2.52: potential of electricity generation in Bethlehem city.

	The potential of electricity generation (MWh)						
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Bethlehem	1.51	1.45	0.54	13.86	0.26	0	17.64

11. Hebron:

The number of animals in Hebron city is shown in table 3.2.53 below:

Table 3.2.53: number of animals in Hebron city.

Governate	Cattles	Sheep	Goats	Broilers	Layers	Turkey	Total
Hebron	5,252	184,527	45,139	4,820,267	115,391	2,442	5,173,018

The biogas production in Hebron city is shown in table 3.2.54 below:

Table 3.2.54: biogas production in Hebron city.

	Theoretical Potential of Biogas TPB (Million m3 /year)						
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Hebron	3.234	1.400	0.342	18.184	0.435	0.009	23.607

The Potential of methane (CH4) in Hebron city is shown in table 3.2.55 below:

Table 3.2.55: Potential of methane (CH4) in Hebron city.

	Theoretical Potential of CH4 (Million m3 /year)						
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Hebron	1.940	0.630	0.154	10.910	0.261	0.005	13.902

The colorific value (Heating value) of methane in Hebron city is shown in table 3.2.56 below:

Table 3.2.56: colorific value (Heating value) of methane in Hebron city.

	The colorific value (Heating value) of methane (MJ)						
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Hebron	$5.94*10^7$	$1.93*10^7$	$4.72*10^6$	$3.34*10^8$	$7.99*10^6$	$1.69*10^5$	$4.25*10^8$

The potential of electricity generation in Hebron city is shown in table 3.2.57 below:

Table 3.2.57: potential of electricity generation in Hebron city.

	The potential of electricity generation (MWh)						
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Hebron	11.1	3.61	0.88	62.5	1.5	0.03	79.6

12. North Gaza:

The number of animals in North Gaza city is shown in table 3.2.58 below:

Table 3.2.58: number of animals in North Gaza city.

Governate	Cattles	Sheep	Goats	Broilers	Layers	Turkey	Total
North Gaza	2,564	16,565	2,424	2,965,084	134,571	2,750	3,123,958

The biogas production in North Gaza city is shown in table 3.2.59 below:

Table 3.2.59: biogas production in North Gaza city.

	Theoretical Potential of Biogas TPB (Million m3 /year)						
Governate	Cattle	Sheep	Goats	Broilers	Layers	Turkey	Total
North Gaza	1.579	0.125	0.018	11.185	0.507	0.010	13.427

The Potential of methane (CH4) in North Gaza city is shown in table 3.2.60 below:

Table 3.2.60: Potential of methane (CH4) in North Gaza city.

	Theoretical Potential of CH4 (Million m3 /year)						
Governate	Cattles	Sheep	Goats	Broilers	Layers	Turkey	Total
North Gaza	0.947	0.056	0.008	6.711	0.304	0.006	8.034

The colorific value (Heating value) of methane in North Gaza city is shown in table 3.2.61 below:

Table 3.2.61: colorific value (Heating value) of methane in North Gaza city.

	The colorific value (Heating value) of methane (MJ)						
Governate	Cattles	Sheep	Goats	Broiler	Layers	Turkey	Total
North Gaza	$2.90*10^{7}$	$1.73*10^{6}$	$2.53*10^{5}$	$2.05*10^{8}$	$9.32*10^{6}$	$1.90*10^{5}$	$2.46*10^{8}$

The potential of electricity generation in North Gaza city is shown in table 3.2.62 below:

Table 3.2.62: potential of electricity generation in North Gaza city.

	The potential of electricity generation (MWh)						
Governate	Cattles	Sheep	Goats	Broilers	Layers	Turkey	Total
North Gaza	5.42	0.32	0.05	38.42	1.74	0.03	46

13. Gaza:

The number of animals in Gaza city is shown in table 3.2.63 below:

Table 3.2.63: number of animals in Gaza city.

Governate	Cattles	Sheep	Goats	Broilers	Layers	Turkey	Total
Gaza	1,266	12,326	2,318	310,699	96,950	0	423,559

The biogas production in Gaza city is shown in table 3.2.64 below:

Table 3.2.64: biogas production in Gaza city.

Theoretical Potential of Biogas TPB (Million m3 /year)							
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Gaza	0.779	0.093	0.017	1.172	0.365	0	2.428

The Potential of methane (CH4) in Gaza city is shown in table 3.2.65 below:

Table 3.2.65: Potential of methane (CH4) in Gaza city.

Theoretical Potential of CH4 (Million m3 /year)							
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Gaza	0.467	0.042	0.007	0.703	0.219	0	1.440

The colorific value (Heating value) of methane in Gaza city is shown in table 3.2.66 below:

Table 3.2.66: colorific value (Heating value) of methane in Gaza city.

The colorific value (Heating value) of methane (MJ)							
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Gaza	$1.43*10^7$	$1.29*10^6$	$2.42*10^5$	$2.15*10^7$	$6.72*10^6$	0	$4.41*10^7$

The potential of electricity generation in Gaza city is shown in table 3.2.67 below:

Table 3.2.67: potential of electricity generation in Gaza city.

The potential of electricity generation (MWh)							
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Gaza	2.67	0.24	0.04	4.02	1.25	0	8.25

14. Deir Al-Balah:

The number of animals in Deir Al-Balah city is shown in table 3.2.68 below:

Table 3.2.68: number of animals in Deir Al-Balah city.

Governate	Cattles	Sheep	Goats	Broilers	Layers	Turkey	Total
Deir Al-Balah	1,546	8,679	1,827	3,367,157	88,029	5,343	3,472,581

The biogas production in Deir Al-Balah city is shown in table 3.2.69 below:

Table 3.2.69: biogas production in Deir Al-Balah city.

	Theoretical Potential of Biogas TPB (Million m3 /year)						
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Deir Al-Balah	0.952	0.065	0.013	12.702	0.332	0.020	14.086

The Potential of methane (CH4) in Deir Al-Balah city is shown in table 3.2.70 below:

Table 3.2.70: Potential of methane (CH4) in Deir Al-Balah city.

	Theoretical Potential of CH4 (Million m3 /year)						
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Deir Al-Balah	0.571	0.029	0.006	7.621	0.199	0.012	8.440

The colorific value (Heating value) of methane in Deir Al-Balah city is shown in table 3.2.71 below:

Table 3.2.71: colorific value (Heating value) of methane in Deir Al-Balah city.

	The colorific value (Heating value) of methane (MJ)						
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Deir Al-Balah	$1.75*10^7$	$9.07*10^5$	$1.91*10^7$	$2.33*10^8$	$6.10*10^6$	$3.70*10^5$	$2.58*10^8$

The potential of electricity generation in Deir Al-Balah city is shown in table 3.2.72 below:

Table 3.2.72: potential of electricity generation in Deir Al-Balah city.

	The potential of electricity generation (MWh)						
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Deir Al-Balah	3.27	0.17	0.03	43.64	1.14	0.07	48.33

15. Khan Yunis:

The number of animals in Khan Yunis city is shown in table 3.2.73 below:

Table 3.2.73: number of animals in Khan Yunis city.

Governate	Cattles	Sheep	Goats	Broilers	Layers	Turkey	Total
Khan Yunis	883	17,175	2,739	613,627	31,649	0	666,073

The biogas production in Khan Yunis city is shown in table 3.2.74 below:

Table 3.2.74: biogas production in Khan Yunis city.

Theoretical Potential of Biogas TPB (Million m3 /year)							
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Khan Yunis	0.543	0.130	0.020	2.314	0.119	0	3.129

The Potential of methane (CH4) in Khan Yunis city is shown in table 3.2.75 below:

Table 3.2.75: Potential of methane (CH4) in Khan Yunis city.

Theoretical Potential of CH4 (Million m3 /year)							
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Khan Yunis	0.326	0.058	0.009	1.388	0.071	0	1.854

The colorific value (Heating value) of methane in Khan Yunis city is shown in table 3.2.76 below:

Table 3.2.76: colorific value (Heating value) of methane in Khan Yunis city.

The colorific value (Heating value) of methane (MJ)							
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Khan Yunis	$9.99*10^6$	$1.80*10^6$	$2.86*10^5$	$4.25*10^7$	$2.19*10^6$	0	$5.68*10^7$

The potential of electricity generation in Khan Yunis city is shown in table 3.2.77 below:

Table 3.2.77: potential of electricity generation in Khan Yunis city.

The potential of electricity generation (MWh)							
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Khan Yunis	1.87	0.33	0.05	7.94	0.4	0	$5.63*10^6$

16. Rafah:

The number of animals in Rafah city is shown in table 3.2.78 below:

Table 3.2.78: number of animals in Rafah city.

Governate	Cattles	Sheep	Goats	Broilers	Layers	Turkey	Total
Rafah	2,109	5,817	1,090	961,613	0	0	970,629

The biogas production in Rafah city is shown in table 3.2.79 below:

Table 3.2.79: biogas production in Rafah city.

Theoretical Potential of Biogas TPB (Million m3 /year)							
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Rafah	1.299	0.044	0.008	3.627	0	0	4.979

The Potential of methane (CH4) in Rafah city is shown in table 3.2.80 below:

Table 3.2.80: Potential of methane (CH4) in Rafah city.

Theoretical Potential of CH4 (Million m3 /year)							
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Rafah	0.779	0.019	0.003	2.176	0	0	2.979

The colorific value (Heating value) of methane in Rafah city is shown in table 3.2.81 below:

Table 3.2.81: colorific value (Heating value) of methane in Rafah city.

The colorific value (Heating value) of methane (MJ)							
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Rafah	$2.38*10^7$	$6.08*10^5$	$1.14*10^5$	$6.66*10^7$	$0.00*10^0$	0	$9.12*10^7$

The potential of electricity generation in Rafah city is shown in table 3.2.82 below:

Table 3.2.82: potential of electricity generation in Rafah city.

The potential of electricity generation (MWh)							
Governate	**Cattles**	**Sheep**	**Goats**	**Broilers**	**Layers**	**Turkey**	**Total**
Rafah	4.46	0.11	0.02	12.5	0	0	17.05

Figure 3 shows the biogas production based on our results in west bank and Gaza strip cities:

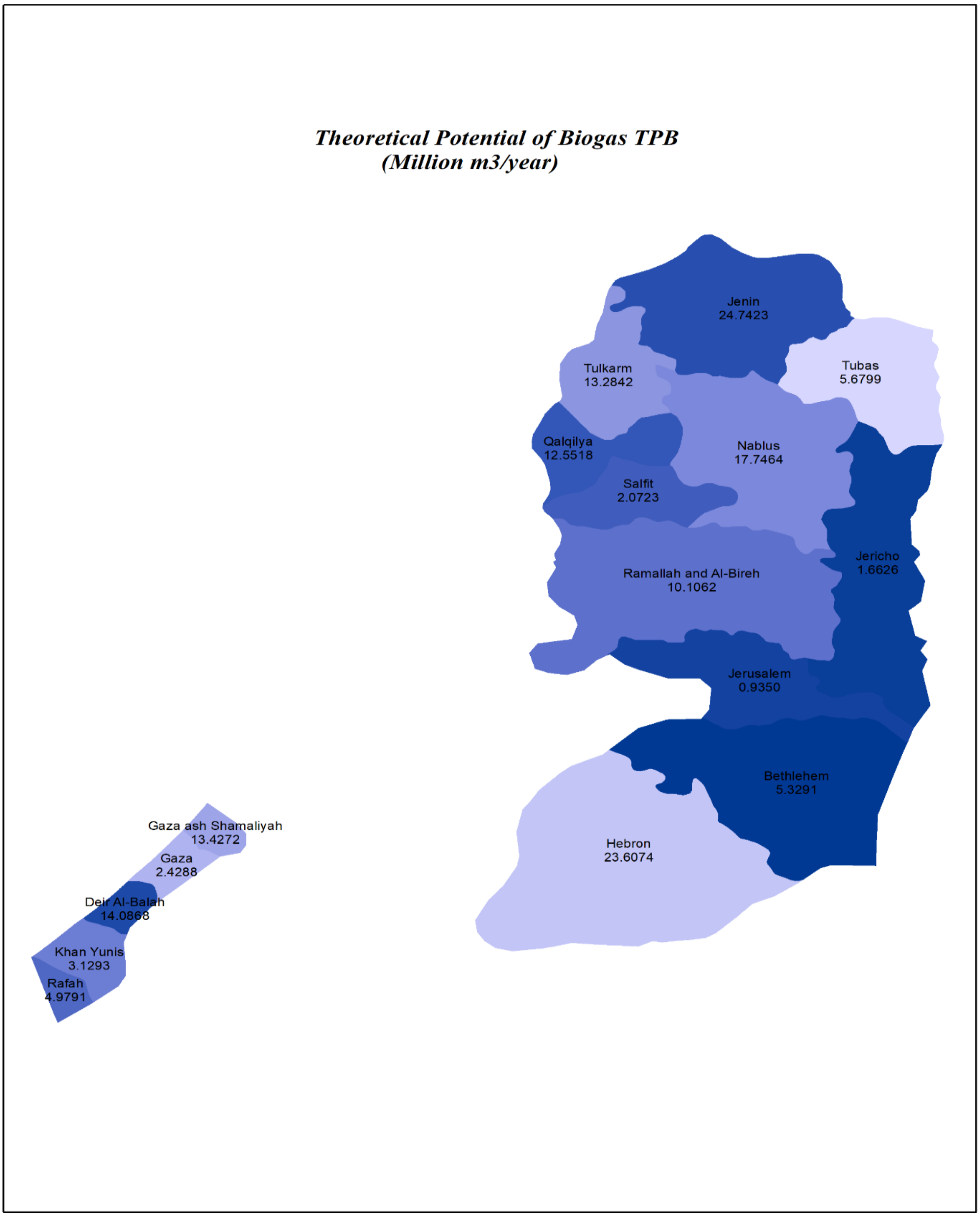

Figure 3: potential of biogas in Palestine.

Figure 4 shows The Potential of methane based on our results in west bank and Gaza strip cities:

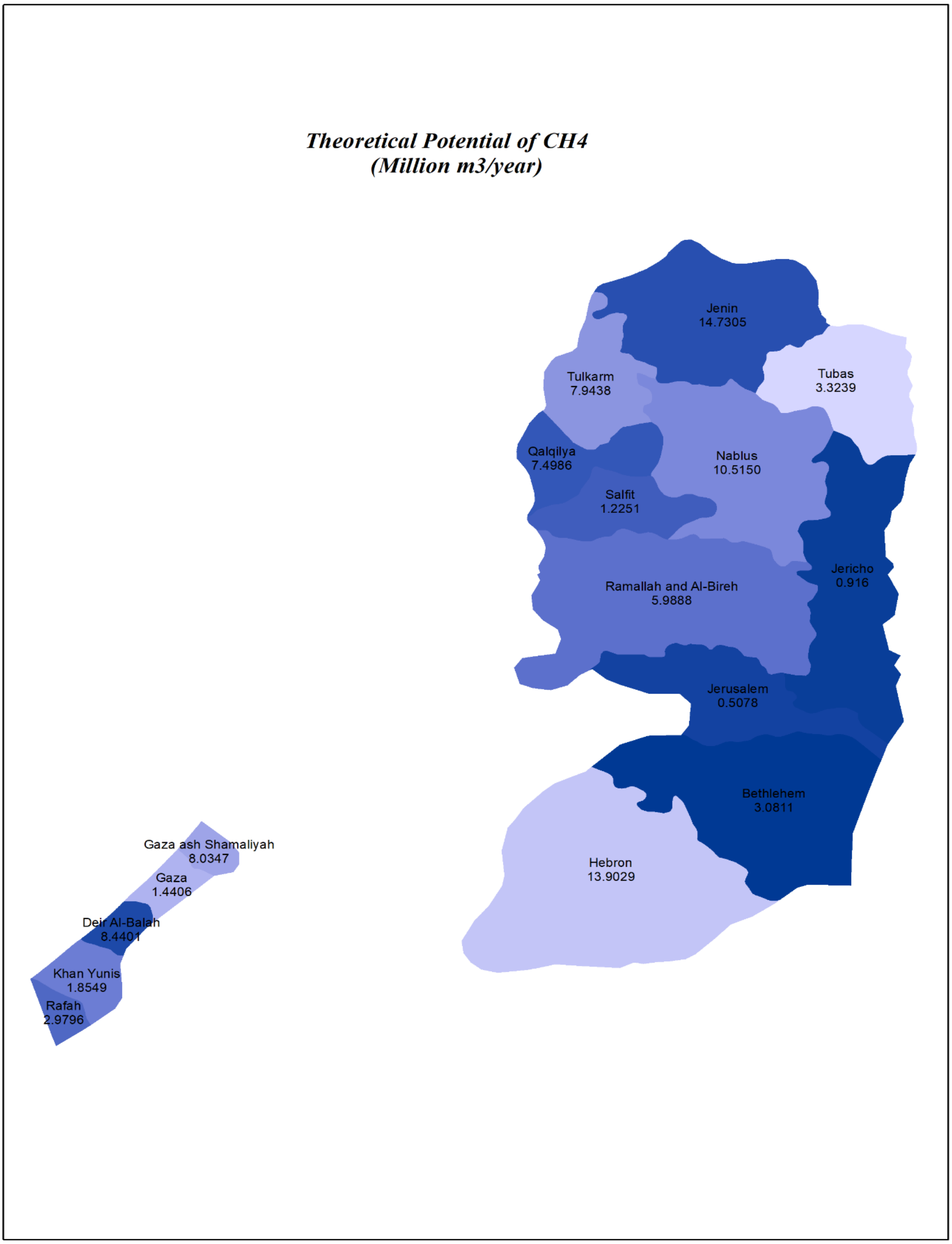

Figure 4: potential of methane in Palestine.

Figure 5 shows the colorific value (Heating value) of methane based on our results in west bank and Gaza strip cities:

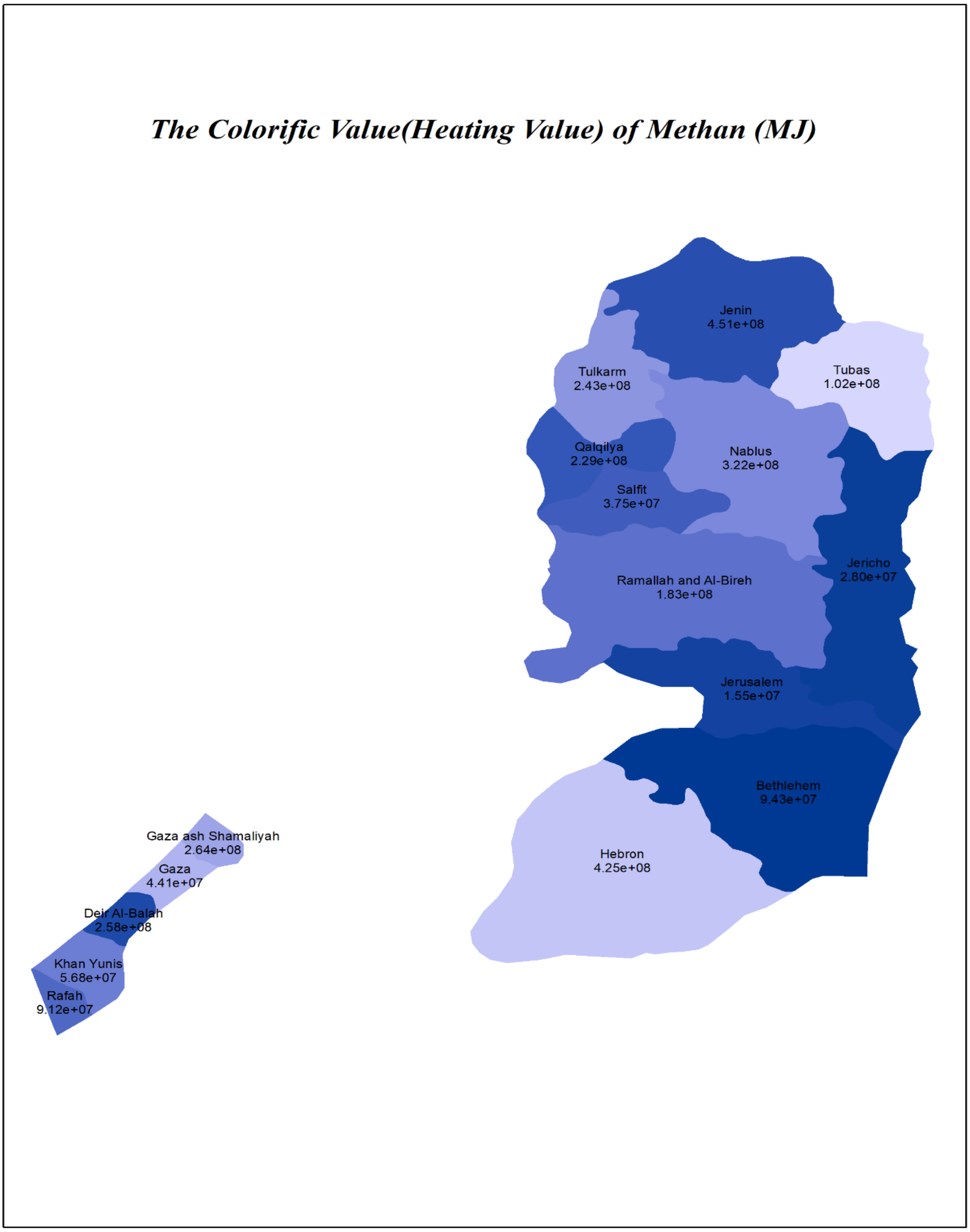

Figure 5: Heating value of methane in Palestine.

Figure 6 shows the colorific value (Heating value) of methane based on our results in west bank and Gaza strip cities:

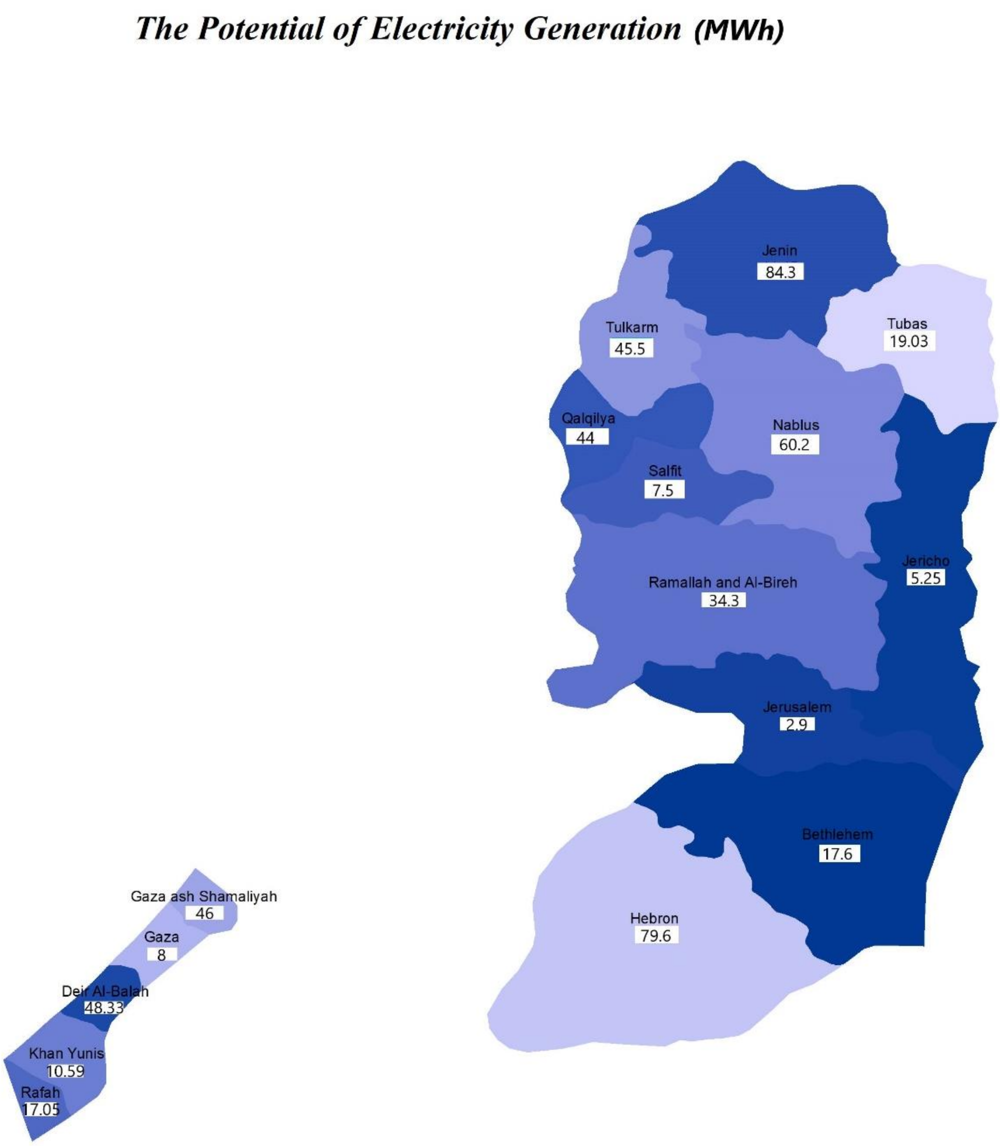

Figure 6: electricity generator in Palestine.

Chapter 4: Designing the biogas stations.

Biogas station contains different equipment which is mentioned in figure 2 (general design for the biogas plant), in this chapter we will specialize in designing the digester, sizing the generator and choosing the location for the stations.

What is the digester?

Digester (fermenter): is a reservoir where the main process of biogas production is completed, in the environment without the presence of oxygen. It is usually covered with a double-layer gas permeable, mechanical membrane, but it can also have a concrete roof.

Engine with generator (CHP unit): This is in fact a gas engine, which is merged with a generator, to form a device that will produce the electrical energy.

For choosing the location of the biogas stations, we will take into consideration the following points:

1) Locate the biogas stations near the animal farms that produce a large amount of manure in case to reduce the transportations cost.

2) Existing of a water source near the station.

3) A wide space to build the biogas stations.

4) The site should be ventilated and exposed to sunlight.

Figure 7 shows structure of digester.

Where:

-Hgs: height of gas chamber.

-Hf: height of fermentation chamber.

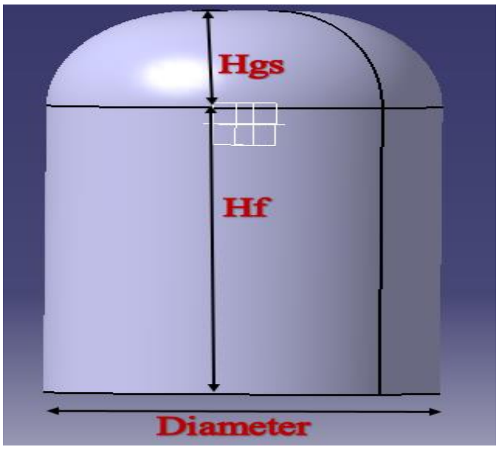

Figure 7: structure of digester

. Calculating the digester dimensions and digester volume.

At first, we calculate the total influent (Q):

Q=$\frac{Total\ discharge}{TS\%}$

Then, we calculate the quantity of water needed:

$Water\ =\ Q - Total\ discharge.$

Then, we calculate the digester size:

$V\ =\ Vgs\ +\ Vd\,.$

Here, Vgs represents the volume of the gas storage chamber and Vd represents the volume of the fermentation chamber.

.Vgs represents also the dome part of the digester and it's shape is as an oval shape, so the volume of it will be the same as the oval shape:

Vgs=$\frac{4}{3} \times \pi \times a \times b \times c$

.Vd represents the cylindrical part of the digester and it's shape is as an cylindrical, so the volume of it will be the cylindrical volume:

Vd=$\pi \times r^2 \times h$

. We will show specifically how we calculate the digesters volume for the first city (Jenin city) and the other cities are calculated as the same way.

1) Jenin city:

The Volume of fermentation chamber is shown in table 4.1 below:

Table4.1: Volume of fermentation chamber.

Animal	heads at Jenin	Manure (kg/day)	Total Manure (kg/day)	FD (kg)	The total influent (Q)	Water (kg)	V_d (m^3)
Cattle	5,269	22.5	118,553	29,638	370,478	251,925	16,672
Sheep & goats	100,881	1.6	161,410	40,352	504,405	342,995	22,698
Layers, broilers &turkey	5,495,318	0.045	247,289	71,714	896,424	649,134	40,339

. Number of heads and the amount of manure are given information

. For cattle:

Total manure=$number\ of\ heads\ \times manure$=$5{,}269\ \times 22.5$=118,553 kg/day

Then, FD=$Total\ manure\ \times 0.25$=$118{,}553 \times 0.25$= 29,638

Then, Q= $\frac{FD}{0.08} = \frac{29{,}638.25}{0.08} =$ 370,478

Then, Water to be added=$370{,}478.125 - 118{,}553$= 251,925 kg

Finally, Vd=$Q \times HRT$= $\frac{370{,}478}{1000} \times 45$= 16,672 m^3

. For sheep and goats:

Total manure=$number\ of\ heads\ \times manure$=100,881 $\times$ 1.6=161,410 kg/day

Then, FD=$Total\ manure\ \times 0.25$=$161{,}410\ \times 0.25$= 40,352

Then, Q= $\frac{FD}{0.08} = \frac{40{,}352}{0.08} =$ 504,405

Then, Water to be added=504,405$-$161,410= 251,925 kg

Finally, Vd=$Q \times HRT$= $\frac{504{,}405}{1000} \times 45$= 22,698 m^3

. For Layers, broilers &turkey:

Total manure=$number\ of\ heads\ \times manure$=5,495,318×0.045=247,289 kg/day

Then, FD=$Total\ manure\ \times 0.25 = 247{,}289\ \times 0.25 =$ 71,714

Then, Q= $\frac{FD}{0.08} = \frac{71{,}714}{0.08}$ = 896,424

Then, Water to be added=896,424−247,289= 251,925 kg

Finally, Vd=$Q \times HRT = \frac{896{,}424}{1000} \times 45 =$ 40,339 m^3

The Volume of gas storage chamber is shown in table 4.2 below:

Table 4.2: Volume of gas storage chamber.

Animal	biogas (m^3/day)	V_{gs}(m^3)
Cattle	8,891	2,223
Sheep & goats	2,098	2,098
Layers, broilers &turkey	56,797	5,680

. Here, biogas field is given, and for Vgs it is the volume for each digester, as it shown in the next table, we have 4 digesters for cattle, so 8,891/4=2,223 m^3

Number of digester and the dimensions is shown in table 4.3 below:

Table 4.3: number of digesters needed in Jenin.

Animal	Number of digesters	Diameter(m)	H_f(m)	H_{vg}(m)
Cattle	4	25	8.5	4
Sheep & goats	6	25	8	3
Layers, broilers &turkey	10	25	8.5	4.5

. Here, we choose the number of digesters by taking into consideration that the maximum diameter must be 25m and Hf does not exceed 8.5m and Hvg does not exceed 4.5m

So, Hf was calculated as we said before, by using the cylinder volume equation:

Vd=$\pi \times r^2 \times h$

$\frac{16{,}672}{4} = \pi \times 12.5^2 \times hf$, now hf is calculated.

Then, for Hvg was calculated by using the oval shape volume:

Vgs=$\frac{4}{3} \times \pi \times a \times b \times c$

$\frac{2,223}{4} = \frac{4}{3} \times \pi \times 12.5 \times 12.5 \times hgs$, now hgs is calculated.

For cattle, a gas storage is needed because of the lack of gas chamber volume, and to avoid volume shortage, gas storage chamber will discharge the biogas every 6 hours to the gas storage, the same is needed for layers, broilers and turkey with a periodic time of 3 hours to discharge the biogas.

Generator size depends on the methane gas produced per hour, in Jenin city the methane gas production expected is 40,356m^3/h, which is produce an 84.3MWh of electricity.

Due to the large area needed for the station, four stations will be built with a total power of 84.3 MWh, ten gas engines with the capacity of 2MW will be used for each station.

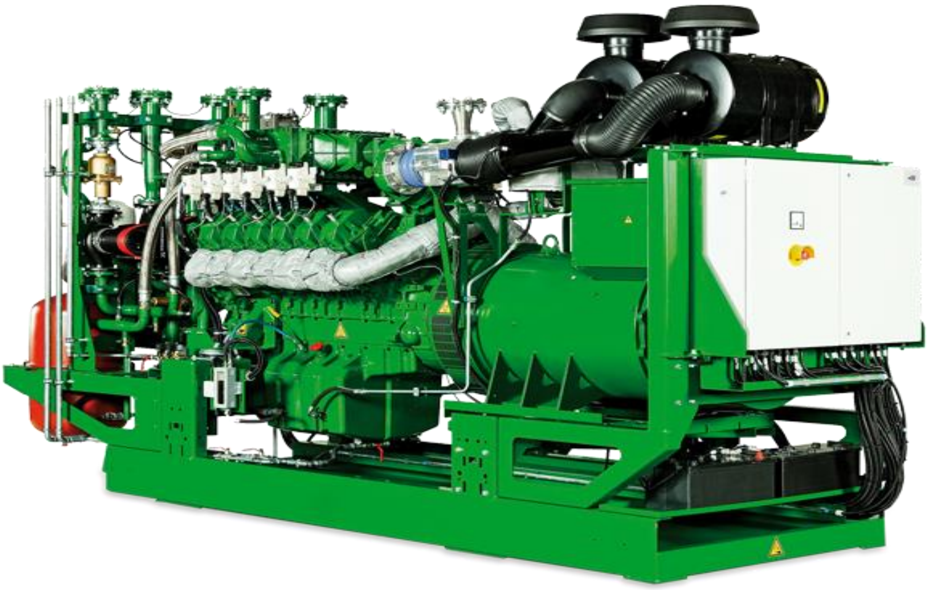

Figure 8: avus 2000c gas engine.

Table 4.4: technical data for the 2MW gas engine.

Type	Output(electrical)	Output(thermal)	Efficiency(electrical)	Efficiency(thermal)	Total efficiency
Avus 2000c	2,000 kW	6,817 MBTU	42.3 %	42.2 %	84.5 %

Regarding to the location of the stations in Jenin city, we assume them to be in Marj ibn Amir, it is also known as the valley of Megiddo, which are shown in figure 9 below:

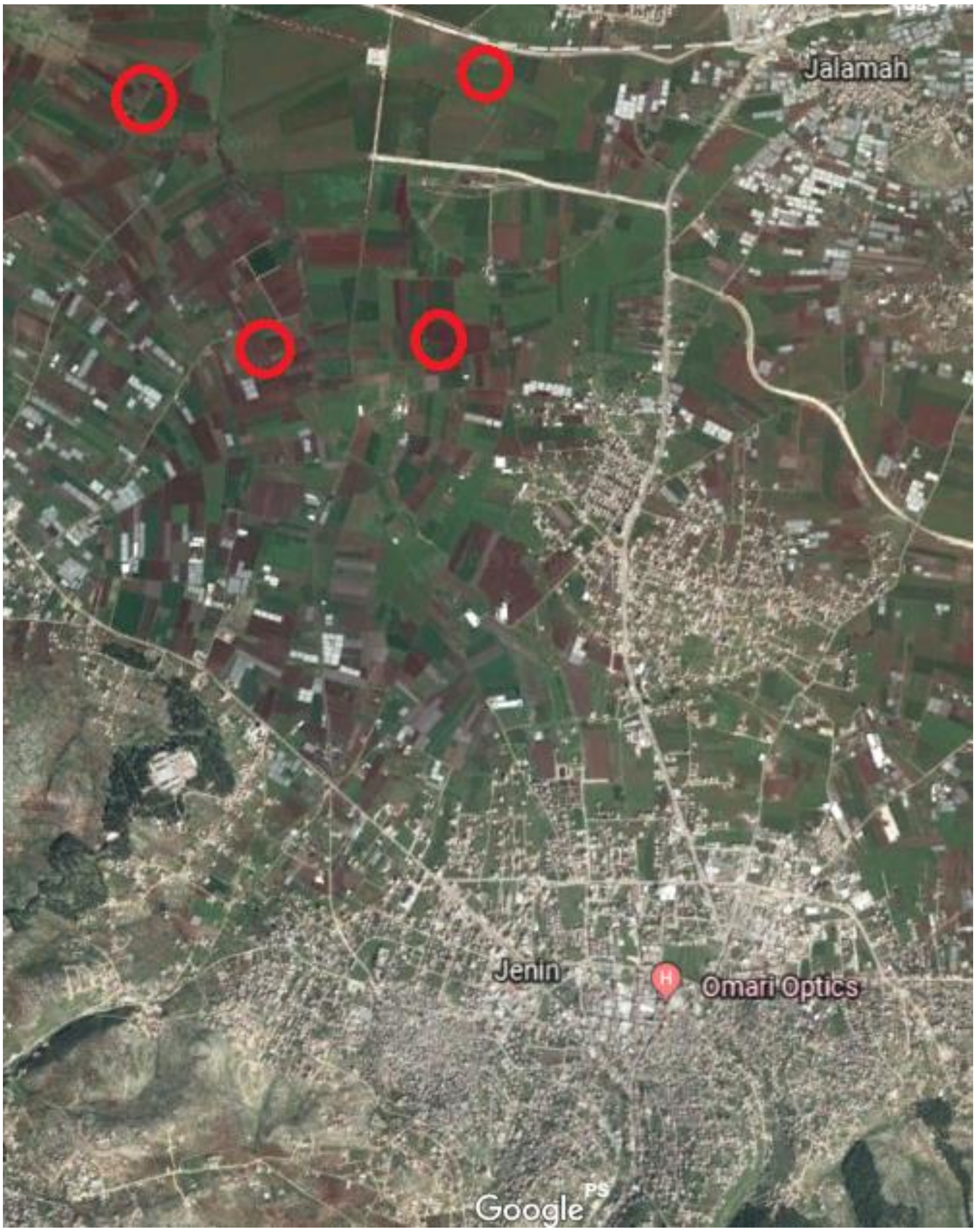

Figure 9: location of biogas stations in Jenin city

2) Tubas city:

The Volume of fermentation chamber is shown in table 4.5 below:

Table4.5: Volume of fermentation chamber

Animal	heads at Tubas	Manure (kg/day)	Total Manure (kg/day)	FD (kg)	The total influent (Q)	Water (kg)	V_d (m^3)
Cattle	3,208	22.5	72,180	18,045	225,563	153,383	10,150
Sheep & goats	73,781	1.6	118,050	29,512	368,905	250,855	16,600
Layers, broilers &turkey	833,363	0.045	37,501	10,875	135,942	98,441	6,117

The Volume of gas storage chamber is shown in table 4.6 below:

Table 4.6: Volume of gas storage chamber.

Animal	biogas (m^3/day)	V_{gs}(m^3)
Cattle	5,414	1,805
Sheep & goats	1,535	1,535
Layers, broilers &turkey	8,613	1,436

Number of digester and the dimensions is shown in table 4.7 below:

Table 4.7: number of digesters needed in Tubas.

Animal	Number of digesters	Diameter(m)	H_f(m)	H_{vg}(m)
Cattle	3	25	7	4
Sheep & goats	4	25	8.5	3
Layers, broilers &turkey	2	25	7	4.5

For cattle, a gas storage chamber will discharge the biogas every 8 hours to the gas storage, the same is needed for layers, broilers and turkey with a periodic time of 4 hours to discharge the biogas.

In Tubas city the methane gas production expected is 9,107m^3/h which is produce a 19.03MWh of electricity.

For this city, one station will be built with a total power of 19.03 MWh, nine gas engines with the capacity of 2MW and one gas engine with the capacity of 1.2MW will be used for this station.

The 2MW gas engines used is as that which we explained previously, but for the 1.2MW gas engine used will be explained in the next table (table 4.8).

Table 4.8: technical data for the 1.2MW gas engine.

Type	Output(electrical)	Output(thermal)	Efficiency(electrical)	Efficiency(thermal)	Total efficiency
Avus 1200c	1,200 kW	4,080 MBTU	43.4 %	43.2 %	86.6 %

Regarding to the location of the station in Tubas city, we assume it to be in Aqbat Tayasir region, which is shown in figure 10 below:

Figure 10: location of biogas station in Tubas city

3) Tulkarm city:

The Volume of fermentation chamber is shown in table 4.9 below:

Table4.9: Volume of fermentation chamber.

Animal	heads at Tulkarm	Manure (kg/day)	Total Manure (kg/day)	FD (kg)	The total influent (Q)	Water (kg)	V_d (m^3)
Cattle	1,258	22.5	28,305	7,076	88,453	60,148	3,980
Sheep & goats	23,459	1.6	37,534	9,384	117,295	79,761	5,230
Layers, broilers &turkey	3,268,744	0.045	147,093	42,657	533,214	386,120	23,995

The Volume of gas storage chamber is shown in table 4.10 below:

Table 4.10: Volume of gas storage chamber.

Animal	biogas (m^3/day)	V_{gs}(m^3)
Cattle	2,123	707
Sheep & goats	488	488
Layers, broilers &turkey	33,784	4,223

Number of digester and the dimensions is shown in table 4.11 below:

Table 4.11: number of digesters needed in Tulkarm.

Animal	Number of digesters	Diameter(m)	H_f(m)	H_{vg}(m)
Cattle	1	25	8.5	4.5
Sheep & goats	2	25	6	2
Layers, broilers &turkey	6	25	8.5	4.5

For cattle, a gas storage chamber will discharge the biogas every 12 hours to the gas storage, the same is needed for layers, broilers and turkey with a periodic time of 4 hours to discharge the biogas.

In Tulkarm city, the methane gas production expected is 21,766m^3/h which is produce a 45.5MWh of electricity.

In this city, three stations will be built with a total power of 45.5 MWh, seven gas engines with the capacity of 2MW and one gas engine with the capacity of 1.2MW will be used for each station.

The gas engines used are as that which we explained previously.

Regarding to the location of the stations in Tulkarm city, we assume them to be in Anabta region, Nur Shams region and Shuweika region, which are shown in figure 11,12 and 13 sequentially below:

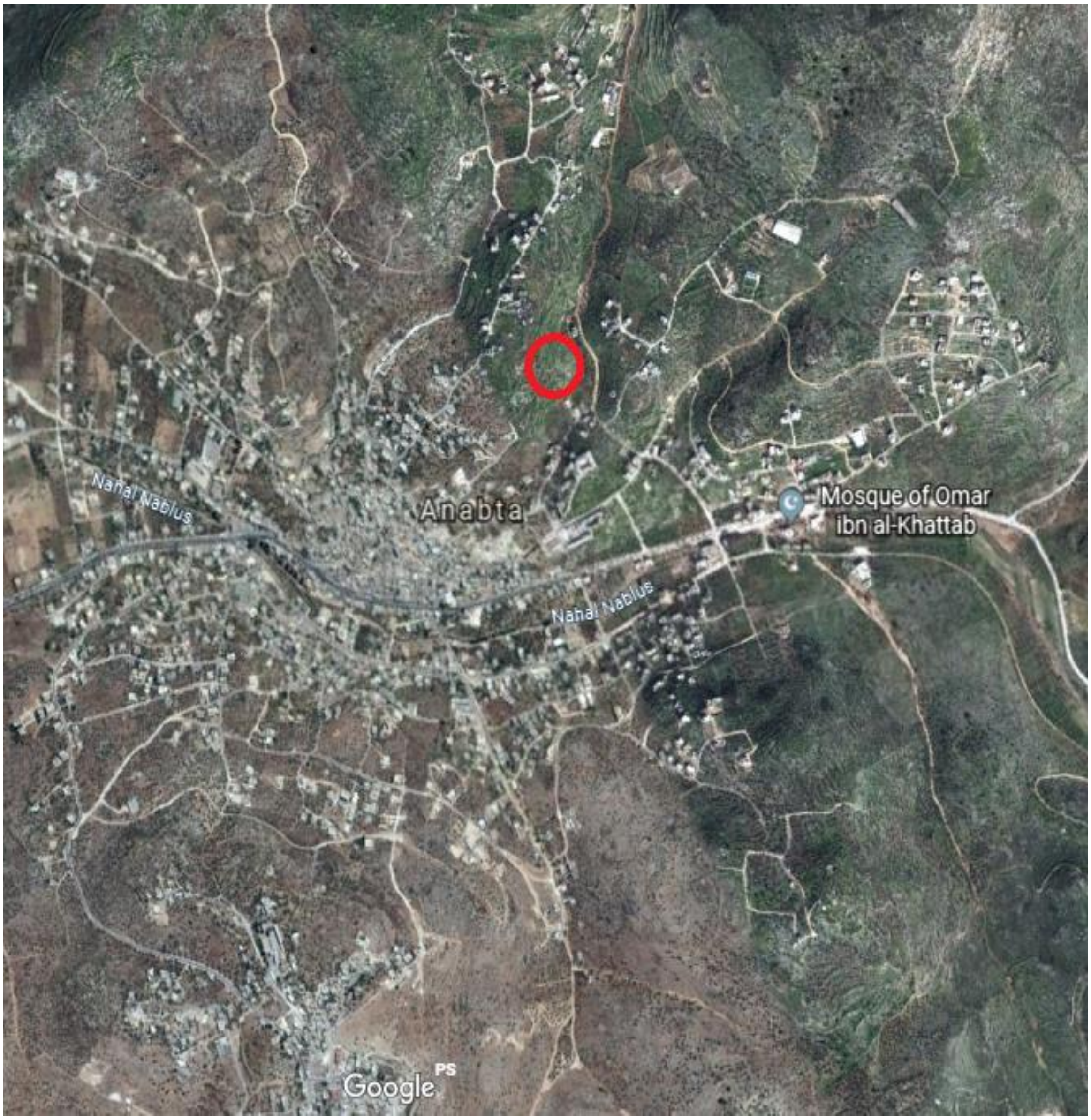

Figure 11: location of the first biogas station in Tulkarm city

Figure 12: location of the second biogas station in Tulkarm city

Figure 13: location of the third biogas station in Tulkarm city

4) Nablus city:

The Volume of fermentation chamber is shown in table 4.12 below:

Table4.12: Volume of fermentation chamber.

Animal	heads at Nablus	Manure (kg/day)	Total Manure (kg/day)	FD (kg)	The total influent (Q)	Water (kg)	V_d (m^3)
Cattle	5,063	22.5	113,918	28,480	355,994	242,076	16,020
Sheep & goats	116,666	1.6	186,666	46,667	583,332	396,666	26,250
Layers, broilers &turkey	3,642,571	0.045	163,924	47,538	594,225	430,300	26,741

The Volume of gas storage chamber is shown in table 4.13 below:

Table 4.13: Volume of gas storage chamber.

Animal	biogas (m^3/day)	V_{gs}(m^3)
Cattle	8,544	2,848
Sheep & goats	2,427	2,427
Layers, broilers &turkey	37,750	4,720

Number of digester and the dimensions is shown in table 4.14 below:

Table 4.14: number of digesters needed in Nablus.

Animal	Number of digesters	Diameter(m)	H_f(m)	H_{vg}(m)
Cattle	4	25	8.5	4.5
Sheep & goats	6	25	9	2.5
Layers, broilers &turkey	8	25	7	4

For cattle, a gas storage chamber will discharge the biogas every 8 hours to the gas storage, the same is needed for layers, broilers and turkey with a periodic time of 3 hours to discharge the biogas.

In Nablus city the methane gas production expected is 28,808.2m^3/h, which is produce a 60.2MWh of electricity.

Three stations will be built with a total power of 60.2 MWh, ten gas engines with the capacity of 2MW will be used for each station.

Regarding to the location of the stations in Nablus city, we assume them to be near Zwata and Der Sharaf areas, which are shown in figure 14 below:

Figure 14: location of biogas station in Nablus city

5) Qalqiliya city:

The Volume of fermentation chamber is shown in table 4.15 below:

Table 4.15: Volume of fermentation chamber.

Animal	heads at Qalqiliya	Manure (kg/day)	Total Manure (kg/day)	FD (kg)	The total influent (Q)	Water (kg)	V_d (m^3)
Cattle	2916	22.5	65610	16403	205031	139421	9226
Sheep & goats	28456	1.6	45529	11382	142280	96750	6403
Layers, broilers &turkey	2793836	0.045	125723	36456	455744	330021	20509

The Volume of gas storage chamber is shown in table 4.16 below:

Table 4.16: Volume of gas storage chamber.

Animal	biogas (m^3/day)	V_{gs}(m^3)
Cattle	4,920	2,460
Sheep & goats	594	594
Layers, broilers &turkey	28,802	4,800

Number of digester and the dimensions is shown in table 4.17 below:

Table 4.17: number of digesters needed in Qalqiliya.

Animal	Number of digesters	Diameter(m)	H_f(m)	H_{vg}(m)
Cattle	6	22	5	3.5
Sheep & goats	2	25	7	2
Layers, broilers &turkey	9	24	5	4

For Cattle, a gas storage chamber will discharge the biogas every 12 hours to the gas storage, the same is needed for layers, broilers and turkey with a periodic time of 4 hours to discharge the biogas.

In Qalqiliya. City the methane gas production expected is 20,542m^3/h, which is produce a 44MWh of electricity.

Two stations will be built with a total power of 44 MWh, 11-gas engine with the capacity of 2MW will be used for each station.

Regarding to the location of the stations in Qalqiliya city, we assume them to be in south of Jayus region, which are shown in figure 15 below:

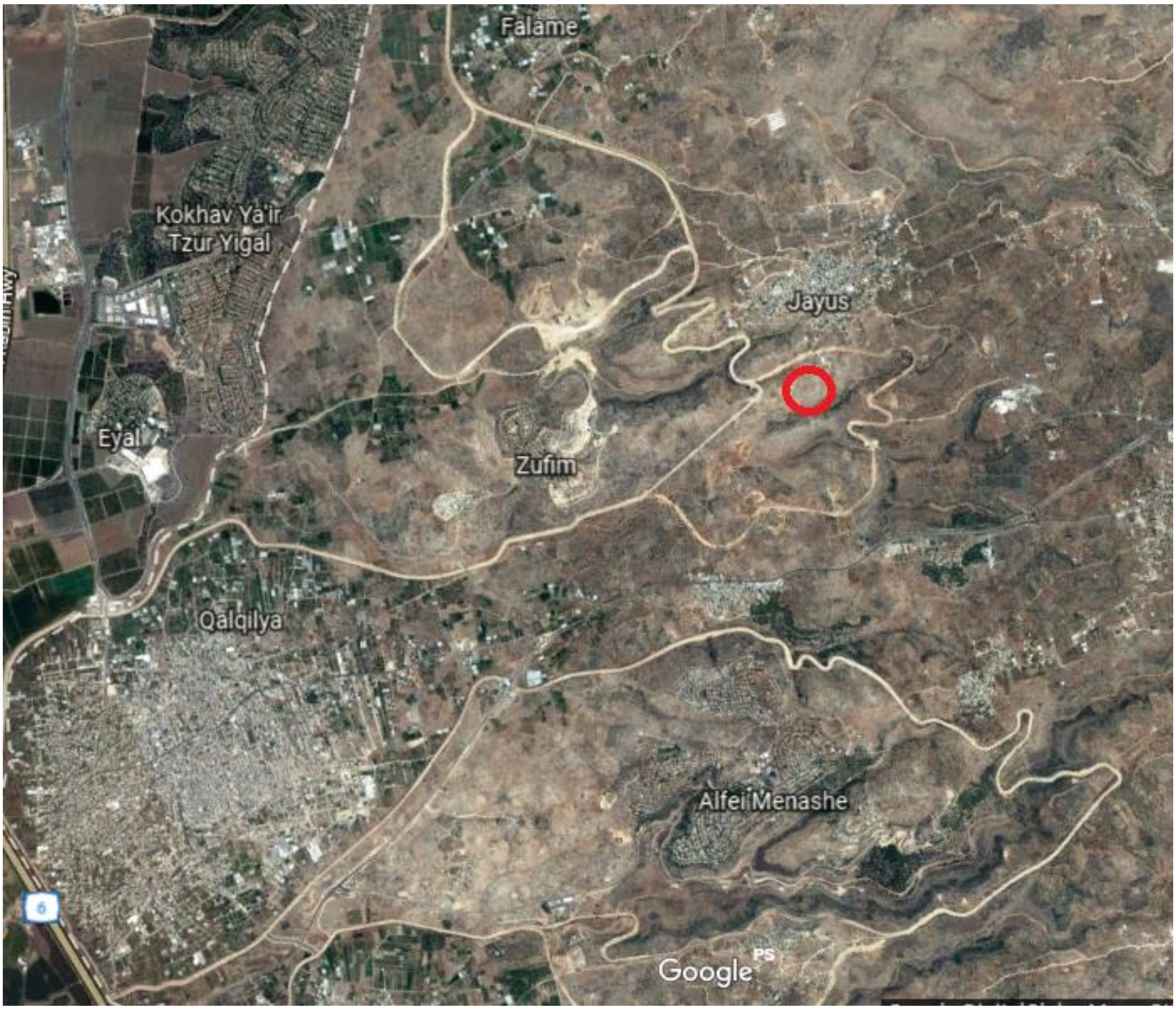

Figure 15: location of biogas station in Qalqiliya city

6) Salfit city:

The Volume of fermentation chamber is shown in table 4.18 below:

Table 4.18: Volume of fermentation chamber.

Animal	heads at Salfit	Manure (kg/day)	Total Manure (kg/day)	FD (kg)	The total influent (Q)	Water (kg)	V_d (m^3)
Cattle	466	22.5	10,485	2,621	32,766	22,281	1,475
Sheep & goats	16,023	1.6	25,637	6,409	80,115	54,478	3,605
Layers, broilers &turkey	441,005	0.045	19,845	5,755	71,939	52,094	3,237

The Volume of gas storage chamber is shown in table 4.19 below:

Table 4.19: Volume of gas storage chamber.

Animal	biogas (m^3/day)	V_{gs}(m^3)
Cattle	787	394
Sheep & goats	334	334
Layers, broilers &turkey	4,559	2,280

Number of digester and the dimensions is shown in table 4.20 below:

Table 4.20: number of digesters needed in Salfit.

Animal	Number of digester	Diameter(m)	H_f(m)	H_{vg}(m)
Cattle	1	20	5	4
Sheep & goats	1	25	8	2.5
Layers, broilers &turkey	4	25	5	3.5

For cattle, a gas storage chamber will discharge the biogas every 12 hours to the gas storage, the same is needed for layers, broilers and turkey with a periodic time of 12 hours to discharge the biogas.

In Salfit city the methane gas production expected is 3355.9m^3/h, which is produce a 7.5MWh of electricity.

One station will be built with a total power of 7.5MWh, 4 gas engines with the capacity of 2MW will be used.

Regarding to the location of the station in Salfit city, we assume it to be near Ein Al-Matwi region, which is shown in figure 16 below:

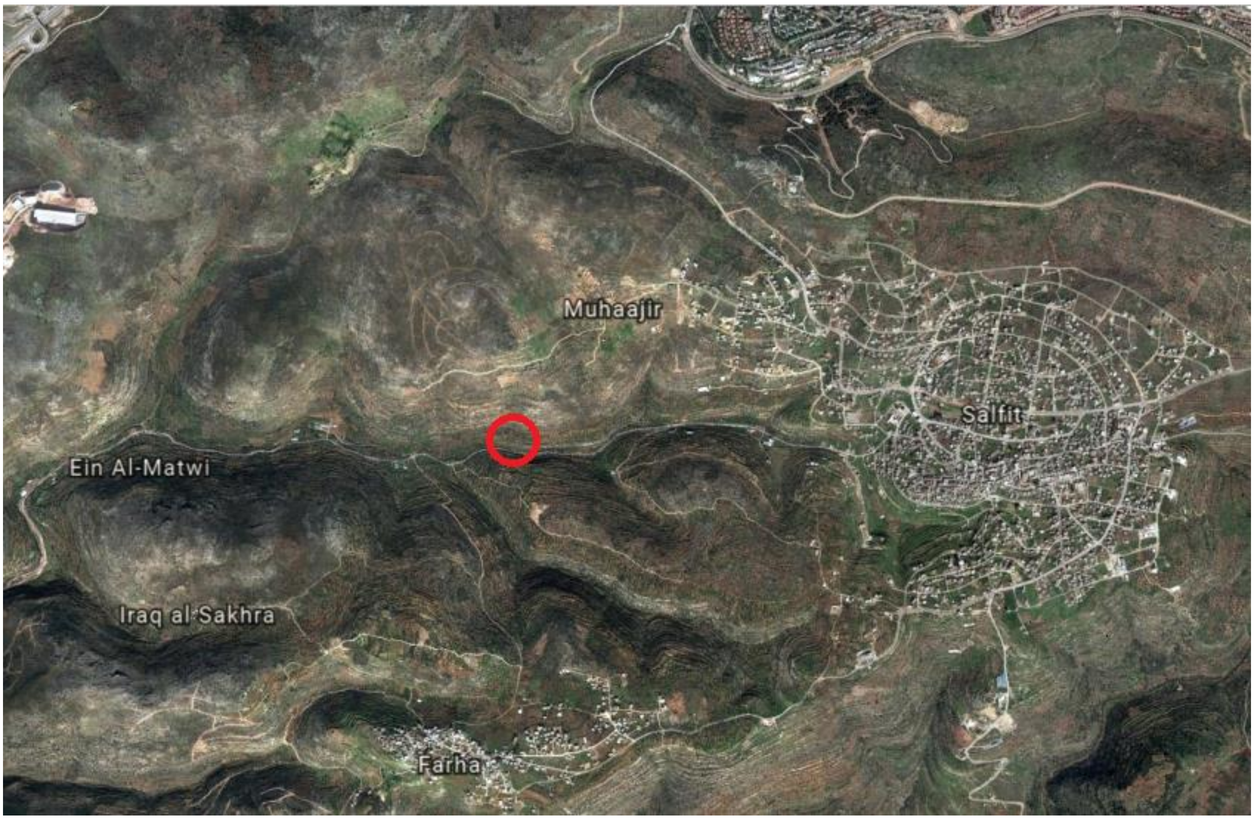

Figure 16: location of biogas station in Salfit city

7) Ramallah and al Bireh city:

The Volume of fermentation chamber is shown in table 4.21 below:

Table 4.21: Volume of fermentation chamber.

Animal	heads at Ramallah and al Bireh	Manure (kg/day)	Total Manure (kg/day)	FD (kg)	The total influent (Q)	Water (kg)	V_d (m^3)
Cattle	490	22.5	11,025	2,757	34,453	23,428	1,600
Sheep & goats	65,790	1.6	105,264	26,316	328,950	223,683	14,810
Layers, broilers &turkey	2,466,527	0.045	110,994	32,189	402,354	291,360	18,106

The Volume of gas storage chamber is shown in table 4.22 below:

Table 4.22: Volume of gas storage chamber.

Animal	biogas (m^3/day)	V_{gs}(m^3)
Cattle	834	834
Sheep & goats	1,370	1,370
Layers, broilers &turkey	25,500	4,250

Number of digester and the dimensions is shown in table 4.23 below:

Table 4.23: number of digesters needed in Ramallah and al Bireh.

Animal	Number of digesters	Diameter(m)	H_f(m)	H_{vg}(m)
Cattle	2	20	3	4
Sheep & goats	3	25	10	3
Layers, broilers &turkey	6	25	7	4.5

For layers, broilers and turkey, a gas storage chamber will discharge the biogas every 4 hours to the gas storage.

In Ramallah and al Bireh city the methane gas production expected is 16,410m^3/day, which is produce a 34.3MWh of electricity.

One station will be built with a total power of 34.4 MWh, 17 gas engines with the capacity of 2MW will be used for the station.

Regarding to the location of the station in Ramallah and al Bireh city, we assume it to be near Der Abu Mash'al region, which is shown in figure 17 below:

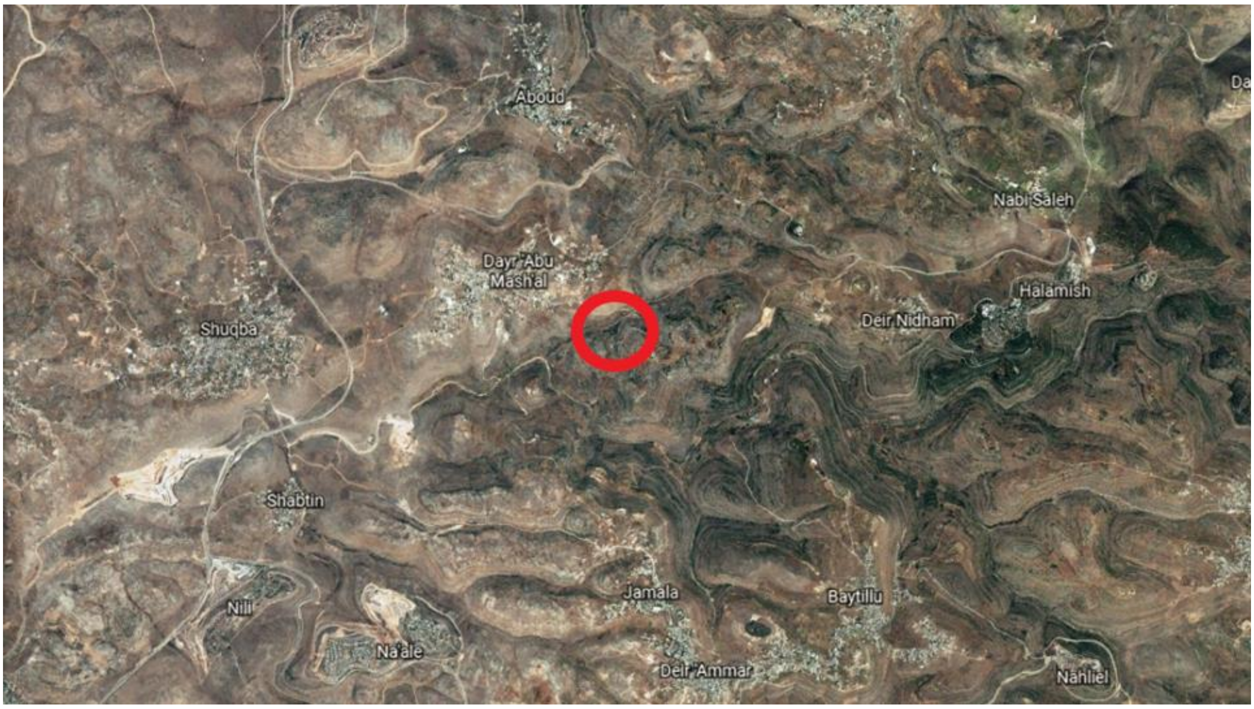

Figure 17: location of biogas station in Ramallah and al Bireh city

8) Jericho & Al- Aghwar city:

The Volume of fermentation chamber is shown in table 4.24 below:

Table4.24: Volume of fermentation chamber.

Animal	heads at Jericho & Al- Aghwar	Manure (kg/day)	Total Manure (kg/day)	FD (kg)	The total influent (Q)	Water (kg)	V_d (m^3)
Cattle	709	22.5	15,953	3,988	49,853	33,900	2,243
Sheep & goats	71,611	1.6	114,578	28,645	358,056	243,478	16,113
Layers, broilers &turkey	180,848	0.045	8,139	2,360	29,500	21,363	1,328

The Volume of gas storage chamber is shown in table 4.25 below:

Table 4.25: Volume of gas storage chamber.

Animal	biogas (m^3/day)	V_{gs}(m^3)
Cattle	1,196	598
Sheep & goats	1,490	1,490
Layers, broilers &turkey	1,869	467

Number of digester and the dimensions is shown in table 4.26 below:

Table 4.26: number of digesters needed in Jericho & Al- Aghwar.

Animal	Number of digesters	Diameter(m)	H_f(m)	H_{vg}(m)
Cattle	1	25	5	4
Sheep & goats	4	25	8.5	3
Layers, broilers &turkey	1	20	5	4.5

For layers, broilers and turkey, a gas storage chamber will discharge the biogas every 8 hours to the gas storage.

In Jericho & Al- Aghwar city the methane gas production expected is 2,510m^3/h which produce a 5.25MWh of electricity.

For this city, one station will be built with a total power of 5.25 MWh, two gas engines with the capacity of 2MW and one gas engine with the capacity of 1.2MW will be used for the station.

Regarding to the location of the station in Jericho & Al- Aghwar city, we assume it to be near Nu’iema region, which is shown in figure 18 below:

Figure 18: location of biogas station in Jericho & Al- Aghwar city

9) Jerusalem city:

The Volume of fermentation chamber is shown in table 4.27 below:

Table 4.27: Volume of fermentation chamber.

Animal	heads at Jerusalem	Manure (kg/day)	Total Manure (kg/day)	FD (kg)	The total influent (Q)	Water (kg)	V_d (m^3)
Cattle	265	22.5	5963	1491	18633	12670	838
Sheep & goats	46737	1.6	74779	18694	233685	158906	10516
Layers, broilers &turkey	110550	0.045	4975	1443	18034	13059	812

The Volume of gas storage chamber is shown in table 4.28 below:

Table 4.28: Volume of gas storage chamber.

Animal	biogas (m^3/day)	V_{gs}(m^3)
Cattle	411	206
Sheep & goats	973	973
Layers, broilers &turkey	1,140	570

Number of digester and the dimensions is shown in table 4.29 below:

Table 4.29: number of digesters needed in Jerusalem.

Animal	Number of digesters	Diameter(m)	H_f(m)	H_{vg}(m)
Cattle	1	15	5	3.5
Sheep & goats	3	24	8	2.5
Layers, broilers &turkey	2	20	3	3

For Cattle, a gas storage chamber will discharge the biogas every 12 hours to the gas storage, the same is needed for layers, broilers and turkey with a periodic time of 12 hours to discharge the biogas.

In Jerusalem city the methane gas production expected is 1389m^3/h, which is produce a 2.9MWh of electricity.

One station will be built with a total power of 2.9MWh, one gas engine (avus 2000 gas engine) with the capacity of 2MW will be used and one gas engine with the capacity of 1.2MW will be used for the station.

Regarding to the location of the station in Jerusalem city, we assume it to be in Jabal Al-Zaytoun region, which is shown in figure 19 below:

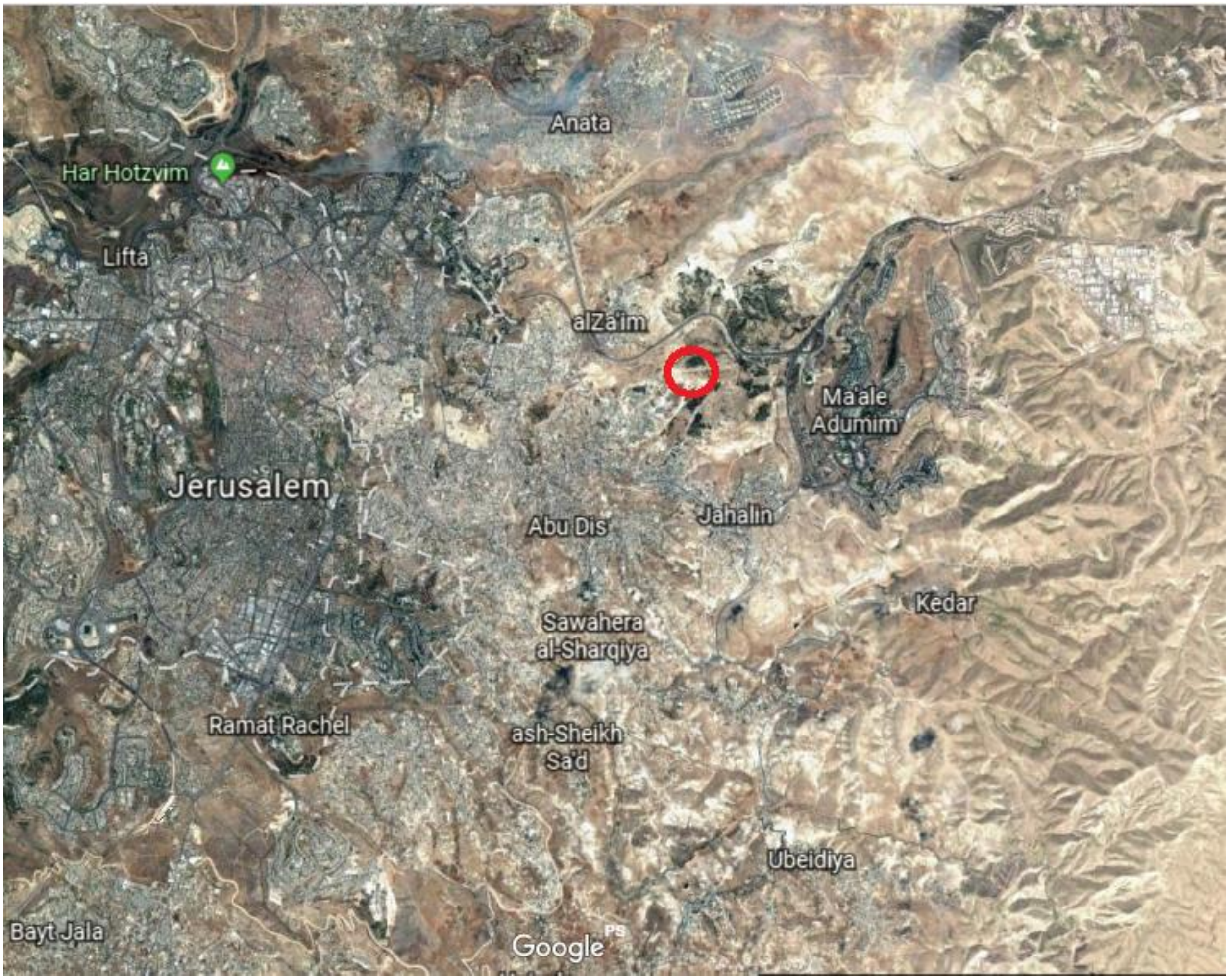

Figure 19: location of biogas station in Jerusalem city

10) Bethlehem city:

The Volume of fermentation chamber is shown in table 4.30 below:

Table 4.30: Volume of fermentation chamber.

Animal	heads at Bethlehem	Manure (kg/day)	Total Manure (kg/day)	FD (kg)	The total influent (Q)	Water (kg)	V_d (m^3)
Cattle	716	22.5	16,110	4,028	50,344	34,234	2,266
Sheep & goats	102,199	1.6	163,519	40,880	510,997	347,477	22,995
Layers, broilers &turkey	1,090,060	0.045	49,053	14,226	177,817	128,764	8,002

The Volume of gas storage chamber is shown in table 4.31 below:

Table 4.31: Volume of gas storage chamber.

Animal	biogas (m^3/day)	V_{gs}(m^3)
Cattle	1,209	605
Sheep & goats	2,172	2,172
Layers, broilers &turkey	11,267	1,409

Number of digester and the dimensions is shown in table 4.32 below:

Table 4.32: number of digesters needed in Ramallah and al Bireh.

Animal	Number of digesters	Diameter(m)	H_f(m)	H_{vg}(m)
Cattle	1	25	5	4
Sheep & goats	6	25	8	2.5
Layers, broilers &turkey	2	25	8.5	4.5

For Cattle, a gas storage chamber will discharge the biogas every 12 hour to the gas storage, the same is needed for layers, broilers and turkey with a periodic time of 3 hour to discharge the biogas.

In Bethlehem city the methane gas production expected is 8,442m^3/day, which is produce a 17.6MWh of electricity.

One station will be built with a power of 17.6 MWh, 9-gas engines with the capacity of 2MW will be used for the station.

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Regarding to the location of the station in Bethlehem city, we assume it to be near Za’tara region, which is shown in figure 20 below:

Figure 20: location of biogas station in Bethlehem city

11) Hebron city:

The Volume of fermentation chamber is shown in table 4.33 below:

Table4.33: Volume of fermentation chamber.

Animal	heads at Hebron	Manure (kg/day)	Total Manure (kg/day)	FD (kg)	The total influent (Q)	Water (kg)	V_d (m^3)
Cattle	5,252	22.5	118,170	29,543	369,282	251,112	16,620
Sheep & goats	229,666	1.6	367,466	91,867	1,148,332	780,866	51,675
Layers, broilers &turkey	4,938,100	0.045	222,215	64,443	805,530	583,315	36,250

The Volume of gas storage chamber is shown in table 4.34 below:

Table 4.34: Volume of gas storage chamber.

Animal	biogas (m^3/day)	V_{gs}(m^3)
Cattle	8,836	2,216
Sheep & goats	4,778	4,778
Layers, broilers &turkey	51,035	6,380

Number of digester and the dimensions is shown in table 4.35 below:

Table 4.35: number of digesters needed in Hebron.

Animal	Number of digesters	Diameter(m)	H_f(m)	H_{vg}(m)
Cattle	4	25	8	4
Sheep & goats	11	25	9.5	3
Layers, broilers &turkey	9	25	8.5	4.5

For Cattle, a gas storage chamber will discharge the biogas every 6 hour to the gas storage, the same is needed for layers, broilers and turkey with a periodic time of 3 hour to discharge the biogas.

The methane gas produced per hour, in Hebron city the methane gas production expected is 38,088m^3/h that is produce a 79.6MWh of electricity.

Due to the large area needed for the station, four stations will be built with a total power of 79.6 MWh, ten gas engines with the capacity of 2MW will be used for each station.

Regarding to the location of the stations in Hebron city, we assume them to be in ad-Dhahiriya region, Khursa region, Dura region and Idhna region, which are shown in figure 21,22 and 23 sequentially below:

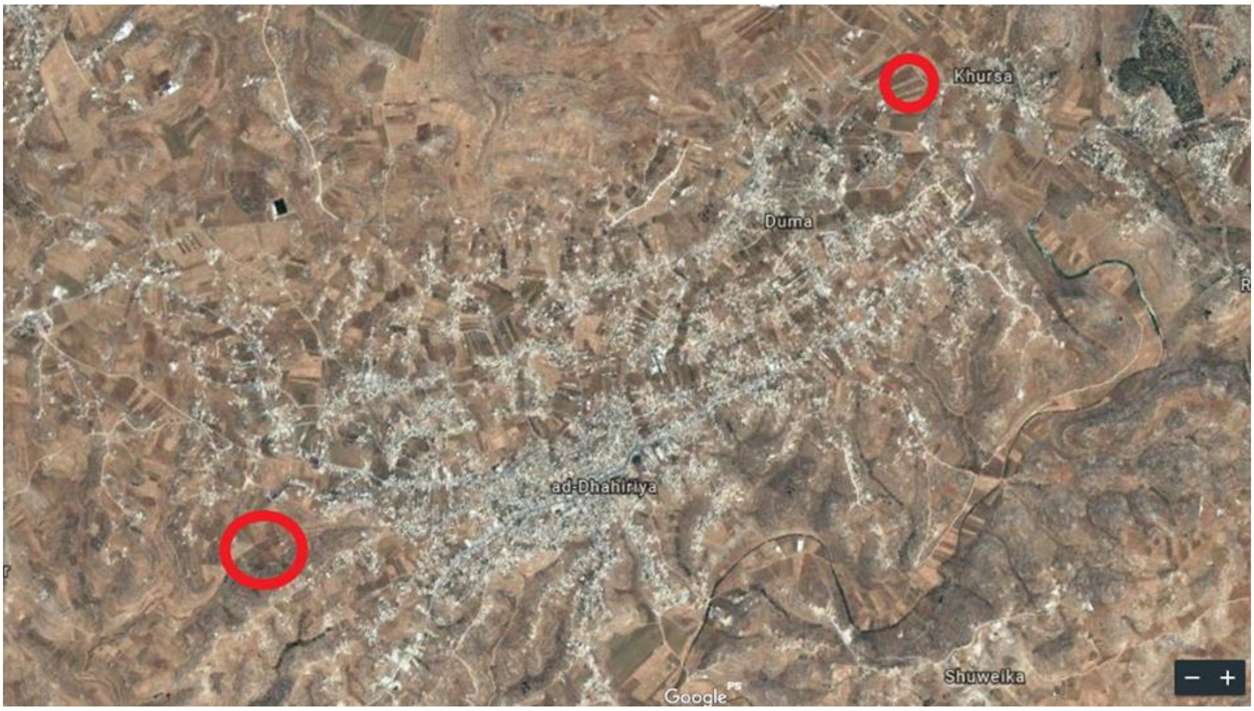

Figure 21: location of the first and second biogas stations in Hebron city

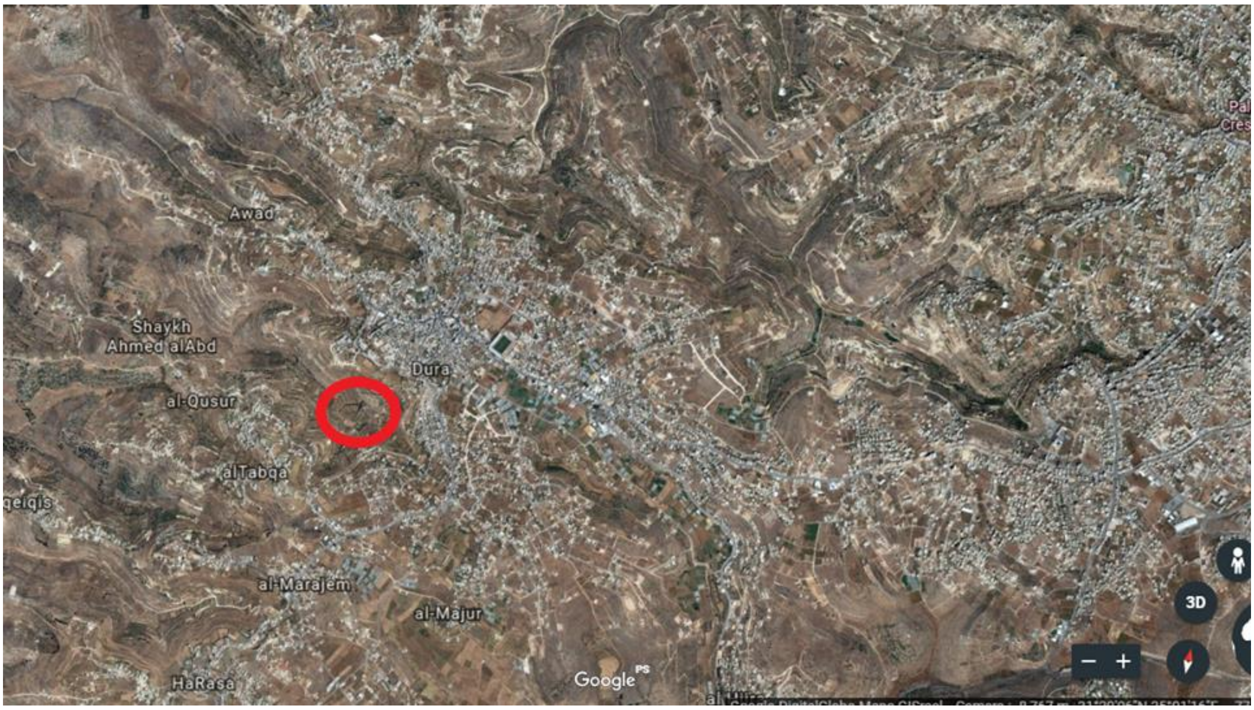

Figure 22: location of the third biogas station in Hebron city

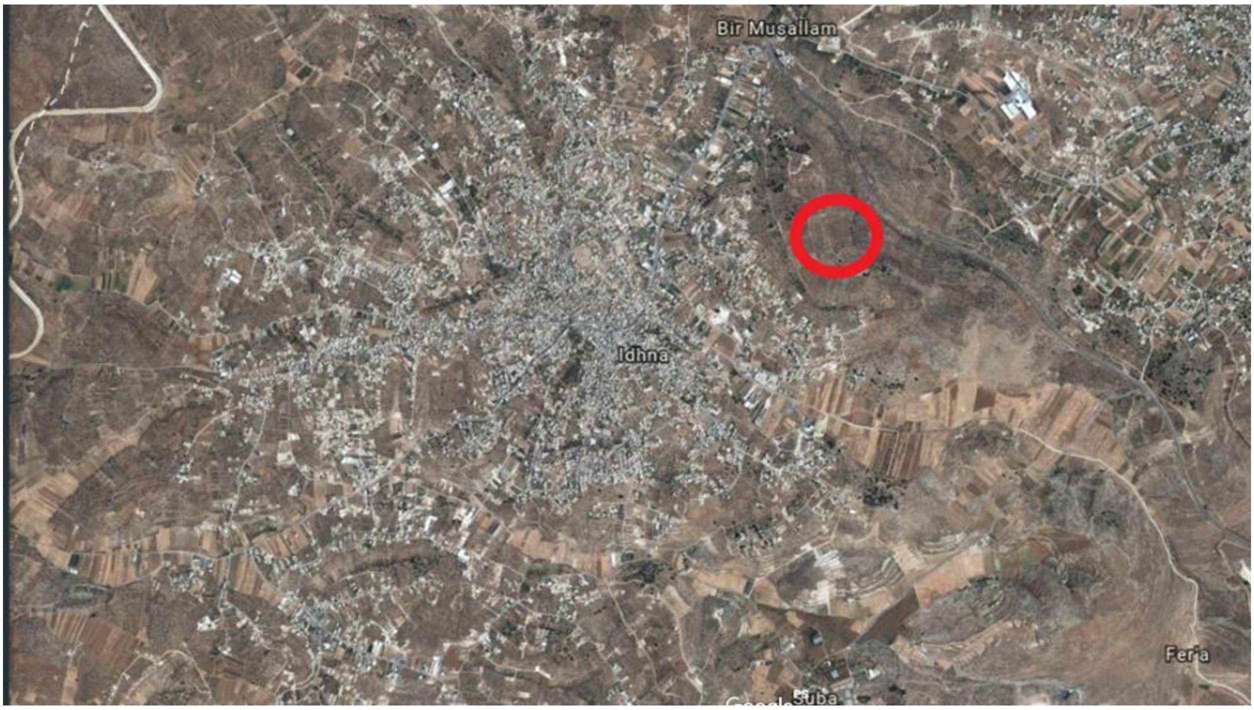

Figure 23: location of the fourth biogas station in Hebron city

12) Gaza city:

The Volume of fermentation chamber is shown in table 4.36 below:

Table 4.36: Volume of fermentation chamber.

Animal	heads at Gaza	Manure (kg/day)	Total Manure (kg/day)	FD (kg)	The total influent (Q)	Water (kg)	V_d (m^3)
Cattle	1266	22.5	28485	7121	89016	60531	4006
Sheep & goats	14644	1.6	23430	5857	73220	49790	3295
Layers, broilers &turkey	407649	0.045	18344	5320	66498	48154	2992

The Volume of gas storage chamber is shown in table 4.37 below:

Table 4.37: Volume of gas storage chamber.

Animal	biogas (m^3/day)	V_{gs}(m^3)
Cattle	2134	1072
Sheep & goats	305	305
Layers, broilers &turkey	4212	2105

Number of digester and the dimensions is shown in table 4.38 below:

Table 4.38: number of digesters needed in Gaza.

Animal	Number of digesters	Diameter(m)	H_f(m)	H_{vg}(m)
Cattle	2	25	5	3.5
Sheep & goats	1	24	8	2.5
Layers, broilers &turkey	4	25	5	3.5

For cattle, a storage chamber will discharge the biogas every 12 hours to the gas storage, the same is needed for layers, broilers and turkey with a periodic time of 12 hours to discharge the biogas.

In Gaza city the methane gas production expected is 3945m^3/day, which is produce an 8MWh of electricity.

One station will be built with a power of 8 MWh, 4-gas engines with the capacity of 2MW will be used for the station.

Regarding to the location of the station in Gaza city, we assume it to be in Beit Hanoun region, which is shown in figure 24 below:

Figure 24: location of the fourth biogas station in Gaza city

Conclusion:

increase in the number of animals in the West Bank and Gaza Strip farms, and their production of large amounts of animal manure, this animal manure contributes to the production of large quantities of biogas, which in turn helps in the production of electric power, this project has been working on the designing of biogas stations in west bank cities and Gaza city, to produce electricity with the help of Biogas. Where the calculations showed that the amount of biogas produced from animal manure is equal to 155.77 (million m3 / year), thus the amount of electric energy that can be produced is 520 MWh, which help to cover the shortage in electricity in these areas.

References:

[1] P. Abdeshahian, J. S. Lim, W. S. Ho, H. Hashim, and C. T. Lee, "Potential of biogas production from farm animal waste in Malaysia," *Renewable and Sustainable Energy Reviews,* vol. 60, pp. 714-723, 2016/07/01/ 2016.

[2] P. J. A. m. Weiland and biotechnology, "Biogas production: current state and perspectives," vol. 85, no. 4, pp. 849-860, 2010.

[3] M. Abdallah, A. Shanableh, M. Adghim, C. Ghenai, and S. Saad, "Biogas production from different types of cow manure," in *2018 Advances in Science and Engineering Technology International Conferences (ASET)*, 2018, pp. 1-4.

[4] M. Arshad *et al.*, "Electricity generation from biogas of poultry waste: An assessment of potential and feasibility in Pakistan," *Renewable and Sustainable Energy Reviews,* vol. 81, pp. 1241-1246, 2018/01/01/ 2018.

[5] I. L. Moreda, "The potential of biogas production in Uruguay," *Renewable and Sustainable Energy Reviews,* vol. 54, pp. 1580-1591, 2016/02/01/ 2016.

[6] B. Igliński, R. Buczkowski, and M. Cichosz, "Biogas production in Poland—Current state, potential and perspectives," *Renewable and Sustainable Energy Reviews,* vol. 50, pp. 686-695, 2015/10/01/ 2015.

[7] M. Al-Maghalseh and W. Saleh, "Design and cost analysis of biogas based power plant: Jenin perspective," in *2017 14th International Conference on Smart Cities: Improving Quality of Life Using ICT & IoT (HONET-ICT)*, 2017, pp. 31-35.

[8] A. O. Avcioğlu and U. Türker, "Status and potential of biogas energy from animal wastes in Turkey," *Renewable and Sustainable Energy Reviews,* vol. 16, no. 3, pp. 1557-1561, 2012/04/01/ 2012.

[9] H. Afazeli, A. Jafari, S. Rafiee, and M. Nosrati, "An investigation of biogas production potential from livestock and slaughterhouse wastes," *Renewable and Sustainable Energy Reviews,* vol. 34, pp. 380-386, 2014/06/01/ 2014.

[10] A. Perez Garcia, "Techno-economic feasibility study of a small-scale biogas plant for treating market waste in the city of El Alto," Independent thesis Advanced level (degree of Master (Two Years)) Student thesis, 2014.

[11] S. E. Hosseini and M. A. Wahid, "Development of biogas combustion in combined heat and power generation," *Renewable and Sustainable Energy Reviews,* vol. 40, pp. 868-875, 2014/12/01/ 2014.

[12] UNICEF, "Palestinian Central Bureau of Statistics " 2013.