An-Najah National University

Faculty of Graduate Studies

Environmental Impact Assessment of Centralized and Decentralized Biogas Power Plants in Palestine

By

Ruba Ahmad Hasan Alia

Supervisor

Dr. Abdelrahim Abusafa

Co-Supervisor

Prof. Amer El-Hamouz

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This thesis was defended successfully on 31/01 /2017 and approved by:

Defense committee Members	**Signature**
– **Dr. Abdelrahim Abusafa/Supervisor**	**…...…………….….. **
– **Prof. Amer El-Hamouz/Co-Supervisor**	**……………...…… **
– **Dr. Mahmoud Salah /External Examiner**	**………………...… **
– **Dr. Husni Odeh /Internal Examiner**	**………………...… **

Dedication

To my parents

To my husband

To my daughter

To my brother and sister

To my family

To all friends and colleagues

To all of them

I dedicate this work

Acknowledgment

I would like to take the opportunity to thank all people who spent their time and shared their knowledge for helping me to complete my thesis with the best possible result. To begin with, my special thanks to Dr. Abdelrahim Abusafa, direct supervisor for his continued support, complete cooperation and distinguish supervision throughout the whole course of this study. I wish to express my gratitude to my Prof. Amer El-Hamouz who participated as the second supervisor of this study for his valuable suggestions, assistance, and for his great and continuous effort in helping me at all stages of this study.

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Thank you

الإقرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان

Environmental Impact Assessment of Centralized and Decentralized Biogas Power Plants in Palestine

أقر بأن ما شملت عليه الرسالة هو نتاج جهدي الخاص، باستثناء ما تمت الإشارة إليه حيثما ورد، وأن هذه الرسالة ككل أو أي جزء منها لم يقدم من قبل لنيل أي درجة أو لقب علمي أو بحثي لدى أي مؤسسة علمية أو بحثية.

Declaration

The work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degrees or qualifications.

Student's Name: **اسم الطالب: ربا احمد حسن عليا**

Signature: **التوقيع:**

Date: **التاريخ:2017/01/31**

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List of symbols

€	Euro = 4.2 NIS
C	Cost (NIS)
CV	calorific value (MJ/m^3)
D	Distance (km)
E	Electrical Energy (kWh)
i	Annual interest rate (% /year)
n	project estimated useful life [years]
P	Power (kW)
T	Temperature (°C)
V_d	Volume of digester (m^3)
V_g	Volume of biogas
W	Wight (kg)
η	Efficiency

List of abbreviations

AW	Annual Worth
AWt	Annual Worth with transportation
CH4	Methane
CO2	Carbon dioxide
EIA	Environmental Impact Assessment
DM	Dry Matter
EQA	Environmental Quality Authority
HRT	Hydraulic Retention Time
IEC	Israel Electric Corporation
JSC	Joint Service Council Regulations
kWh	Kilo watt hour
LPG	Liquid petroleum gas
MOA	Ministry of Agriculture
MOH	Ministry of Health
NEAP	National Environmental Action Plan
MT	Metric Ton
O&M	Operation and maintenance
PA	Palestinian Authority
OTS	Organic (volatile) of total solid
PCBS	Palestinian Central Bureau of Statistics
PEAP	Palestinian Environmental Assessment Policy
PH	power of hydrogen (acidity degree value)
PLC	Palestinian legislative council
PW	Present Worth
PWA	Palestinian Water Authority
PWL	Palestinian Labor Ministry
RT	Retention time
P.B.P	payback period
Sd	daily substrate input rate ,
TS	Total Solid
VFAs	Volatile fatty acids

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Abstract

Biogas production by biodigestion is considered as an important method for the production of renewable energy. One of the most important methods in utilization biogas is the production of electrical energy by means of special generators. In West Bank, there are a lot of animals such as cattle, goats, sheep and poultry. These animals produce a huge amount of dung which can be anaerobically digested and produces what is called biogas.

In order to estimate the amount of electrical energy that can be generated from biogas produced by the biodigestion of animal dung, many statistical data were collected according to the type and number of animals and the mass of daily manure production. This was done for most villages in ten governorates in West Bank.

This research is aimed at studying the economic feasibility and environmental impact assessment for electrical energy production from biogas plants. After the calculation of annual waste production in each village, the biodigester volume, the capacity of electrical generator and the potential of production electrical energy were calculated. Consequently, Annual Worth (AW) was calculated. Moreover, the Levelized Cost of Energy (LCoE) was calculated. For profitable and environmentally friendly production, the selling price for one kWh of electricity is considered to be 0.3 NIS in order to compete with Israel electrical company which sells electricity for local electricity distribution companies by 0.4 NIS /kWh.

To guarantee short payback period, it was found that biodigesters of volume less than 100m^3 were infeasible.

Since the levelized cost of energy depends directly on the volume of the biodigeter, the design of centralized biogas stations were investigated. The proposed methods depends on collecting the manure from all nearby villages and construct a single centralized biodigester for each clusters at one of the villages taking in consideration the environmental impacts and the feasibility. It was obvious that all of proposed centralized biogas power plant is feasible from economical aspects with shorter payback period than decentralized biogas power plant.

It was also found that from environmental impact assessment that centralized biogas power plant is better from social and environmental aspects.

Based on the results of this study, it was found that the proposed Hebron governorate biogas power plant has the largest amount of biogas production from all governorates, which has 45,670 m^3 daily biogas production that is equivalent to annual electrical energy of 28.8GWh. The least biogas production was found to be in Salfeet governorate, with a daily biogas production of 2,860 m^3 which is equivalent to annual electrical energy of 2GWh.

Potential electrical energy production is estimated to be 2% of total energy consumption in west bank.

In the case of proper utilization of these bioenergy sources, it is expected to minimize the amount of greenhouse emissions equivalent to 100,000 ton CO_2 which may produced from the same amount from the production of electrical energy from coal.

Chapter One

Introduction

Chapter One

Introduction

Energy is one of the most important factors to global prosperity. The dependence on fossil fuels as primary energy source has lead to global climate change, environmental degradation, human health problems, and infrastructure problems. Moreover, the recent rise in oil and natural gas prices leads to search for alternative energy sources such as renewable energy.

Renewable energy has different types and can be found in different forms, for instance, wind energy, solar energy, hydroelectric energy, biomass energy. But we have problems with the availability of wind and water in Palestine, and the high cost of solar energy, therefore these sources are not available in Palestine. Redundant biomass can be considered a good source of producing energy usage, this biomass can reduce the volume of generated wastes that should be disposed off with more positive impacts on our health, economy and our environment in general. Biogas production in Palestine is still not mature as biogas technology application started in from some rural areas, these initiatives are carried out on family level where animals and agricultural wastes are available. One of the problems facing biomass energy production is that biomass waste spread all over the country and also the high cost of building power plants [1].

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Additionally and according to Palestinian Environmental Quality Authority (EQA), construction of biogas power plant required an environmental impact assessment.

In this thesis, theoretical study of the use of manure from animals waste to produce electrical using biogas digesters will be studied.

The environmental impacts of producing electricity from all exiting animal farms in all Palestinian governorates were studied in terms economy and environmentally. Centralized and decentralized biogas digester plant concepts were used.

The main objectives for this research are:

- Collect necessary data related the number of animals and amount of animals waste.
- Calculate the biogas and possible energy production rates.
- Calculate the volume of digester and apply cost analysis of biogas plants for both centralized and decentralized plants.
- Perform or brief Environmental Impact Assessment for the construction of biogas plants.

Chapter Two

Biomass Technology

Chapter Two

Biomass Technology

2.1 Introduction

The biomass resource can be considered as organic matter, in which the energy of sunlight is stored in chemical bonds. When the bonds between adjacent carbon, hydrogen and oxygen molecules are broken by digestion, combustion, or decomposition, these substances release their stored, chemical energy. Biomass has always been a major source of energy for mankind and is presently estimated to contribute of the order 10–14% of the world's energy supply [2].

2. 2 Biogas Technology History

Evidence of biogas-use can be found in ancient civilizations. Anecdotal evidence indicates that biogas was used for heating bath water in Assyria during the 10th century BC. Marco Polo, in the 13th century AD, discovered people in China using covered sewage tanks to generate heat. In the 17th century, Jan Baptita Van Helmont determined that decaying organic matter produced flammable gas. Additionally, in 1808 Sir Humphrey Davy discovered that methane was present in the gases produced in cattle manure piles [3].

. In Arab countries the applying of biogas plants started in 1970s in Egypt, Morocco, Sudan and Algeria while it began in 1980s in other Asian Arab countries as Iraq, Jordan and Yemen In Egypt there were 18 family biogas plants and 2 farm plants built in 1998 . Palestine has different types of plant products that can be used as energy sources. The main type of these products is the reject of olive oil pressers waste called jefit which is used in household for heating in winter. Another more important energy material is animal dung [4].

The number of biogas plants in Arab countries is very small in compared with other countries. For example; digesters spreading vital heavily in China and approached the 4.5 million digesters, China has the largest biogas program in the world. Then India came second with a total of 200000 digesters [5].

According to the California Energy Commission web site, California produces about 60 million tons of biomass in 2006, which means around 2000MW of electrical power [6].

In the USA, Canada, and Western Europe anaerobic digestion has been used mainly for processing animal manure till the mid-1970s. The advancements in high rate anaerobic digesters began with the introduction of anaerobic filter in 1967.

The use of anaerobic digestion per million inhabitants in European countries in 2006 is shown in figure (2.1) [7].

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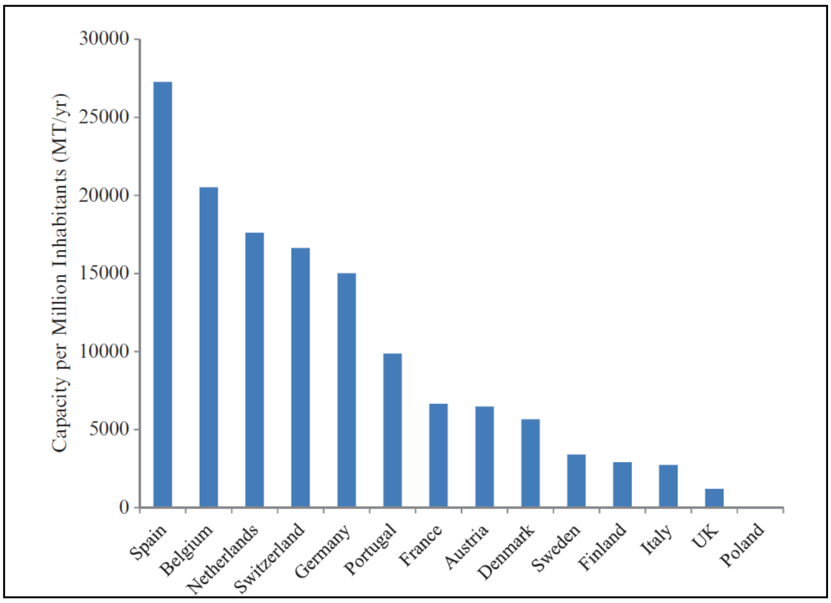


Figure (2. 1): Use of anaerobic digestion per million inhabitants in European countries for year of 2006 [6]

2.3 Composition of Biogas

Biogas technology is about capturing the gas that results from the aerobic fermentation of biomass. The plant uses the natural processes of anaerobic digestion to produce biogas to produce biogas from animal waste. Biogas is a mixture of gas produced by methanogenic. Bacteria while acting upon biodegradable materials in an anaerobic condition.

Biogas is a flammable gas produced by microbes when organic materials are fermented in a certain range of temperature and moisture content. Biogas is about 20% lighter than air and has ignition temperature in the range of 650 to 750 C^{o}. It is odorless and colorless gas that burns with clear blue flame similar to that of LPG gas.

Naturally occurring bacteria (methanogenic bacteria) produce biogas during digestion or fermentation of organic matter in the absence of oxygen (anaerobic process). The produced gas consists mainly of methane (CH_4) and carbon dioxide (CO_2). There are also traces of water vapor, hydrogen, nitrogen and hydrogen sulphide. Biogas is combustible if the methane content is more than 50%, Biogas from animal dung contains approximately 60% methane. Composition of Biogas is shown in Table (2.1).

Table (2. 1): Composition of Biogas [8, 9]

Composition of Biogas			
Gases	**Symbol**	**Percentage (%)**	**Gross Heating Value (kJ/kg)**
Methane	CH_4	50-70	55,510
Carbon dioxide	CO_2	25-30	0
Hydrogen	H_2	5-10	141,780
Nitrogen	N_2	1-2	0
Water vapor	H_2O	0.3	0

2.4 Biogas Production:

To ensure continuous gas production, the biogas plants shown schematically in Figure (2.2) must be fed daily with an ample supply of substrate, preferably in liquid and chopped or crushed form. The slurry is fed into the digester by way of the mixing pit [8] .

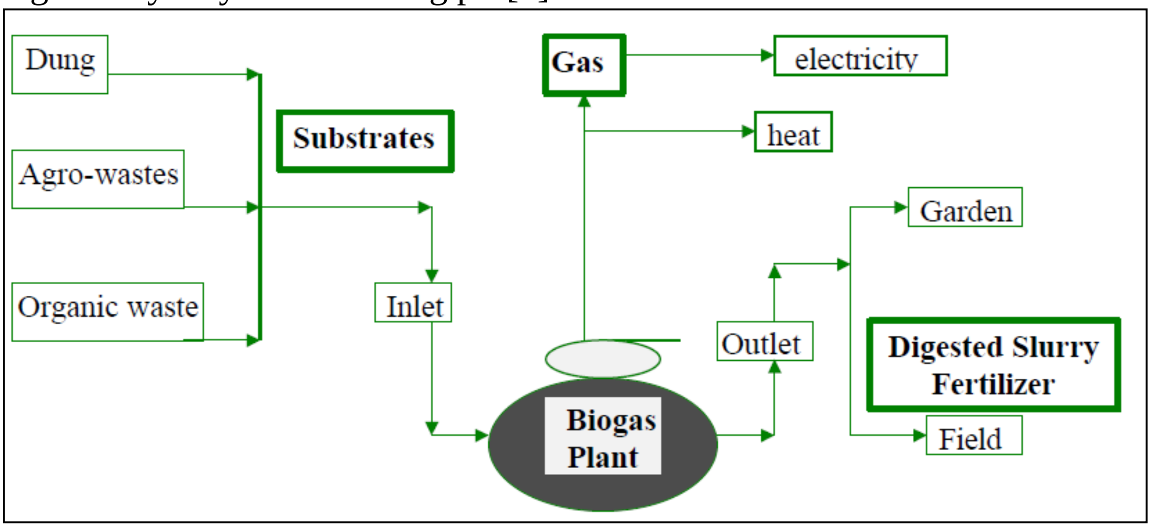


Figure (2. 2): biogas production process [8]

If possible, the mixing pit should be directly connected to the livestock housing by a manure gutter, in figure (2.3), the Schematic representation of the sustainable cycle of anaerobic co-digestion of animal manure and organic wastes. Carbon dioxide in the atmosphere is taken up by plants and converted, using solar energy through the process of photosynthesis, into organic compounds. Some of these organic compounds are then used as food by herbivores and humans, whose respiration returns CO_2 to the atmosphere. CO_2 is also returned to the atmosphere when carbon compounds are burned as fuel. Fossil fuels were formed as a result of photosynthesis millions of years ago.

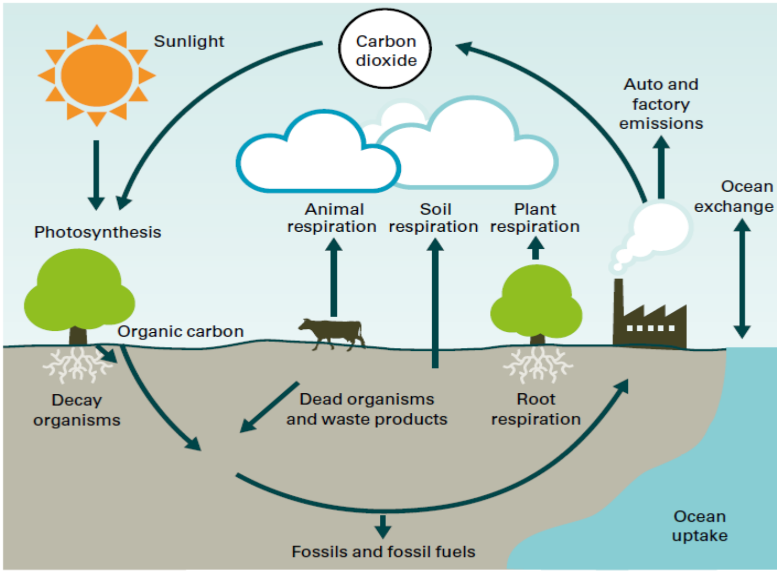


Figure (2. 3): Schematic representation of the sustainable cycle of anaerobic co-digestion of animal manure and organic wastes [10]

2.4.1 The Stages of Anaerobic Digestion

Anaerobic digestion consists of four stages:

- **Hydrolysis**: Enzymes break down and liquefy the smaller molecules and break down large polymers in the material.
- **Acidogenesis**: The products of the hydrolysis (soluble monomers) are fermented to volatile fatty acids (or VFAs) and alcohols.
- **Acetogenesis**: During the acetogenesis acetate is created from carbon and energy sources by acetogens. Acetogens splits biomass so that it could be used in methanogenesis process to create methane.
- **Methanogenesis**: the methanogenic bacteria convert acetic acid and hydrogen into CO_2 and methane.

These stages need to be managed early on in starting a digester, but if the process is properly maintained, methane production should require a minimum of chemical testing and treatment. Bacteria must do their work in the earlier stages to use up the oxygen in the material, and then break it down into volatile fatty acids and fermented alcohols, before the methanogenic bacteria can start to make methane, A schematic representation of these stages is shown in Figure (2.4) [11].

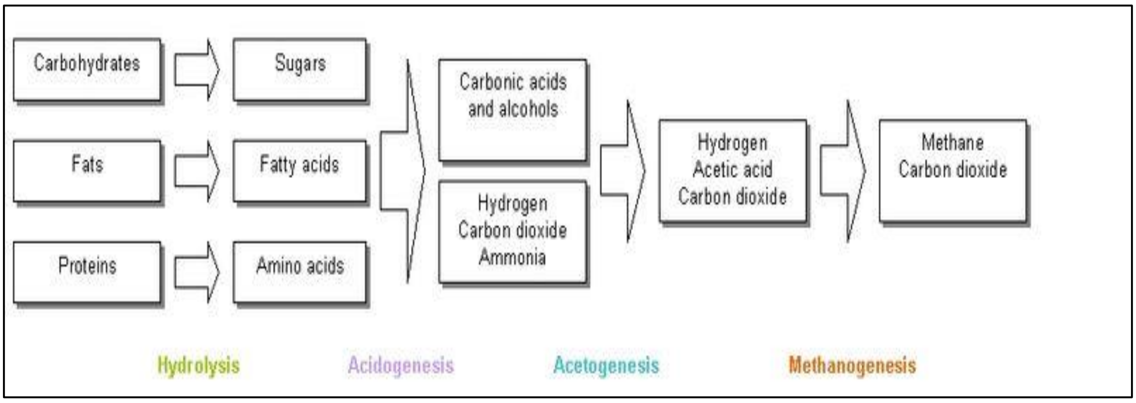


Figure (2. 4): The Stages of Anaerobic Digestion [12]

2.4.2 Factors Affecting Anaerobic Degradation:

There are several factors which may affect the anaerobic degradation of biodegradable materials. A short description of each is followed

2.4.1.1 PH Value

The pH of the digester is a function of the concentration of volatile fatty acids produced, bicarbonate alkalinity of the system, and the amount of carbon dioxide produced. The optimum range of pH for biogas production is between 7.0 and 7.2. But the substantial biogas can be produced for the pH range of 6.6 to 7.6. Biogas production reduces many fold for the pH value of less than 5 as the bacteria Population decrease significantly under the circumstances. [13].

2.4.2.2 Temperature

Temperature has the most pronounced impacts on anaerobic digestion. It has three main temperature ranges: from 10-25°C (psychrophilic conditions), from 30-37°C (mesophilic conditions) and from 48-55°C (thermophilic conditions). Psychrophilic digestion process is very slow hence only mesophilic and thermophilic digestion processes are used in practice. At very low or high temperature the activities of bacteria population is almost stopped consequently the digestion process becomes very long. Hence the production of biogas is reduced. The methane content becomes very low [13].

2.4.2.3 Loading Rate

The amount of raw materials fed per unit volume of digester or capacity per day is known as loading rate. It is important to optimize the loading rate in order to avoid overfeeding which leads to inhibited methane production. However, underfeeding the plant would lead to low gas production and economically ineffective process as well [10].

2.4.2.4 Retention Time

Hydraulic Retention Time (HRT) is also known as hydraulic residence is the time required for complete digestion time of the substrates in Digester as shown in figure (2.5). Hydraulic retention time is the volume of the digester divided by the influent flow rate. HRT = Volume of Digester / Influent Flow Rate where using (SI Units) Volume is in [m^3] and Influent flow rate is in [m^3 /h]. HRT is usually expressed in hours (or sometimes days). Therefore, the appropriate retention time is determined due to careful consideration of process temperature and substrate type [14].

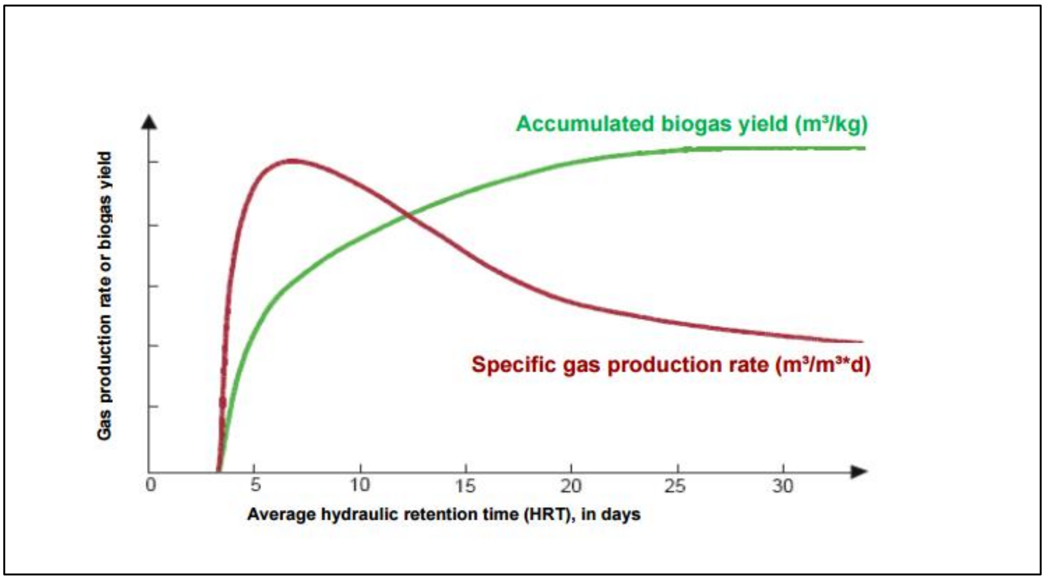


Figure (2. 5): Biogas productions after addition of substrate [14]

2.4.2.5 Toxicity

Some of the toxic materials that might inhibit the normal growth of pathogens in the digester include mineral ions, heavy metals and detergents.

However, low concentrations of the mineral ions, such as sodium, potassium, calcium, magnesium, ammonium and sulphur, are needed for stimulation of bacterial growth. At the same time, if the concentration of these ions were too high, it would lead to toxification. Addition of substances including soap, antibiotics, organic solvents, etc should be avoided, since this would lead to inhibition of the activity of methane producing bacteria [10].

2.4.2.6 Available Nutrients

Apart from providing a source of carbon and energy through organic substances for the bacteria to be able to grow, they require other mineral nutrients as well. Except from carbon, oxygen and nitrogen for the production of biomass a sufficient amount of nitrogen, sulphur, phosphorous, potassium, calcium, magnesium and a little amount of trace elements such as manganese, molybdenum, cobalt, zinc, selenium and nickel etc are also needed. [10].

2.4.2.7 C/N Ratio

Both nitrogen and carbon is essential for microorganisms in order to assimilate these into their cell structure. Based on studies, the metabolic activity of methanogenic bacteria is possible to be optimized at a C/N ratio around 20-30. However, depending on the characteristics of the substrate, the optimum point can vary, C/N Ratio is for different animal wastes is given in Table (2.2) [15].

Table (2. 2): C/N Ratio of some organic materials [15]

Raw materials	C/N Ratio
Duck dung	8
Human excreta	8
Chicken dung	10
Pig dung	18
Sheep dung	19
Goat dung	12
Water hyacinth	25
Cow dung/ Buffalo dung	24

2.5 Types of Biomass

2.5.1 Animal Waste

Beef cattle, dairy cattle, hogs, and poultry all produce manure, which can be used to produce energy. Manure is typically categorized as liquid, slurry, or solid. In its solid state, manure can be burned for heating and cooking or to produce a gas for energy production. As a slurry, manure releases methane (CH_4), which can be captured to produce heat, power, electricity, and biofuel [16].

2.5.2 Wood and Agriculture Products

Woody biomass is the accumulated mass, above and below ground, of the roots, wood, bark, and leaves of living and dead woody shrubs and trees [16].

2.5.3 Municipal Solid Waste

The portion of MSW could include items such as furniture, pallets, packaging materials processed lumber, and yard and tree trimmings. Some municipalities provide large yard debris carts, which are collected weekly.

Other areas work with local businesses to ensure collection options such as drop-off bins and designated collection facilities. [17].These types are shown as the following figure (2.6).

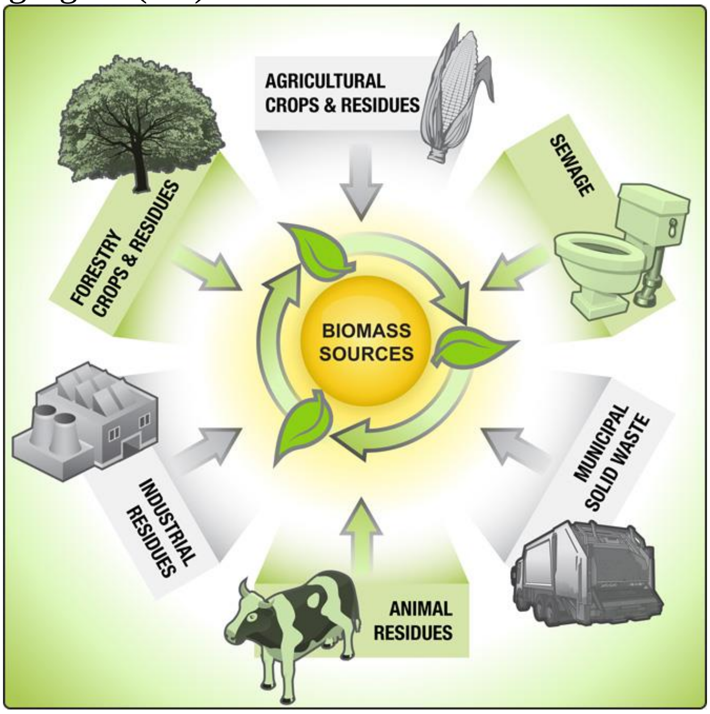


Figure (2. 6): Type of biomass [18]

2.6 Advantages of Using Biomass:

Using biomass as an alternative source of energy to generate electrical power has some economical benefits. Moreover, it can be a useful source for energy in small societies or small industrial areas. In contrast, even developed countries can use this source to compensate for the lack of the other sources, such as, oil, gas or coal. One of the most important advantages of biomass is its cheap prices; also it is a readily available source of energy. In addition, it is a continuous and long term source, it can be found easily, any time and almost anywhere. One more advantage for biomass power plants is helping to reduce the unemployment in various countries [17, 18].

2.7 Design of Biogas Plant:

A biogas plant consists of three main components as shown in figure (2.7), namely: mixing chamber, digester and expansion chamber. The required quantity of dung and water is mixed in the mixing chamber and this mix in the form of slurry is allowed to flow and be digested inside the digester. The gas produced in the digester is collected in the dome, called gasholder. The digested slurry flows to the expansion tank from the digester through the manhole. The slurry then flows through an overflow opening to the storage pit where it is collected and taken to the fields for application as fertilizer. The gas is supplied to the point of use through a pipeline. Before deciding on the size of plant, it is necessary to collect dung for several days to determine the average daily dung production. The amount of dung available daily helps in determining the size of the plant [19].

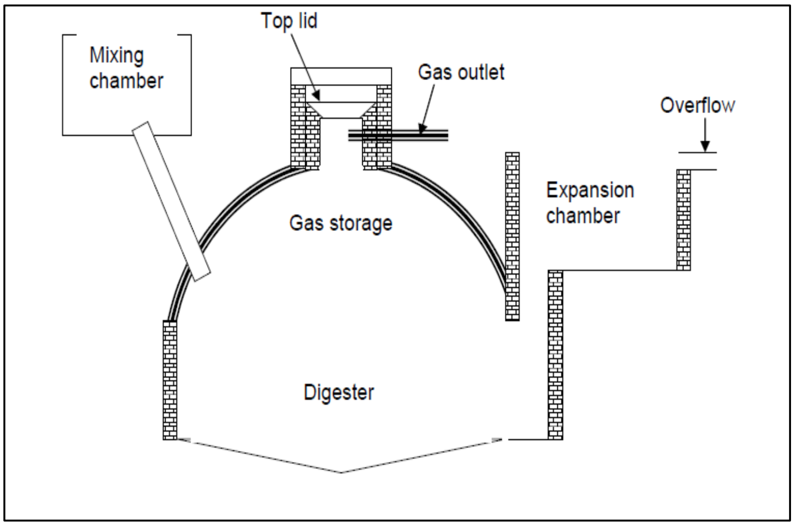


Figure (2. 7): Biogas schematic diagram of biogas digester

2.8 Biogas - Digester types

The most important types of biogas plants are described as follow:

- Fixed-dome plants
- Floating-drum plants
- Balloon plants
- Horizontal plants
- Earth-pit plants
- Ferrocement plants

In developing countries, the selection of appropriate design is determined largely by the prevailing design in the region. Typical design criteria are space, existing structures, cost minimization and substrate availability. The designs of biogas plants in industrialized countries reflect a different set of conditions.

In this research we used the ferrocement digester as the reasons listed in Table (2.3). Table (2.3) summarizes the types of digester [4, 19].

Table (2. 3): The types of digesters

Digester types	Design principle	Main components	Referred substrates	Anticipated useful life (year)	Digester volume (m^3)	Advantages	Disadvantages
Floating-drum	continuous-feed, mixed digester	masonry digester, floating metal gasholder	Animal excrements, with or without vegetable waste	8-12	6-100	Easy construction and operation. uniform gas pressure	metal gasholder can rust
Water-jacket	continuous-feed, mixed digester	masonry digester, floating metal gasholder in step. water jacket	Animal excrements, with or without vegetable waste	10-15	6-100	Very reliable, easy construction and operation. Long useful life, mature Technology.	expensive
Fixed-dome	continuous-feed, mixed digester with slurry store	masonry digester, gas holder with displacement pit	Animal excrements plus vegetable waste	12-20	6-20	Low cost of construction. long useful life. well insulated	Sealing of gasholder. Fluctuating gas pressure.
balloon-type	continuous-feed, mixed digester with slurry store	integrated digester gas-holder made of plastic sheeting	Animal excrements only	2-5	4-100	easy operation	short useful life plastic mate low gas pressure

Earth pit	continuous-feed, mixed digester with slurry store	earth pit as digester, plastic gasholder	Animal excrements	2-5	4-500	extremely inexpensive easy operation	Plastic gasholder plus soil permeability
Ferrocement	continuous-feed, mixed digester with slurry store	ferrocement digeste gasholder made of metal or ferrocement	Animal excrements, with or without vegetable waste	6-10	4-20	potentially inexpensive, long useful life, easy operation, reliable	ferrocement construction not yet adequately time years- tested
Horizontal (shallow)	continuous-feed, fermentation channel	masonry digester, floating metal gas holder or separate	Animal excrements, with or without vegetable waste	8-12	20-150	shallowness, easy operation	expensive, metal gasholder

2.9 Applications of Biogas in Household Digesters

2.9.1 Cooking and Heating

Biogas produced from the household digesters is mainly used for cooking. The amount of biogas used for cooking purposes usually varies between 30 to 45 m^3 per month [20].

2.9.2 Biogas Stoves

The biogas burners are designed to meet a mixture of bio-gas and air in the ratio of 1:10. The efficiency of the heat entering the vessel from the stove was high for biogas with 57.4%, followed by LPG, kerosene, and wood with 53.6%, 49.5%, and 22.8%, respectively [20].

2.9.3 Lighting and Power Generation

The other major application of household biogas is for lighting and power generation. In many developed countries, biogas from the digesters is sentto a combustion engine to convert it into electrical and mechanical energy [20].

Chapter Three

Methodology

Chapter Three

Methodology

The methodology adopted in the research can be divided into five steps, these are:

1) Data collection 2) Biogas production 3) Cost analysis

4) Centralized /decentralized option 5) EIA

The steps are shown in figure (3.1) and will be discussed in the following sections.

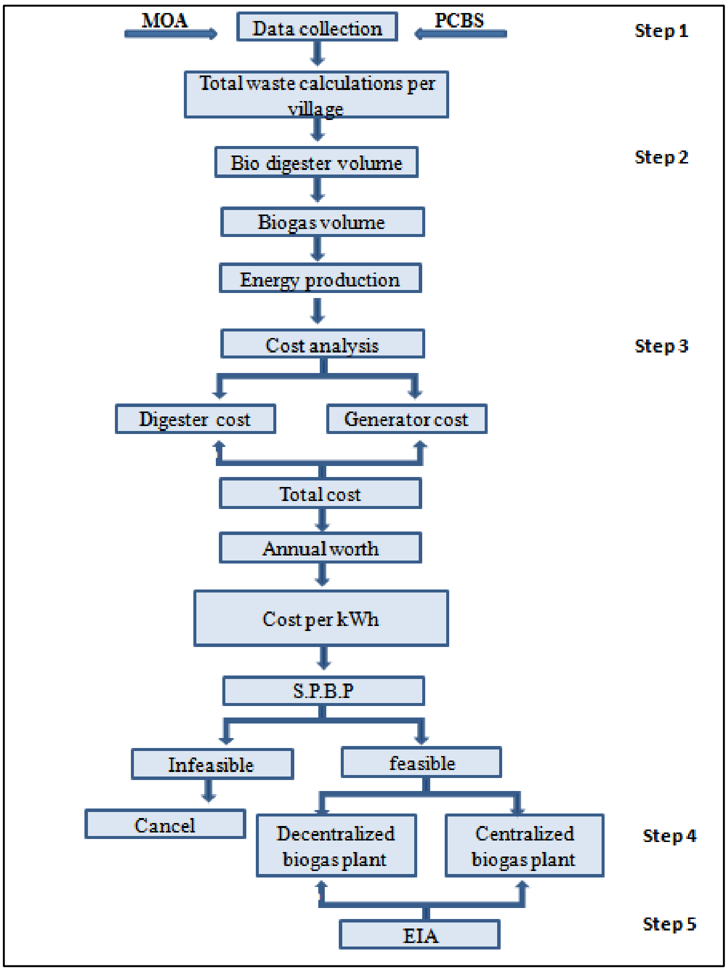


Figure (3. 1): Research Methodology Diagram

3.1 Data Collection of Raw Materials

Data of animal waste used in this study were collected from the Palestinian Ministry of Agriculture and Palestinian Central Bureau of Statistics.

The data include the number of cattle, sheep, goat and poultry in each village in West bank.

3.2 Animal Waste Calculation

The amount of organic waste that can be collected for each type of animal is shown in Table (3.1). For the aim of calculation the percent of dry matter, some factors were used as shown in Table (3.14) [21-25].

Table (3. 1): Amount of animals and poultry waste production

Animal		Animal Weight-kg	waste-dung-kg/day	Excreta- Fresh	
				DM (%)	
			Range	Range	Average
Poultry	Broilers	1.4-1.3	0.06	0.10-0.29	0.195
	Mothers of Broiler	2	0.15		
	Layer	2	0.15		
	Turkey	10	0.45		
Cattle	Calf (male)	450	30		0.180
	Hurry or cow milk (female)	580	34.5		
Sheep		60	2	0.18-0.25	0.215
Goat		40	2	0.18-0.25	0.215
Total (average)					0.201

Where: DM: Dry Matter

3.3 Biogas Volume Calculation:

The amount of biogas was calculated based on the amount of animal's waste production by using factors listed in Table (3.2) [22, 23].

Table (3. 2): Amount and percent of biogas yield from waste of animals and poultry.

Animal		Biogas yield m^3/kg.OTS	
		Range	Average
Poultry	Broilers	0.3-0.8	0.550
	Mothers of Broiler		
	Layer		
	Turkey		
Cattle	Calf		0.575
	Hurry		
	Cow-milk		
Sheep		0.3-0.4	0.350
Goat		0.3-0.4	0.350
Total (average)			0.3558

3.4 Calculation of energy potential:

The energy potential from animal wastes was calculated based on the biogas values and engines efficiency as listed in Table (3.3) [26].

Table (3. 3): parameters for energy calculation

Biogas calorific value -MJ/m^3	23
Biogas calorific value -kWh/m^3	6.4
generator efficiency	0.3

3.5 Sizing the Plant

The biogas plant size depends on the average daily feed stock and expected hydraulic retention time of the material in the biogas system. Capacity of the plant should be designed based on the availability of raw materials. Sizing of biogas plant is based on three parameters: Daily feed and Retention time [27, 28].

3.5.1 Sizing the digester

The size of the digester is determined based on the retention time and on daily slurry (substrates) supplied as in equation (3.1). Fermentation slurry consists of the feed material and the mixing water.

$$V = Sd * Rt \qquad (3\ .1)$$

Where:

V: Digester volume (m^3); where ($1m^3 \sim 1000kg$)

Sd: daily substrate input rate (kg/day)

Rt: Retention time (day)

3.6 Cost of Plant

The total cost of biogas plant consists from the cost of digester and the cost of generator. The land cost was not included in the total cost, considering the lands are available and awarded from animals farmers owners.

3.6.1 Digester cost

The following equation (3.2) was used to calculate the digester cost [29].

$$\text{DigesterCost}\ (€) = 23182 + (89 * V) \qquad (3.2)$$

Where:

V: Digester volume (m^3)

This equation includes Building price (Granular subbase, Bio-reactor, Heat insulation, Gas line, Gas storage, Substrate line) and Techniques price (Heating Pump, Gas preparation, Electrical installation, Tube extruder, Sensors, Controller, and Granary)

3.6.2 Generator Cost:

Equation (3.3) was used to calculate the generator cost which includes Engine equipment, Heat line electrical installation, sonic insulated site, then the following equation (3.3) is used [29].

$$\text{Generator Cost} = 11870 + (283 * \text{P}) \quad (3.3)$$

Where:

P: Rated Engine Power (kW)

3.7 Annual Cost Calculation

In order to calculate the cost of kWh produced, then the following steps are followed: [30]

1) Calculate the equivalent annual cost [NIS/year] by using equation (3.4).

$$\text{AW} = \text{PW}\frac{\text{i}(1+\text{i})^{\text{n}}}{(1+\text{i})^{\text{n}}-1} + \text{O}\&M \quad (3.4)$$

Where:

AW: is the required equivalent annual worth.

PW: the estimated present (now) costs, which includes digester initial cost, generator initial costs, and any other required initial costs [NIS].

O&M: estimated annual operating and maintenance cost [NIS/year], where it could be 5% of the first term from the AW equation shown above.

i: annual interest rate [%/year], where values around 10%/year are reasonable.

n: project estimated useful life [years], for such project ,16 years is suitable figure .

2) Now, the cost per kWh [NIS/kWh] can be estimated easily by using equation (3.5).

$$\mathrm{kWh_{cost}} = \frac{\mathrm{AW}}{\mathrm{annual\ kWh_{prod}}} \tag{3.5}$$

Where kWh production is the estimated kWh production from the proposed unit size.

3) 0.3NIS/ kWh was taken to be the sales cost for local municipalities in order to compete the Israel Electric Corporation(IEC) where their selling price is about (0.4-0.45).

3.8 Clustering of Power plant

Decentralized power plants were formed in centralized cluster, depending on the volume and the distance between the plants.

3.9 Transportation Cost

The transporting cost was calculated for the centralized power plant, where the truck transporting the manure was taken to accommodate at least 5 tons, thus any station where less than this weight is not taken into account.

We calculated the time for upload and download the manures, where it was 10 minutes calculated for each 5 km. The time of filling the manure in the decentralized power plant and discharging in centralized power plant is considered as one hour.

The cost of transport was calculated by the following equations (3.6-8) and this cost included the cost of labor, number of workers per truck, size of the truck and the period which the truck spent in each trip [31].

$$\text{Cost (NIS/ton)} = ((188+0.9*\text{km})/ \text{ total wet waste (ton/day)}) \quad (3.6)$$

$$\text{Total cost (NIS/year)} = \text{Cost} * \text{total wet waste} * \text{No. of day} \quad (3.7)$$

$$\text{AWt(NIS/year)} = \text{Total cost} + \text{AW} \quad (3.8)$$

3.10 Payback Period Calculation

The payback period was calculated based on selling cost of kWh to be 0.3 NIS.

$$\text{Levelized cost of energy} = \text{AW (NIS)} / \text{Energy potential (kWh)} \quad (3.9)$$

$$\text{Profit} = \text{Selling cost} - \text{Levelized cost of energy} \quad (3.10)$$

$$\text{Yearly profit} = \text{Profit} * \text{Annual Energy potential (kWh)} \quad (3.11)$$

$$\text{P.B.P} = \text{AW (NIS)} / \text{Yearly profit} \quad (3.12)$$

The average P.B.P was calculated to compare with the centralized power plants.

3.11 Environmental Impact Assessment

Taking into consideration the economical, social, political and environmental parameter in centralized and decentralized are discussed in chapter four as Environmental Impact Assessment (EIA) is carried out.

Chapter Four

Environmental Impact Assessment of Establishing Biogas Plant

Chapter Four

Environmental Impact Assessment of Establishing Biogas Plant

4.1 Definition of EIA

Environmental Impact Assessment, EIA, is a tool for decision-makers to identify potential environmental impacts of proposed projects, to evaluate alternative approaches, and to design and incorporate appropriate prevention, mitigation, management and monitoring measures [32].

EIA process goes though several steps started from screening to the implementation and follow up procedure of the permission of the approval of the project, as illustrated in Figure (4.1).

To assess the expected impacts of establishing a biogas production unit on the environment, an environmental, social and economic aspects are carried .EIA should therefore be viewed as an integral part of the project planning process.

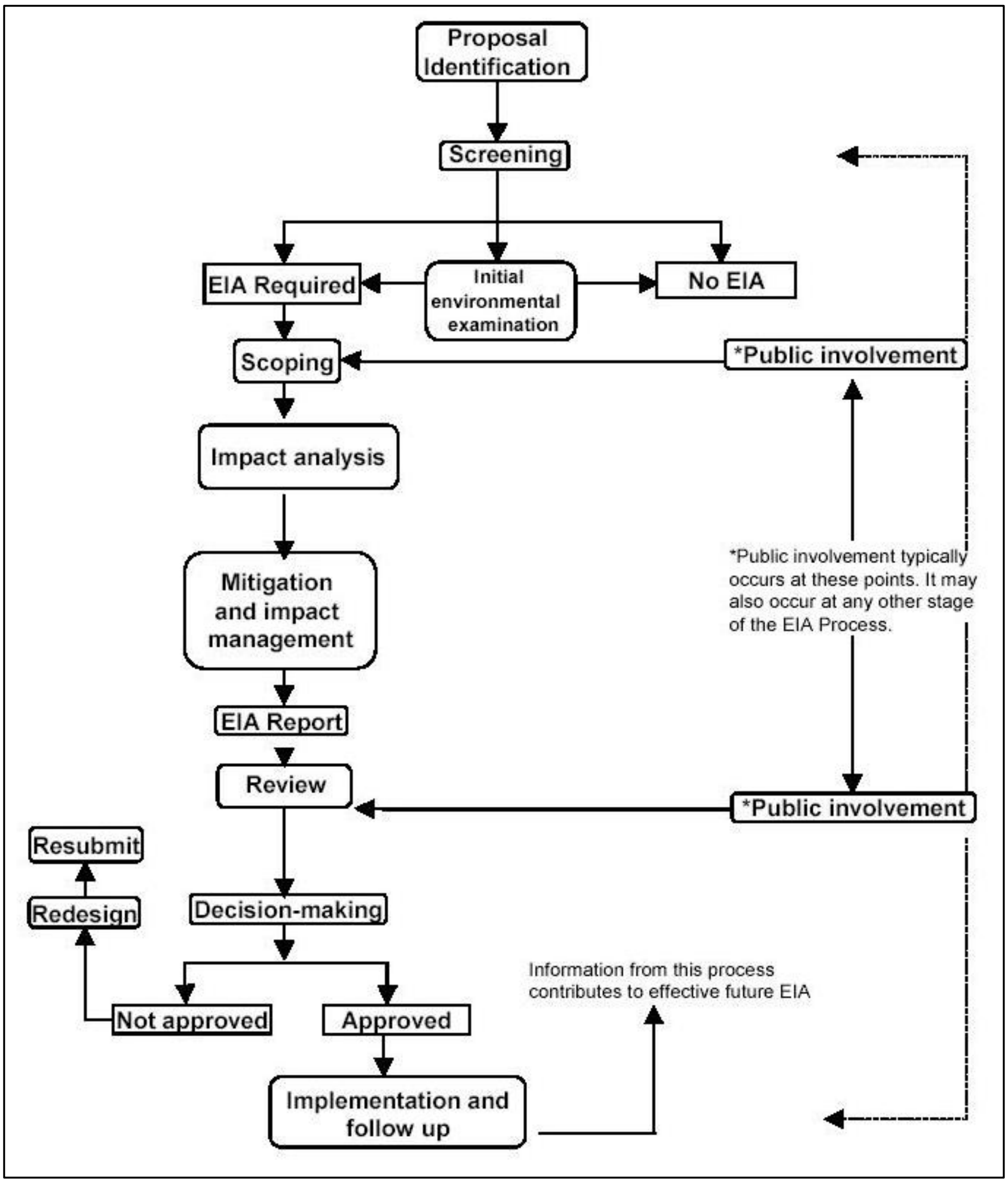


Figure (4. 1): Generalized EIA Process Flow-Chart [33]

4.1.1 Project description, and legal and administrative framework:

A brief description of any project is necessary before the start of EIA process. This includes:

4.1.2 Screening

Means the process of determining whether or not an environmental assessment study is required for a proposed development activity based on the laws of Environmental Quality Authority (EQA), for all projects [34].

All information are then required in order to decide if we need to build a centralized biogas plant in each governorate.

4.1.3 Description of the existing environment:

Precise data relevant to the site is required: intended uses, quality, physical, biological, social, and economic conditions. This description must include other existing or proposed developments. In addition, quantities analysis of biomass is needed.

Ease of transportation of biomass will be taken into consideration for a found decision of centralized and decentralized plant.

4.1.4 Scoping

If screening step shows that EIA is needed then the process of establishing the range of action alternatives and potential impacts to be included in terms of reference for environmental assessment studies is called scooping. In our case the physical, biological and Socio-economic impacts of the biogas power plant will be studied.

Physical impact :water pollution related to disposal of animal wastes, water pollution from oil type wastes and/or spills used for the maintenance of equipment, noise pollution resulting from the operation of equipments, air pollution resulting from the stack emissions during energy generation, soil problem.

Biological impact: included the wildlife and biodiversity.

Socio-economic impacts: health/safety, education, culture, population and land use [33].

4.1.5 Mitigating measures:

Means any measure included in the plan for a development activity to avoid, reduce or rectify an adverse environmental impact, or to compensate for an adverse environmental impact by replacing or providing substitute resources [34].

For example the fermentation waste storage areas shall be hermetically covered. This will enable the emission of gaseous compounds to be reduced and the biogas generated in storage to be collected and used.

4.1.6 Environmental management and training and environmental monitoring plan:

In order to try and prevent environmental accidents, it is necessary to prepare a document to define the role of each person or group for good environmental management and train workers on issues related to monitoring and training procedures undertaken to enhance the capabilities of the staff and workers [35].

4.2 Policy and Legal Framework

Since its establishment in 1994, the Palestinian Authority (PA) has worked hard to recover and improve the Palestinian environment and strive towards sustainable development. The PA had established the institutions that could deal with the challenges of building a new state and worked hard to build the capacity of the different ministries and agencies along with building the capacity of the human resources. Laws and legislations were also developed and endorsed to organize and manage the various sectors such as environment, water, wastewater, land use planning, etc. Palestinian legislative council PLC is the formal legislative body in Palestine [36].

In 1999 PEAP developed a new environmental law which identifies waste, hazardous materials, and hazardous waste. More information about this law and the summary of the laws and regulations are existing in appendix J [37].

4.2.1 Environmental Assessment Policy

Environmental Assessment policy shall be implemented to support the sustainable economic and social development of the Palestinian people through assisting in the following goals:

1. Ensuring an adequate standard of life in all its aspects, and not negatively affecting the basic needs, and the social, cultural and historical values of people as a result of development activities.
2. Preserving the capacity of the natural environment to clean and sustain it.
3. Conserve biodiversity, landscapes and the sustainable sue of natural resources.
4. Avoiding irreversible environmental damage, and minimizing reversible environmental damage from development activities [36].

4.3 EIA type methods

Scoping should be an ongoing exercise throughout the course of the project. The following environmental tools can be used in the scoping exercise [35].

- Checklists – Checklists are standard lists of the types of impacts associated with a particular type of project. They comprise list questions on features the project and environments impacts.
- Matrices - Matrix methods identify interactions between various project actions and environmental parameters and components.
- Networks – these are cause effect flow diagrams used to help in tracing the web relationships that exist between different activities associated with action and environmental system with which they interact
- Consultations – with decision-makers, affected communities, environmental interest groups to ensure that all potential impacts are detected.

A matrix serves as a checklist and a summary of the impact assessment. The matrices are very suitable for EIAs as they link a particular environmental aspect to a specific action of the development project and in a way explain the nature of the impact. This type of matrix is usually called as interaction matrix. In this project, a leopold matrix will be constructed. Follow are:

1- It can be considered as a basic tool, the matrix provides the assessor with the entire picture of the environmental impacts of the project highlighting the particular part of the project with the major impact.

2- It allows the application of only the relevant part of the matrix for a particular project.
3- It indicates both beneficial as well as adverse impacts by writing a plus or minus sign to the entries in the cells.

In constructing such matrix, all activities listed these on one axis, and environmental and social conditions are listed on the other axis, and are divided into three major groups:

- Physical conditions: soil, water, air…,
- Biological conditions: fauna, flora, ecosystems…,
- Social and cultural conditions: land use, historical and cultural issues, populations, economy…

4.3.1 Construction of Leopold Matrix for Centralized and Decentralized Biogas Power Plant

Potential negative and beneficial impacts are identified for the proposed development prior to, during and after construction activities.

The identification and assessment of potential impacts seeks not only to identify the potential impacts, but also to evaluate the significance of the impacts within the framework of the proposed preventative measures and relative to the existing impacts in the area. The impacts relating to the construction and operational phases of the development are described and summarized in the impact matrix below, this was carried out for proposed centralized and decentralized biogas power plants as shown in Table (4.1) and Table (4.2) [38].

Table (4. 1): Leopold matrix for centralized biogas power plant

Activities		Pre construction			Construction					Operation	
Environmental Items		Road arrangement	Construction area preparation, ground works	Site clearance	water source,	Storage water tank	Auxiliary tunnel	Power house	Water intake	Maintenance service/ repairs	Operation of equipment
Physical	Microclimate										
	Air	-	-	-	-	-	--	--	-	-	
	Water quality	-		-	--		-	-	-	-	-
	Ground waters		-	-	-	-	--	--		-	
	Noise	-	-	-	-	-	-	--	-	-	-
	Soil integrity	-	--	-	-				-	-	
	Soil quality	-	--	-	-	-			-	-	
Biological	Birds	-	-	-	-	-			-	-	-
	Mammals	-	-	-						-	
	Vegetation	-	-	-	-	-		-	-	-	
	Landscape/visual	-	--		-	-			-		-
Socio-economic	Archaeological sites		-								
	Employment	++	++		++	++		++	++	++	++
	Agriculture		-	-						-	
	Living conditions	++	++		++	++		++	++	++	++
	Health	-	-	-	-	-	-	-	-	-	-
	Protected areas										

- Where: plus (+) or minus (-) sign can be used to show whether an impact is beneficial or adverse.

+++	High positive impact	- - -	High negative impact
++	Medium positive impact	- -	Medium negative impact
+	Low positive impact	-	Low negative impact
	No impact		

Table (4. 2): leopold matrix for decentralized biogas power plant

Activities		Pre construction			Construction					Operation	
Environmental Items		Road arrangement	Construction area preparation, ground works	Site clearance	water source,	Storage water tank	Auxiliary tunnel	Power house	Water intake	Maintenance service/ repairs	Operation of equipment
Physical	Microclimate										
	Air	--	--	--	--	-	---	--	--	--	
	Water quality	--			--		--	--	--	--	--
	Ground waters		--	--	--	--	--	--		--	
	Noise	--	-	--	--	--	-	--	--	--	--
	Soil integrity	--	--	--	--				--	--	
	Soil quality	--	--	--	--	--			--	-	
Biologica	Birds	--	-	--	--	--			--	--	--
	Mammals	--	-	--						--	
	Vegetation	--	-	--	-	--		--	--	--	
	Landscape/visual	--	--		-	-			--		--
Socio-	Archaeological sites		-								
	Employment	+	+		+	+		+	+	+	+
	Agriculture		--	--						--	
	Living conditions	+	+		+	+		+	+	+	+
	Health	--	--	--	--	--	--	--	--	--	--
	Protected areas										

It is noted that the centralized biogas power plant has less negative environmental impact than decentralized biogas power plant. Section (4.4) illustrates impacts in details.

4.4 Environmental Aspects, Impacts and Mitigation

Following the considering of Leopold matrix, then most important impacts on various environmental elements during the construction and operation of the biogas plant are listed in Table (4.3) which summarized the different impact in the construction and operational phases on various environmental elements.

Table (4. 3): the different impact types in the construction and operational phases [36, 39, 40]

#	Environmental parameter	Impact during construction	Impact during Operation	Mitigation	Monitoring	Frequency /time	Responsible institutions
1	Water quality	The potential impacts on surface water quality may arise from increased sediment loads from the stockpiling of construction aggregates and excavation activities during heavy rainfall	Increase in water demand. Impact on the water resources	- The design and the implementation should comply with the local and international codes. - Water storage reservoir to meet the demand for several days.	Document any potential concerns for spills and stagnant water body creation and its resolution - Take photographs prior, during, and post construction to ensure site restoration back to original characteristics as much as practical	Twice in year	Contractor ,PWA
2	Ground Water Quality and quantity	Water pollution (split fuel/oils, wastes - including liquid ones)	leaks and potential population and industrial growth	Ensure all necessary equipment is available and in good working condition• Ensure that a qualified operator is available at all	Maintain a log of all equipment and its condition - Maintain licenses of all operators -Document safe storage of any toxic materials	Twice in year	Contractor, PWA

				times of the project activities			
3	Air quality	-Pollution of air with exhaust gases from construction machinery. - Dust may be emitted during construction and by transport vehicle, but it will have no critical impact in the case of prolonged hot and dry weather the soil shall be watered, if required.	- Particulate and gaseous emissions from diesel generating set. Odor from the¬ Anaerobic digester.	- Use of properly service machinery during construction. - Continuous regulation of gas production in the digester to ensure constant and effective operation condition. -Regulation of biogas production to ensure minimum flaring and venting of biogas	Document baseline noise and air emission during the start and end of the work - Log noise and air emission - Document complaints and how it was resolved	Quarterly	Contractor, MOA,PWA ,EQA
4	Soil quality and quantity	- Soil disturbance due to excavation.	- Operating a biogas plant involves the use of grease in	-Regular cleaning and proper storage in barrels and its	Take photographs prior, during, and post construction to ensure site restoration back	Annually	Contractor, Municipality ,MOA,PWA

		- Heavy machinery used will cause soil compaction. - Soil will be removed and re-located to construct foundations and bases.	small quantities and maintenance chemicals required for the operation of machines. Impact on the soil is related to emergency cases and Accidents, the probability of which is very low.	proper waste disposal. -Limiting the excavation area	to original characteristics as much as practical - Document soil placement if moved from original site Review of bid documents to ensure that applicable codes and regulations are incorporated, inspection during construction to ensure that measures are implemented.		
5	Noise	-Excessive or prolonged exposure to noise (typically more than 8 hrs above 85-90 decibels) leads to hearing loss.	-Excess noise at site cause disturbance on the wildlife.	- Noise to be controlled by use of acoustic enclosures for respective equipment. -Minimize the unnecessary use of vehicles and equipment	Document baseline noise and air emission during the start and end of the work - Log noise and air emission - Document complaints and how it was resolved	Weekly	Contractor, Municipality, MOL,MENA
6	Health and safety	- Fire outbreak increased noise levels from	Accidents and injuries to worker	- Identification and elimination of potential hazard.	Record when the public was informed of work schedules	Every time	Contractor, MOH,PWA,PWL

		construction equipment. - The probability of accidents causing a significant impact on the environment is little if building safety and environmental requirements are followed.		- Provision and use of appropriate and adequate personal protective equipment ensuring contractor compliance. - Provision adequate firefighting equipment. - Proper training of workers, and use of proper storage tanks and protective clothing.	and management plans - Document any concerns and its resolution with work schedules and management plans -Conduct and document with checklists site inspections -Document and report potential health and safety concerns -conduct site visits and document that workers are properly wearing		
6	Socio-economic impacts	- increasing employment opportunities for the local communities.	- Increasing technological and professional know –how among local worker depends on the requirement construction in	-assure purchase of high quality material. -improve local economy by involvement of local contractors	- putting measure in place to ensure the operational. -procedures are followed always in identification and non conformity	Monthl y	Contracto r, ,PWA,P WL

			the construction process at the plan.		identified and addressed.		
7	Vegetation	Disruption or interference of biological resources may occur during construction work activities Change in the landscape, degrade the aesthetic of the project area and cause odors attract insects and rodents	attract and create habitat for migratory birds flying over the region during their semi-annual migrations	minimize amount of dust generated through construction works activity - Work within the existing road corridors as practical as possible - Install proper fencing or other suiTable protection during project -construction to prevent the exposure of wild and domestic animals to construction hazards	Log any presence of wild or domestic animals within the project site and action taken • Take photographs prior, during, and post construction to ensure site restoration back to original characteristics as much as practical	Once a year	Contractor, Municipality,PWA
8	Employment Opportunities	Several categories of employees will be	Moreover, the project operation	Not required	Not required	------	MOL

		required during the construction phase. This will include skilled and unskilled labors, engineers, and a small number of other professionals. These levels of short-term employment would have a positive impact on the local economy and on regional unemployment.	will provide employment for several persons. This would represent a positive long-term significant impact				

After the result in Table (4.3) it is obvious that centralized biogas power plant is more viable than decentralized biogas plant. Centralized biogas power plant needs less number of used lands, it has less noisy, emission & pollution on nearest residents, more easily for take permission, monitoring, controlling and searching check.

4.5 CO_2 Reduction Potential with Biogas Production

Average implied carbon emission factors from electricity generation for selected products are presented below. These values represent average CO_2 emissions per kWh of electricity produced.

1 kWh produced from biogas stations emits 913g of CO_2 to atmosphere. So producing 1kWh will reduce 913g of CO_2 [42].

- Electrical Energy =104.8 GWh/Year
- Reduction of the emission of CO_2 = 100,000 ton CO_2 per year.

  In the case of proper utilization of these bioenergy supposed system, it is expected to minimize the amount of greenhouse emissions equivalent to 100,000 ton CO_2 which it produced from a same amount of the yearly production electrical energy from coal.

Chapter Five

Results and Discussion

Chapter Five

Results and Discussion

For the aim of presenting results and discuses of these results data based on Tubas governorate is taken for illustration .Same methodology of interpretation of results for other governorates are presented in appendix (A to I)

5.1 Animals Waste in Palestine

Tubas governorate consist of twenty one villages, each village breed many types contains animals such as cattle, goat, sheep, and poultry where the amount of waste of these animals can be used for producing biogas.

'Ein elBeida village has the highest number of cattle of (359), Almailh village has the highest number of goat and sheep of (7,882) and Tammun village has the highest number of poultry of (45,825).

As noted, Almalih city has the highest number of animals and Aththaghra city has the lowest number of animals.

Considering the number of animals shown in Table (5.1), the amount of animal wastes can be estimated for Tubas Governorate based on Table (3.1). For example, the amount of dry waste of Bardala village as seen in the first village in Table (5.1) can be calculated as below:

- The amount of waste (kg/day)=No. of animals * factor of animals waste
- For cattle :

- Total daily waste =waste of male +waste of female

=((15*30) + (180*34.5))

=6660 kg/day

- Total annual waste =6660*365*0.9=2,187,810 kg/year

  (0.9 is a collecting factor)

  - For sheep :

- Total waste =(4788*2)=(9576 kg/day)*0.9*365 = 3,145,716 kg/year

  - For goat :

- Total waste=(942*2)=(1884 kg/day)*0.9*365=618,894 kg/year

  - For poultry:

- Total waste=waste of (broilers+ mother of broilers +layer +turkey)=

  ((4500*0.06)+(0.0*0.15)+(0.0*0.15)+(6000*0.45)
  =2970 kg/day

- Total annual waste = ((4500*0.06*50)+ (0.0*0.15*365)
  + (0.0*0.15*365) +(6000*0.45*150)*0.9)

  =376,650 kg/year

Where: the life cycle/year for (broilers=50day, mother of broilers =365 day ,layer =365day,turkey=150day)

- Total amount of wet waste for all animals =21090*0.9=18981 kg/day
- Total amount of dry waste =total amount of wet waste*avg factor

  =18981*0.201=3,815kg/day

- The amount of animal waste was calculated for all villages in Tubas governorate as in the same pervious method.

Table (5. 1): amounts of animal waste in Tubas Governorate [21]

	Cattle				Sheep			Goats			Poultry		
Location	**No. Male**	**No. Female**	**Waste-dung-kg/year**	**dry dung-kg/year**	**No. Sheep**	**Waste-dung-kg/year**	**dry dung-kg/year**	**No. Goats**	**Waste-dung-kg/year**	**dry dung-kg/year**	**No.**	**Waste-dung-kg/year**	**dry dung-kg/year**
Bardala	**15**	**180**	**2,187,810**	**393,806**	**4,788**	**3,145,716**	**676,329**	**942**	**618,894**	**133,062**	**10,500**	**376,650**	**73,447**
'Ein el Beida	**68**	**291**	**3,968,116**	**714,261**	**724**	**475,668**	**102,269**	**264**	**173,448**	**37,291**	**0**	**0**	**0**
Kardala	**15**	**265**	**3,151,136**	**567,205**	**1,557**	**1,022,949**	**219,934**	**417**	**273,969**	**58,903**	**2,500**	**6,750**	**1,316**
Ibziq	**3**	**66**	**777,560**	**139,961**	**1,447**	**950,679**	**204,396**	**1,212**	**796,284**	**171,201**	**0**	**0**	**0**
Salhab	**0**	**0**	**0**	**0**	**743**	**488,151**	**104,952**	**229**	**150,453**	**32,347**	**3,000**	**147,825**	**28,826**
'Aqqaba	**0**	**17**	**192,665**	**34,680**	**2,194**	**1,441,458**	**309,913**	**235**	**154,395**	**33,195**	**6,900**	**18,630**	**3,633**
Tayasir	**1**	**8**	**100,521**	**18,094**	**1,479**	**971,703**	**208,916**	**340**	**223,380**	**48,027**	**7,560**	**256,082**	**49,936**
Al Farisiya	**0**	**1**	**11,333**	**2,040**	**1,906**	**1,252,242**	**269,232**	**180**	**118,260**	**25,426**	**0**	**0**	**0**
Al 'Aqaba	**1**	**11**	**134,521**	**24,214**	**737**	**484,209**	**104,105**	**632**	**415,224**	**89,273**	**1,800**	**4,860**	**948**
AthThaghra	**0**	**1**	**11,333**	**2,040**	**223**	**146,511**	**31,500**	**67**	**44,019**	**9,464**	**800**	**2,160**	**421**
Al Malih	**30**	**493**	**5,882,942**	**1,058,930**	**5,308**	**3,487,356**	**749,782**	**2,574**	**1,691,118**	**363,590**	**0**	**0**	**0**
Tubas	**45**	**206**	**2,778,125**	**500,062**	**3,522**	**2,313,954**	**497,500**	**1,227**	**806,139**	**173,320**	**21,650**	**221,468**	**43,186**
Kashda	**0**	**1**	**11,333**	**2,040**	**374**	**245,718**	**52,829**	**62**	**40,734**	**8,758**	**0**	**0**	**0**
Khirbet Yarza	**16**	**147**	**1,823,668**	**328,260**	**711**	**467,127**	**100,432**	**707**	**464,499**	**99,867**	**0**	**0**	**0**

Ras al Far'a	**0**	**30**	**339,998**	**61,200**	**1,501**	**986,157**	**212,024**	**63**	**41,391**	**8,899**	**12,000**	**591,300**	**115,304**
El Far'aCamp	**13**	**12**	**264,114**	**47,541**	**166**	**109,062**	**23,448**	**43**	**28,251**	**6,074**	**0**	**0**	**0**
Khirbet arRas al Ahmar	**0**	**0**	**0**	**0**	**5,679**	**3,731,103**	**802,187**	**347**	**227,979**	**49,015**	**0**	**0**	**0**
Wadi al Far'a	**11**	**43**	**595,735**	**107,232**	**1,489**	**978,273**	**210,329**	**381**	**250,317**	**53,818**	**9,900**	**133,853**	**26,101**
Tammun	**5**	**36**	**457,272**	**82,309**	**4,828**	**3,171,996**	**681,979**	**670**	**440,190**	**94,641**	**45,825**	**492,986**	**96,132**
Khirbet 'Atuf	**5**	**24**	**321,273**	**57,829**	**3,859**	**2,535,363**	**545,103**	**1,033**	**678,681**	**145,916**	**9,000**	**24,300**	**4,739**
Khirbet Humsa	**0**	**0**	**0**	**0**	**2,748**	**1,805,436**	**388,169**	**861**	**565,677**	**121,621**	**0**	**0**	**0**
Total	**228**	**1,832**	**23,009,454**	**4,141,702**	**45,983**	**30,210,831**	**6,495,329**	**12,486**	**8,203,302**	**1,763,710**	**131,435**	**2,276,863**	**443,988**

The total number of animals and amount of waste for all governorates is given in Table (5.2).We notice that Hebron governorate has the highest number of animals and Salfeet governorate has the lowest number of animal

Table (5. 2): annual amounts of animal waste for all Governorates

Governorate	No. of Animals	Dry waste (kg/day)
Tubas	191,964	33,820
Hebron	1,181,018	128,360
Bethlehem	270135	25,817
Jericho	284,097	30,495
Ramallah	554,523	33,197
Nablus	831,701	66,530
Qalqilya	694,276	30,654
Salfeet	74,150	8,745
Tulkarem	631,277	27,625
Jenin	1,161,012	77,638

5.2 Potential of Biogas Production

The main advantage of animal manure, with respect to continuous digesters, is that it is easy to collect and easy to mix as slurry and load into digesters. The biogas produced from the digestion of each waste type is different from the others.

The total biogas was calculated by taking only the dry animals waste. Tables (5.3) summarize the amount of biogas than can be produced from different animal waste at Tubas Governorate. The amount of biogas was calculated based on the Table (3.2). For example the amount of biogas production of Bardala village can be calculated as the below method.

- The volume of biogas per day =total amount of dry animal waste*factor of biogas

$$=3815 * 0.3558$$

$$=1,357\ m^3/day$$

The potential of biogas was calculated for all villages in Tubas governorate as the same pervious methods and is given in Table (5.3).

Table (5. 3): The Potential of Biogas Production for Tubas Governorates

Villages	Total dry waste for all animals kg/day	Total Biogas (m^3/day)
Bardala	3815	1,357
'Ein el Beida	2339	815
Kardala	2347	797
Ibziq	1412	445
Salhab	463	148
Aqqaba	1115	348
Tayasir	930	301
Al Farisiya	812	244
Al 'Aqaba	617	191
AthThaghra	127	40
Al Malih	5951	1,953
Tubas	3522	1,169
Kashda	174	52
Khirbet Yarza	1448	486
Ras al Far'a	1124	385
El Far'a Camp	211	71
Khirbet arRas al Ahmar	2332	699
Wadi al Far'a	1174	386
Tammun	3354	1,127
Khirbet 'Atuf	2157	667
Khirbet Humsa	1397	419
Total	36887	12,033

The potential of biogas production for Tubas governorate was found to be about 12,033 m^3/day. Almalih village has the highest amount of biogas but

Aththaghra village has the lowest amount of biogas, Table (5.4) shows the potential of biogas production for all Governorates.

Table (5. 4): The Potential of Biogas Production for all Governorates

governorate	Total Biogas (m^3/day)
Tubas	12,033
Hebron	45,670
Bethlehem	9,186
Jericho	10,850
Ramallah	11,811
Nablus	23,671
Qalqilya	10,907
Salfeet	2,860
Tulkarem	9,829
Jenin	27,623
Total	144,460

Hebron governorate has the highest potential of biogas where Salfeet governorate has the lowest potential of biogas.

5.3 Electrical Energy Production

Based on data presented in Tables (5.1) and (5.2), the total amount of electrical energy that can be produced for biogas is calculated with reference to parameters presented in Table (3.3). The electrical energy potentials are summarized in Tables (5.5).

For example the annual electrical energy production of Bardala village can be calculated as the below method.

- Daily electrical energy production = biogas yield*calorific value *generator efficiency

  = (6.4*1357*0.3)

= 2605 kWh/day

Taking attainment value of 90%, then the daily energy production will be calculated as:

- Annual electrical energy production = daily electrical energy * working days

= (2605*365*0.9) =855,887 kWh/year

The potential of electrical energy production for Tubas governorate is about 8.48GWh

Table (5. 5): The annual electrical energy potential production in Tubas Governorate

Village	Total E (kWh)/year
Bardala	855,887
'Ein el Beida	693202
Kardala	644464
Ibziq	328568
Salhab	97865
'Aqqaba	222553
Tayasir	195706
Al Farisiya	164834
Al 'Aqaba	128623
AthThaghra	24749
Al Malih	1529382
Tubas	835279
Kashda	35843
Khirbet Yarza	393938
Ras al Far'a	262559
El Far'a Camp	57336
Khirbet arRas al Ahmar	471087
Wadi al Far'a	258474
Tammun	573756
Khirbet 'Atuf	435903
Khirbet Humsa	282136

Table (5.6) shows the potential of electrical energy production for all Governorates with 104.8 GWh total energy.

Table (5. 6): Potential of annual electrical energy production for all Governorates

Governorate	Total E (kWh)/year
Tubas	8,479,570
Hebron	28,805,225
Bethlehem	5,793,541
Jericho	6,843,332
Ramallah	7,449,674
Nablus	14,929,970
Qalqilya	6,878,982
Salfeet	2,001,104
Tulkarem	6,199,421
Jenin	17,422,693
Total	104.8 GWh

5.4 Sizing the Digester

The digester volume was calculated for each village of Tubas governorate using equation (3.1). For example the digester volume of Bardala village can be calculated as:

- Digester volume =daily dry waste *ratio of mixing water *retention time

  = 3815 *2.25*40=343 m^3, where (1m^3~ 1000kg)

The digester volume of biogas plant for all villages in Tubas governorate was calculated as the same pervious method and is given in Table (5.7) [27,28].

Table (5. 7): calculated sizes of digesters for Tubas Governorate

Village	volume (m^3)
Bardala	343
'Ein el Beida	206
Kardala	202
Ibziq	113
Salhab	38
'Aqqaba	88
Tayasir	76
Al Farisiya	62
Al 'Aqaba	48
AthThaghra	10
Al Malih	494
Tubas	296
Kashda	13
Khirbet Yarza	123
Ras al Far'a	97
El Far'a Camp	18
Khirbet arRas al Ahmar	177
Wadi al Far'a	98
Tammun	285
Khirbet 'Atuf	169
Khirbet Humsa	106

If all waste collected for Tubas villages will be treated in one digester, then the total digester volume of biogas plant in Tubas governorate will be about 3,044m^3 . Same calculations are carried out to all governorates, and the results are given in Table (5.8).

Table (5. 8): Electricity sizes of digester for all Governorates

Governorate	volume (m^3)
Tubas	3,061
Hebron	11,552
Bethlehem	2,324
Jericho	2,745
Ramallah	2,988
Nablus	5,987
Qalqilya	2,759
Salfeet	787
Tulkarem	2,486
Jenin	6,987

5.5 Analysis Cost of Biogas Plant

The cost of biogas power plant for each village in Tubas governorate is calculated using equations (3.2) and (3.3). The cost of Bardala village plant is calculated as:

- Total cost of biogas power plant =digester cost + generator cost

- Digester cost (€) =23182 +(89*digester volume)

  =23182 + (89*343) =53,709€

- Generator cost (€)=11870 +(283*Power)

  = 11870+ (283*97) =39,321€

Total of biogas power plant=52161+38099

=930, 30€ equivalent to 390,726 NIS

The total cost of biogas plant for all villages in Tubas governorate was calculated using the above method and the results are given in Table (5.9).

Table (5. 9): Total cost of proposed biogas power plant for Tubas Governorate

Village	volume (m^3)	Power (kw)	cost of plant(€)	cost of generator (€)	total cost (€)	total cost (NIS)
Bardala	343	97	53,709	39,321	930,30	390,726
'Ein el Beida	206	58.7	41,535	28,481	70,016	294,065
Kardala	202	57.4	41,131	28,115	69,246	290,834
Ibziq	113	32.1	33,217	20,952	54,169	227,509
Salhab	38	10.7	26,526	14,897	41,423	173,978
'Aqqaba	88	25.1	31,033	18,975	50,008	210,034
Tayasir	76	21.7	29,960	18,005	47,965	201,451
Al Farisiya	62	17.6	28,675	16,841	45,516	191,166
Al 'Aqaba	48	13.8	27,485	15,765	43,250	181,650
AthThaghra	10	2.8	24,070	12,674	36,744	154,326
Al Malih	494	140.6	67,149	51,664	118,814	499,017
Tubas	296	84.2	49,517	35,706	85,223	357,937
Kashda	13	3.8	24,366	12,941	37,307	156,689
Khirbet Yarza	123	35.0	34,134	21,782	55,916	234,848
Ras al Far'a	97	27.7	31,842	19,708	51,550	216,509
El Far'a Camp	18	5.1	24,778	13,314	38,092	159,985
Khirbet arRas al Ahmar	177	50.3	38,919	26,113	65,032	273,133
Wadi al Far'a	98	27.8	31,868	19,732	51,600	216,719
Tammun	285	81.1	48,546	34,827	83,372	350,164
Khirbet 'Atuf	169	48.0	38,201	25,464	63,665	267,395
Khirbet Humsa	106	30.1	32,607	20,400	53,007	222,630

The total cost of Tubas biogas plants is about 2,326,398 NIS and the cost of plant for all governorates is shown in Table (5.10)

Table (5. 10): Total cost of biogas power plant for all Governorates

Governorate	Total cost (NIS)
Tubas	2,327,235
Hebron	8,373,931
Bethlehem	1,801,842
Jericho	2,101,660
Ramallah	2,274,830
Nablus	4,411,187
Qalqilya	2,111,841
Salfeet	679,002
Tulkarem	1,917,760
Jenin	5,123,103
Total	31,122,391

5.6 Equivalent Annual Cost Calculation

The annual cost [NIS/year] for each village of Tubas governorate is calculated by equations (3.4). Thereby for Bardala village the equivalent annual cost is determined by:

- PW of Bardala village =390,729 NIS
- i:interest rate =10% /year
- operating and maintenance cost =5% of PW/year
- n: life time =16 year
- then, AW=69,478 NIS/year

$$AW = PW\frac{i(1+i)^n}{(1+i)^n - 1} + O\&M$$

The estimated present cost (PW) which includes the cost of digester and cost of generator as we calculated in the previous section (5.5).

The annual worth of biogas plant for all villages in Tubas governorate was calculated using the pervious method and the results are given in Table (5.11)

Table (5. 11): The equivalent annual cost for proposed biogas plants for Tubas Governorate

Governorate	AW(NIS/year)
Bardala	69478
'Ein el Beida	56896
Kardala	55767
Ibziq	42554
Salhab	31314
'Aqqaba	38222
Tayasir	36467
Al Farisiya	35017
Al 'Aqaba	32973
AthThaghra	27535
Al Malih	98679
Tubas	67403
Kashda	28085
Khirbet Yarza	44345
Ras al Far'a	39236
El Far'a Camp	28824
Khirbet arRas al Ahmar	51494
Wadi al Far'a	39435
Tammun	60082
Khirbet 'Atuf	49597
Khirbet Humsa	41340

The equivalent annual cost of all Governorates is shown in Table (5.12).

Table (5. 12): The equivalent annual cost for proposed biogas plants for all Governorates

Governorate	AW(NIS)
Hebron	1,489,024
Bethlehem	320,397
Jericho	373,710
Ramallah	404,503
Nablus	784,382
Qalqilya	375,520
Salfeet	126774
Tulkarem	3410010
Jenin	910973

- The cost per kWh [NIS/kWh] is determined by equation (3.5),
  Where: $\text{kWh}_{\text{cost}} = \frac{\text{AW}}{\text{annual kWh}_{\text{prod}}}$

- AW for Bardala village =69478 NIS/year
- Annual kWh production as the pervious section (5.3) is 843303 kWh
- kWh Cost =0.0812NIS/kWh

The kWh Cost of biogas plant for all villages in Tubas governorate was calculated and the results are given in Table (5.13).

Table (5. 13): The cost of one kWh for proposed biogas plants for Tubas governorate

Village	AW(NIS)	cost(NIS)/kWh
Bardala	69478	0.0812
'Ein el Beida	56896	0.0820
Kardala	55767	0.0865
Ibziq	42554	0.1295
Salhab	31314	0.3199
'Aqqaba	38222	0.1717
Tayasir	36467	0.1863
Al Farisiya	35017	0.2124
Al 'Aqaba	32973	0.2563
AthThaghra	27535	1.1125
Al Malih	98679	0.0645
Tubas	67403	0.0806
Kashda	28085	0.7835
Khirbet Yarza	44345	0.1125
Ras al Far'a	39236	0.1494
El Far'a Camp	28824	0.5027
Khirbet arRas alAhmar	51494	0.1093
Wadi al Far'a	39435	0.1525
Tammun	60082	0.1047
Khirbet 'Atuf	49597	0.1137
Khirbet Humsa	41340	0.1465

- It is noted from figure (5.1), the curve starts sloping when the volume of digester is about $100m^3$; which is considered as critical point for determining the feasible volume for construct decentralized biogas power plant, also if the volume of digester less than $100m^3$, the production cost of kWh being more than selling cost. Therefore, it is obvious that the volume of digester needed for decentralized biogas power plant should be greater than $100\ m^3$.

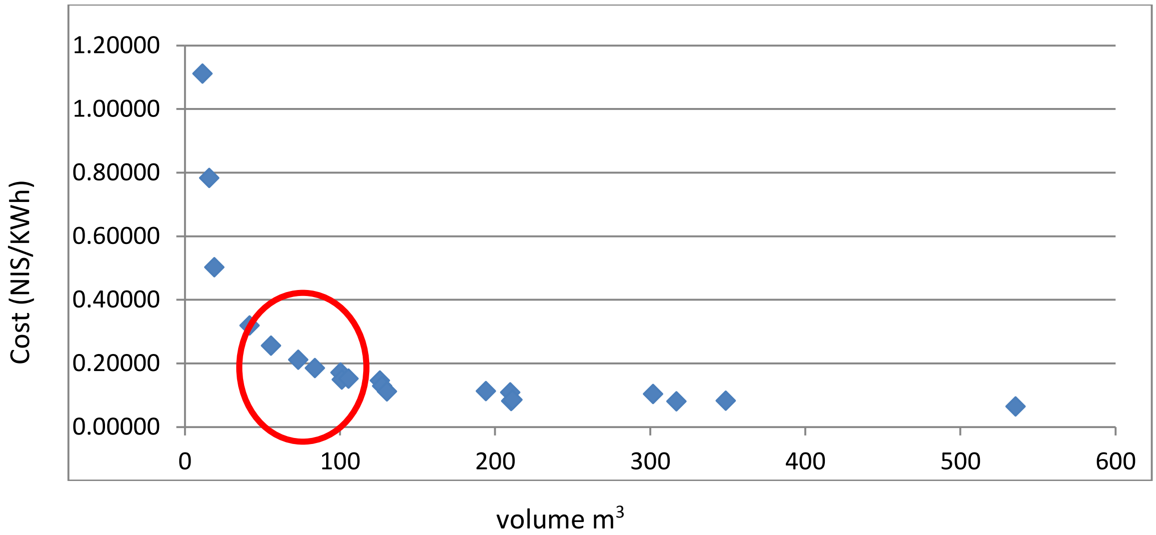


Figure (5. 1): The relationship between volume and cost of produced electrical energy (NIS/kWh)

5.7 Decentralized and Centralized Power Plant

5.7.1 Proposed Decentralized Biogas Plant for Tubas Governorate

A distributed energy system is a relatively new approach in the power industry in most countries. Traditionally, the power industry has focused on developing large, central power stations and transmitting generation loads across long transmission and distribution lines to consumers in the region. Decentralized energy systems seek to put power sources closer to the end user. A decentralized system, are suitable in rural areas where the population density is low. Often much more economically feasible than centralized power plant. [41]

For the purpose of centralizing villages to use one digester, then all villages with digester volume less than 100m^3 are discarded and all villages that need to use a digester of greater than 100m^3 as grouped. This is illustrated in Figure (5.2).

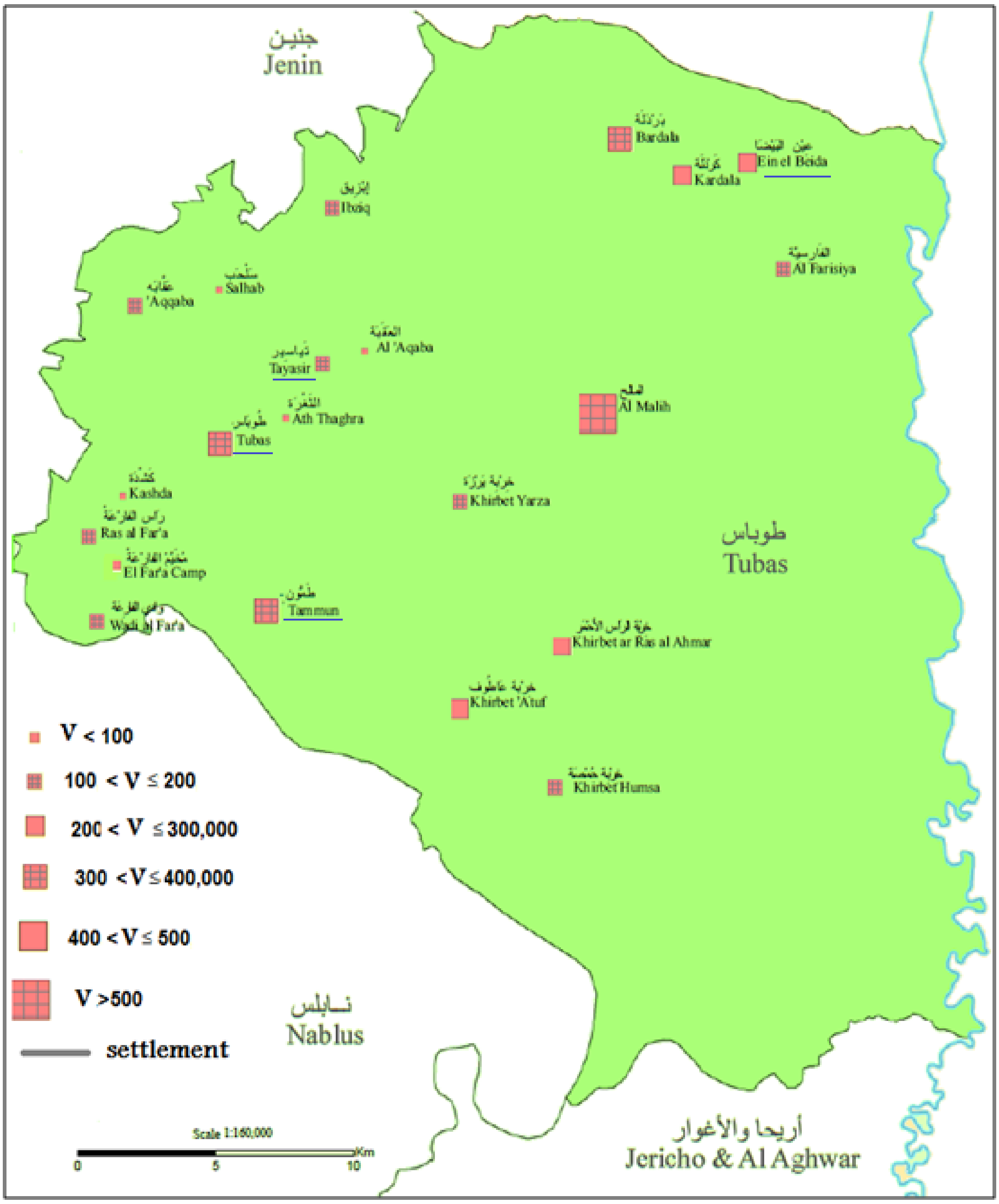


Figure (5. 2):proposed decentralized biogas Plant for Tubas Governorate

5.7.1.1 Payback Period Calculation (P.B.P)

The P.B.P is determined by equations (3.9-12).For example the P.B.P of Bardala village can be calculated as the below method.

- Profit =selling cost – levelized cost of energy
- Profit = 0.3-0.0812 =0.2188 NIS/kWh

- Yearly profit =profit *Electrical Energy =0.2188 * 855,887 =187,268 NIS/year
- P.B.P = AW / Yearly profit =69,478 /187,268=0.37
- 0.3NIS/ kWh was taken to be the sales cost for local municipalities in order to compete the Israel Electric Corporation(IEC) where their selling price is about (0.4-0.45).

The P.B.P was calculated of biogas plant for all villages in Tubas governorate as the same pervious method as shown in Table (5.14)

Table (5. 14): P.B.P of Proposed Decentralized biogas power plant for Tubas Governorate

Village	P.B.P (year)
Bardala	0.37
'Ein el Beida	0.5
Kardala	0.5
Ibziq	0.9
Salhab	N.F*
'Aqqaba	1.3
Tayasir	1.7
Al Farisiya	2.8
Al 'Aqaba	8.4
AthThaghra	N.F*
Al Malih	0.3
Tubas	0.4
Kashda	N.F*
Khirbet Yarza	0.8
Ras al Far'a	1.1
El Far'a Camp	N.F*
Khirbet arRas al Ahmar	0.6
Wadi al Far'a	1.1
Tammun	0.4
Khirbet 'Atuf	0.6
Khirbet Humsa	1.0

** NF*: not feasible

From Table (5.14), it is noticed that construction a biogas digester at El Far'a Camp, Al 'Aqaba, Kashda and Aththaghra, Salhab are not feasible because the size of digester is less than100 m^3, therefore producing cost of one kWh is higher than selling price.

5.7.2 Proposed Centralized Biogas Plant for Tubas Governorate

Tubas governorate was divided into groups of villages, where the central village is the most manures' producer. Villages were distributed to the groups according to the nearest villages from the central village.

Tubas Governorate was divided into three clusters the main cities in these cluster are: Almalha, Bardala and Tubas in figure (5.3).

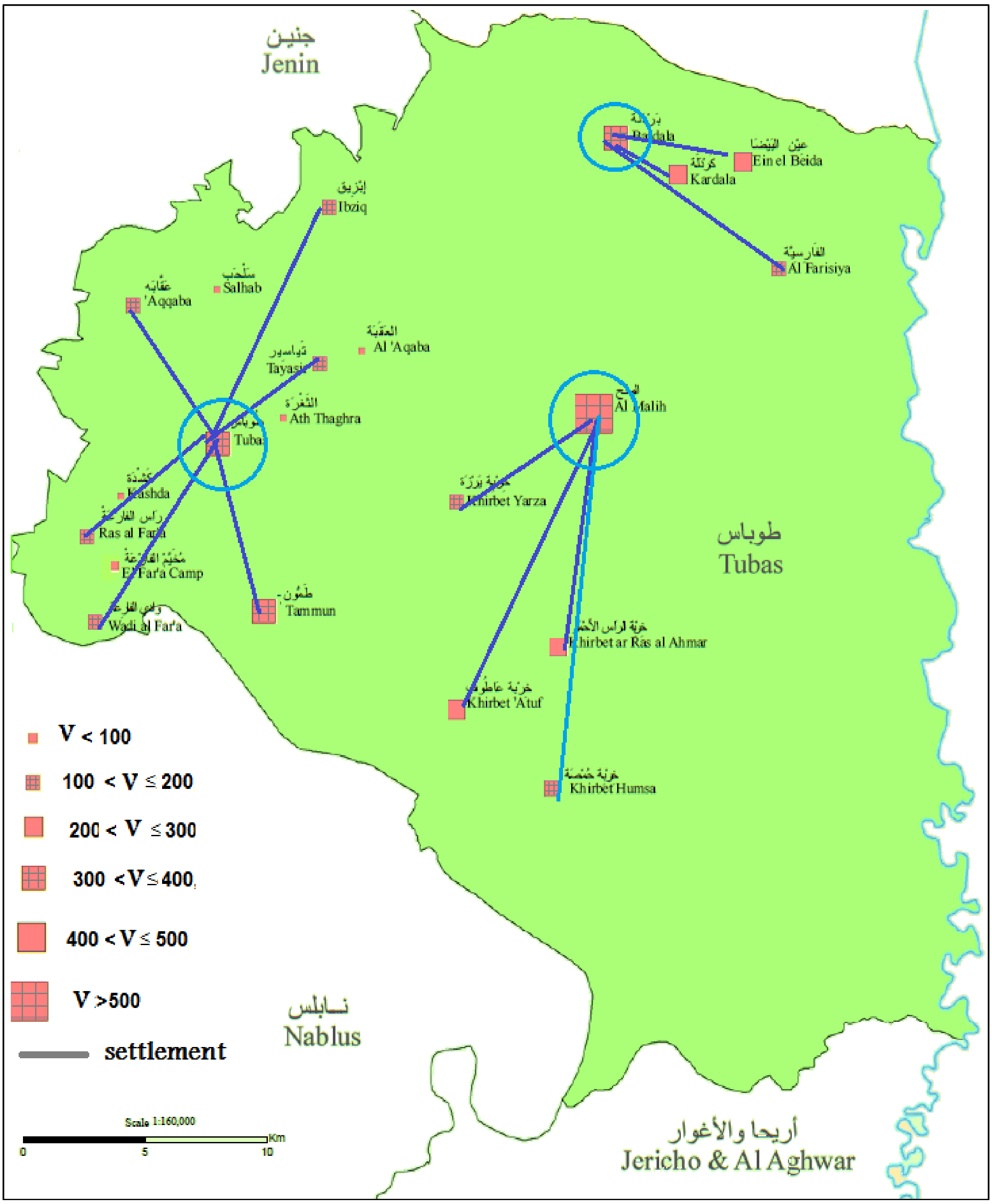


Figure (5. 3): The main proposed clusters in Tubas Governorate

- The first cluster (group 1) as shown in Table (5.15) consists of (Badala, Einalbaida, Kardala and Alfaresia) villages, the main city in this cluster is Bardala which has the highest amount of animal waste and volume of digester in biogas power plant.
- The second cluster (group 2) as shown in Table (5.16) consists of (Almalih, Kherbit Yzara, Kherbit alras, Atuf and Humsa) villages, the main city in this cluster is Almalih which has the highest amount of animal waste and volume of digester in biogas power plant.
- The third cluster (group 3) as shown in Table (5.17) consists of (Ibziq,Tayasir ,Aqaba,Rasalfara,Wadi alfaraa ,Tammun and Tubas) villages , the main city in this cluster is Tubas which has the highest amount of animal waste and volume of digester .

In this section the distance to the main city, total cost of transportation, AW and P.B.P was calculated using the following methods. As illustrated below for first cluster:

- Cost of transportation =(188+0.9*total distance) /total amount of waste

- Cost of transportation =(188+(0.9*(12*2)/25.9=8.1 NIS/ton

Where the total animals waste calculated without animals waste of Bardala village.

- Total cost of transportation = cost of transportation *total wet waste *No. of working days.

- Total cost of transportation =8.1*25.9*365*0.9=68,854 NIS/Year

- AW with transportation cost of centralized biogas power plant

=total cost of transportation+ total AW of all villages

- AW with transportation cost=68,854+126,873 =195,726 NIS

- P.B.P=0.5 year as shown previously

Table (5. 15): calculation for first cluster (group 1) in proposed centralized biogas power plant for Tubas Governorate

Village	NO. of Animals	wet waste kg/day	Biogas (m^3)	Electricity (kWh)	Vd (m^3)	Power (kw)	Total cost of decen. plant (NIS)	AW of decen. Plant (NIS)	distance to (bardala km)	Total Cost of Cent. plant (NIS)	AW of Cent. plant (NIS)	Total Cost of trans. (NIS)	AW including Trans. costs(NIS)	P.B.P
Bardala	16,425	18,891	1,357	855,887	343	97	390,729	69,478	-	713,505	126,873	68,854	195,726	0.5
Einalbaid	1,347	11,385	815	514,174	206	59	294,065	52,290	4					
Kardala	4,754	11,134	797	502,861	202	57	290,834	51,715	1.5					
Alfaresia	2,087	3,407	244	153,881	62	18	191,166	33,993	6.5					
Total	24,613	41,410	2,969	1,782,922	751	213								

Table (5.16): calculation for second cluster (group 2) in proposed centralized biogas power plant for Tubas Governorate

<table>
<tr><th>Village</th><th>NO. of Animals</th><th>Wet waste kg/day</th><th>Biogas (m3)</th><th>Electricity (kWh)</th><th>Vd (m3)</th><th>Power (kw)</th><th>Total cost of plant (NIS)</th><th>AW (NIS)</th><th>distance to (Almalih) km</th><th>Total Cost of Cent. plant (NIS)</th><th>AW of Cent. plant (NIS)</th><th>Total Cost of trans. (NIS)</th><th>AW including Trans. costs(NIS)</th><th>P.B.P</th></tr>
<tr><td>Al Malih</td><td>8,405</td><td>27,275</td><td>1,953</td><td>1,231,796</td><td>494</td><td>141</td><td>499,017</td><td>88,733</td><td>-</td><td rowspan="6">908,149</td><td rowspan="6">161,484</td><td rowspan="6">80,324</td><td rowspan="6">239,828</td><td rowspan="6">0.435</td></tr>
<tr><td>Khirbet Yarza</td><td>1,581</td><td>6,794</td><td>486</td><td>306,829</td><td>123</td><td>35</td><td>234,848</td><td>41,760</td><td>4.5</td></tr>
<tr><td>Khirbet ar Ras</td><td>6,026</td><td>9,762</td><td>699</td><td>440,882</td><td>177</td><td>50</td><td>273,133</td><td>48,568</td><td>7</td></tr>
<tr><td>Khirbet atuf</td><td>13,921</td><td>9,317</td><td>667</td><td>420,789</td><td>169</td><td>48</td><td>267,395</td><td>47,547</td><td>10</td></tr>
<tr><td>Khirbet humsa</td><td>3,609</td><td>5,847</td><td>419</td><td>264,046</td><td>106</td><td>30</td><td>222,630</td><td>39,587</td><td>11</td></tr>
<tr><td>Total</td><td>33,542</td><td>58,995</td><td>4,224</td><td>2,664,343</td><td>1,069</td><td>304</td><td colspan="3"></td></tr>
</table>

Table (5. 17): calculation for third cluster (group 3) in proposed centralized biogas power plant for Tubas Governorate

Village	NO. of Animals	wet waste kg/day	Biogas (m^3)	Electricity (kWh)	Vd (m^3)	Power (kw)	Total cost of plant (NIS)	AW (NIS)	distance to (Tubas) km	Total Cost of Cent. plant (NIS)	AW of Cent. plant (NIS)	Total Cost of trans. (NIS	AW including Transportation costs(NIS)	P.B.P
Ibziq	2,728	6,225	446	281,130	113	32	227,509	40,455	8	897,012	159,504	80,979	242,281	0.44
Tayasir	9,346	4,870	349	219,944	88	25	210,034	37,348	4.5					
Al 'Aqaba	9,388	4,205	301	189,892	76	22	201,451	35,821	3.5					
Ras al Far'a	13,594	5,372	385	242,615	97	28	216,509	38,499	4.5					
Wadi al Far'a	11,824	5,388	386	243,351	98	28	216,719	38,536	6.5					
Tammun	51,364	15,734	1127	710,600	285	81	350,164	62,265	4.5					
Tubas	26,650	16,337	1170	737,815	296	84	357,937	63,647	-					
Total	124,894	58,131	4,162	2,625,347	1,053	300								

5.7.2.2 Summary of Proposed Centralized Biogas Power Plant for Tubas Governorate

We note that the cluster of Almalih has the largest amount of biogas production. Consequently, it has the largest volume of digester. Also, it has the largest total cost of other plants. On the other hand, P.B.P values shows that all the clusters are feasible as shown in Table (5.18).

Table (5. 18): Summary of proposed centralized biogas power plant for Tubas Governorate

Clusters	No. of Animals	Total Dry	Biogas (m^3)	Electricity kWh/year)	V (m^3)	P (kw)	Total cost (NIS)	AW (NIS)	AW with trans.	P.B.P
Almalih	33,542	11,873	4,224	2,664,343	1,069	304	908,149	161,484	242,281	0.435
Tubas	124,894	11,699	4,162	2,625,347	1,053	300	897,012	159,504	239,828	0.44
Bardala	24,613	8,836	3,144	1,982,812	795	226	713,505	126,873	195,726	0.69

5.8 Comparison of Cost between the Proposed Centralized and Decentralized Biogas Plant

Due to results obtained from comparison between the centralized and decentralized biogas plants, we noticed the centralized biogas power plants are the best, because the payback period is shorter than Decentralized biogas plant as shown in Table (5.19).

Table (5. 19): P.B.P of proposed centralized and decentralized biogas plants for Tubas Governorate

Cluster	P.B.P (Centralized) year	P.B.P (Decentralized) year	Result
Almalih	0.435	2	**Centralized**
Tubas	0.44	1.5	**Centralized**
Bardala	0.5	1.9	**Centralized**

5.9 The Percentage of Waste which can be used in Centralized Plant

The following relationship is used to calculate the Percentage of waste used in each centralized plant.

Waste in centralized plant (%) =total waste of centralized plant /total waste of decentralized plant.

As shown in Table (5.20) we notice that the highest percentage of waste (95 %) are in the Tubas and Jericho governorate but the lower percentage of waste (50 %) is in Ramallah governorate .

Table (5. 20): The Percentage of waste used in proposed centralized plant

Governorate	The Percentage of waste %
Tubas	95
Hebron	87
Bethlehem	65
Jericho	95
Ramallah	50
Nablus	78
Qaliqulia	73
Tulkarem	71
Jenin	73

5.10 Summary of Proposed Centralized Biogas Power Plants for All Governorates

5.10.1Proposed Centralized Biogas Power Plants for Hebron governorate

Hebron governorate was divided into six clusters, the main cities are: Halhul, Qalqas, Ithna, Aldaheria, Yata, and Alsamou as shown in figure (5.4) and the related information for these cluster are listed in Table (5.21), as seen the highest biogas production, volume of digester and total cost were in (group 2: Qalqas) in the Hebron Governorate, but the Halhul cluster has the lowest biogas production, volume of digester and total cost. Also, all plants were feasible economically in the centralized and decentralized biogas plants.

Also we noticed that the shortest payback period of centralized biogas plant was in (group 4: Aldaheria) and the shortest payback period of decentralized biogas plant was in (group 1: Halhul).

The summary of Potential Biogas Production and Economic Analysis for Hebron Governorate is shown in appendix A.

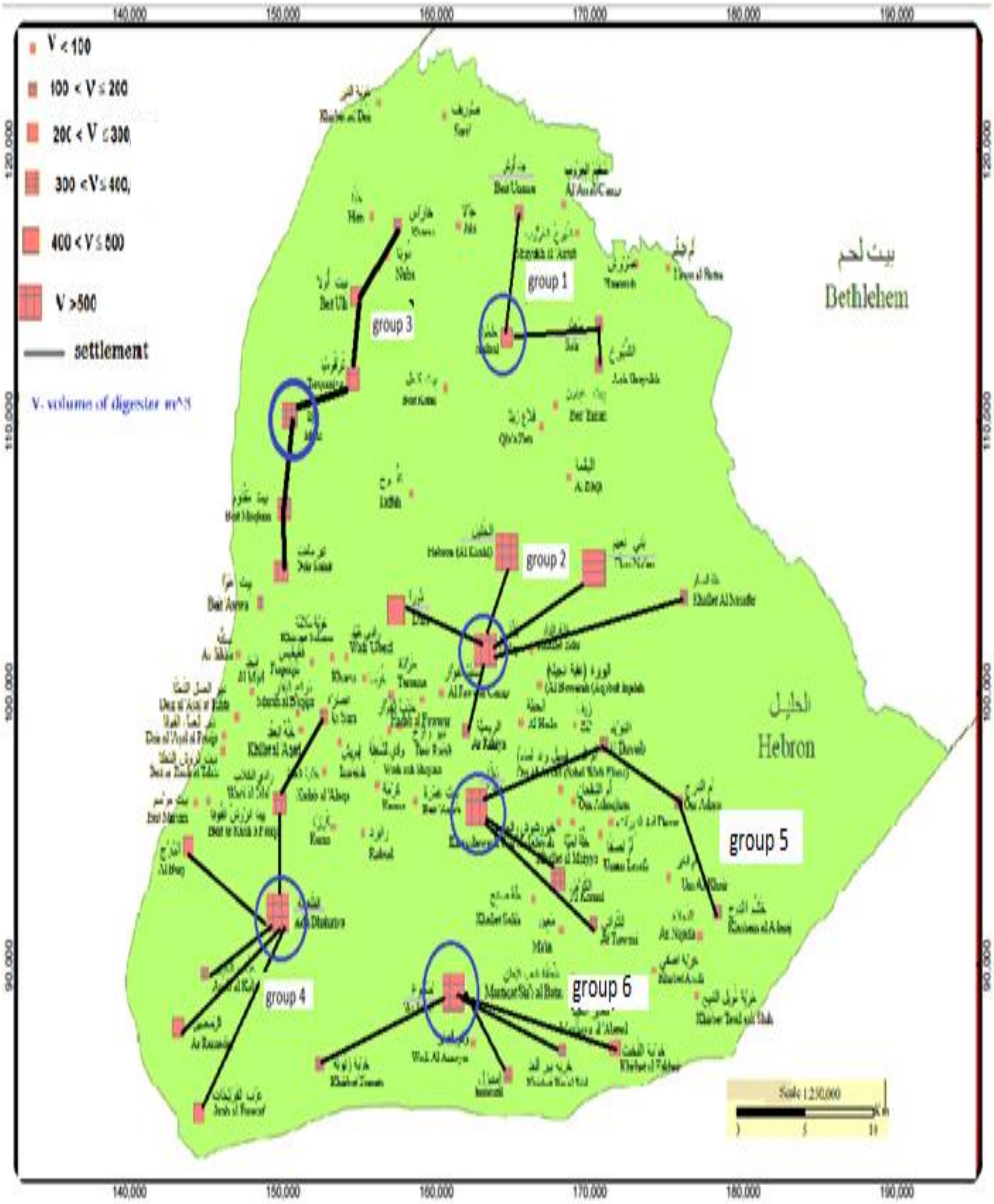


Figure (5. 4): Proposed Centralized biogas plant for Hebron governorate

Table (5. 21): Size and economical summary of proposed centralized biogas plants for Hebron Governorate plant

No. of cluster	Cluster	No. of Animals	Total wet waste kg/day	Total dry waste kg/day	Biogas yield-m^3	Electricity kWh	volume (m^3)	Power (kw)	Total cost of plant	AW including Transportation costs(NIS)	P.B.P (Cent.)	P.B.P (Decent.)
Group 1	**Halhul**	109,627	35,291	7,102	2,527	1,593,815	639	182	602,409	122,542	0.34	1.6
Group 2	**Qalqas**	276,372	200,877	40,426	14,384	9,072,100	3,638	1,036	2,738,191	790,149	0.41	3.4
Group 3	**Ithna**	148,001	88,456	17,802	6,334	3,994,903	1,602	456	1,288,154	311,804	0.35	2.1
Group 4	**Aldaheria**	155,377	100,782	20,282	7,216	4,551,585	1,825	520	1,447,142	329,283	0.32	2.3
Group 5	**Yata**	77,217	64,905	13,062	4,648	2,931,280	1,176	335	984,386	251433	0.40	1.9
Group 6	**Alsamou'**	180,221	65,478	13,178	4,689	2,957,170	1,186	338	991,780	253,280	0.40	2.2

5.10.2 Proposed Centralized Biogas Power Plants for Bethlehem Governorate

Bethlehem governorate was divided into two clusters the main cities in these cluster are: taqu and arab alrashayda as shown in figure (5.5) and Table (5.22).

It is noted that the clusters are few at Bethlehem Governorate, and the Livestock is not wildly available.

The highest biogas production, volume of digester and total cost were in (taqu’) in Bethlehem Governorate, and the shortest payback period was in Arab alrashaydah city.

Summary of Potential Biogas Production and Economic Analysis for Bethlehem Governorate is shown in appendix B.

Table (5. 22): Size and economical summary of proposed centralized biogas plants for Bethlehem Governorate

No. of cluster	Cluster	No. of Animals	Total wet waste kg/day	Total dry waste kg/day	Biogas yield-m^3	E (KWh)	V (m^3)	Power (kw)	Total cost of plant	AW with Trans. costs(NIS)	P.B.P (Cent.)	P.B.P Decent
Group 1	Taqu’	137,961	10,915	3,884	2,449,407	982	280	846,764	150,569	233377	0.47	1.39

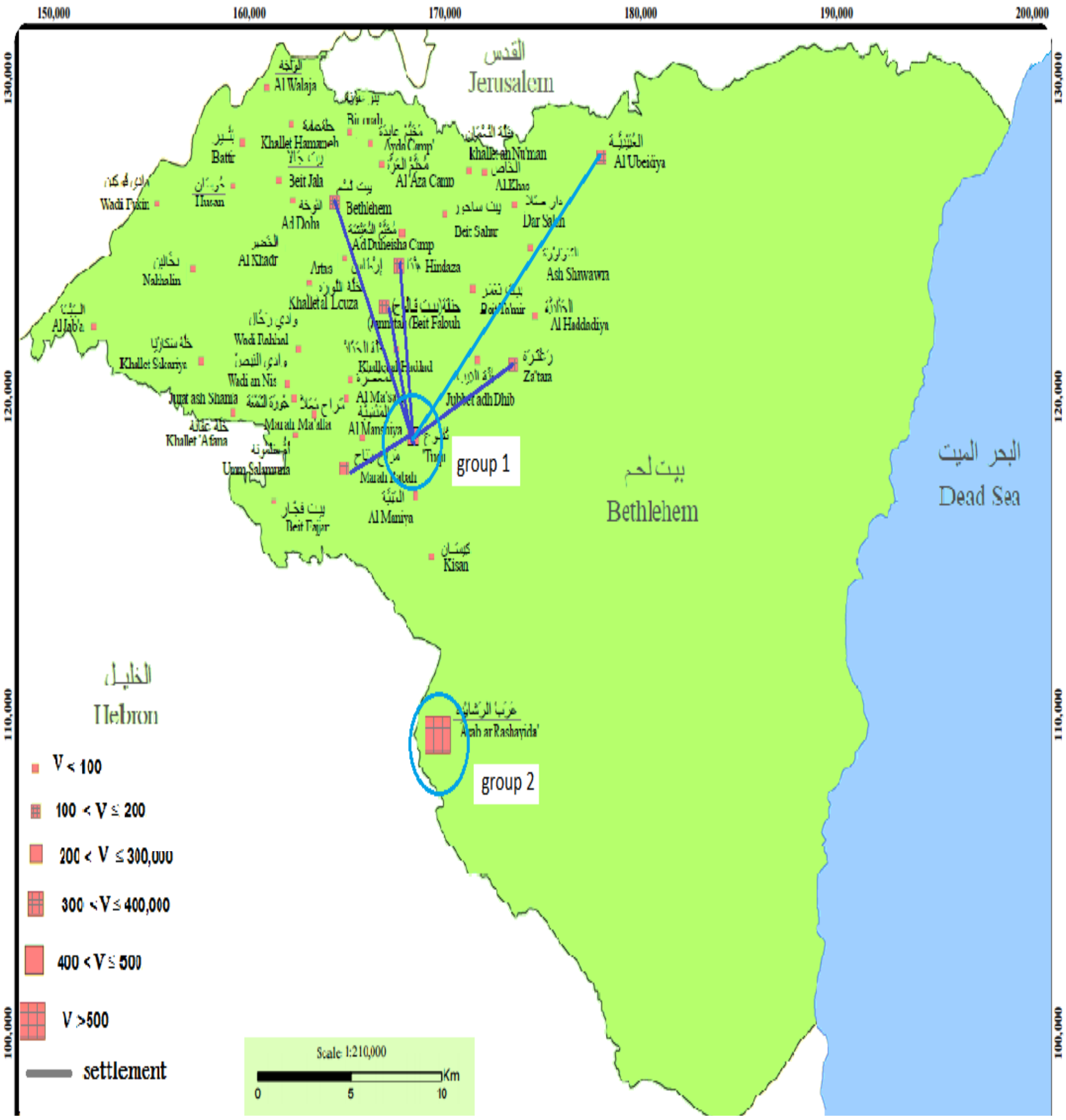


Figure (5. 5): Proposed Centralized biogas power plant for Bethlehem Governorate

5.10.3Proposed Centralized Biogas Power Plants for Jericho Governorate

Jericho governorate was divided into two clusters the main cities in these cluster are: jiftlek and aloja as shown in figure (5.6) and Table (5.23).

Table (5. 23): Size and economical summary of proposed centralized biogas plants for Jericho Governorate

No. of cluster	Cluster	NO. Animals	total dry waste kg/day	Biogas yield (m^3)	E (kWh)	V (m^3)	Power (kw)	Plant cost (NIS)	AW (NIS)	AW with Trans. costs	P.B.P (Cent.)	P.B.P (Decent)
Group 1	**Jiftlek**	15,515	6,871	2,445	1,541,954	618	176	587,597	104,485	480,547	0.6	2.54
Group 2	**Aloja**	264,388	22,163	7,886	4,973,608	1,995	568	1,567,671	278,758	764,736	0.33	2.64

The highest biogas production, volume digester and total cost were in (aloja) in Jericho Governorate, and the shortest payback period at centralized biogas plant was in aloja cluster but has the larger P.B.P than other.

Summary of Potential Biogas Production and Economic Analysis for Jericho governorate is shown in appendix C.

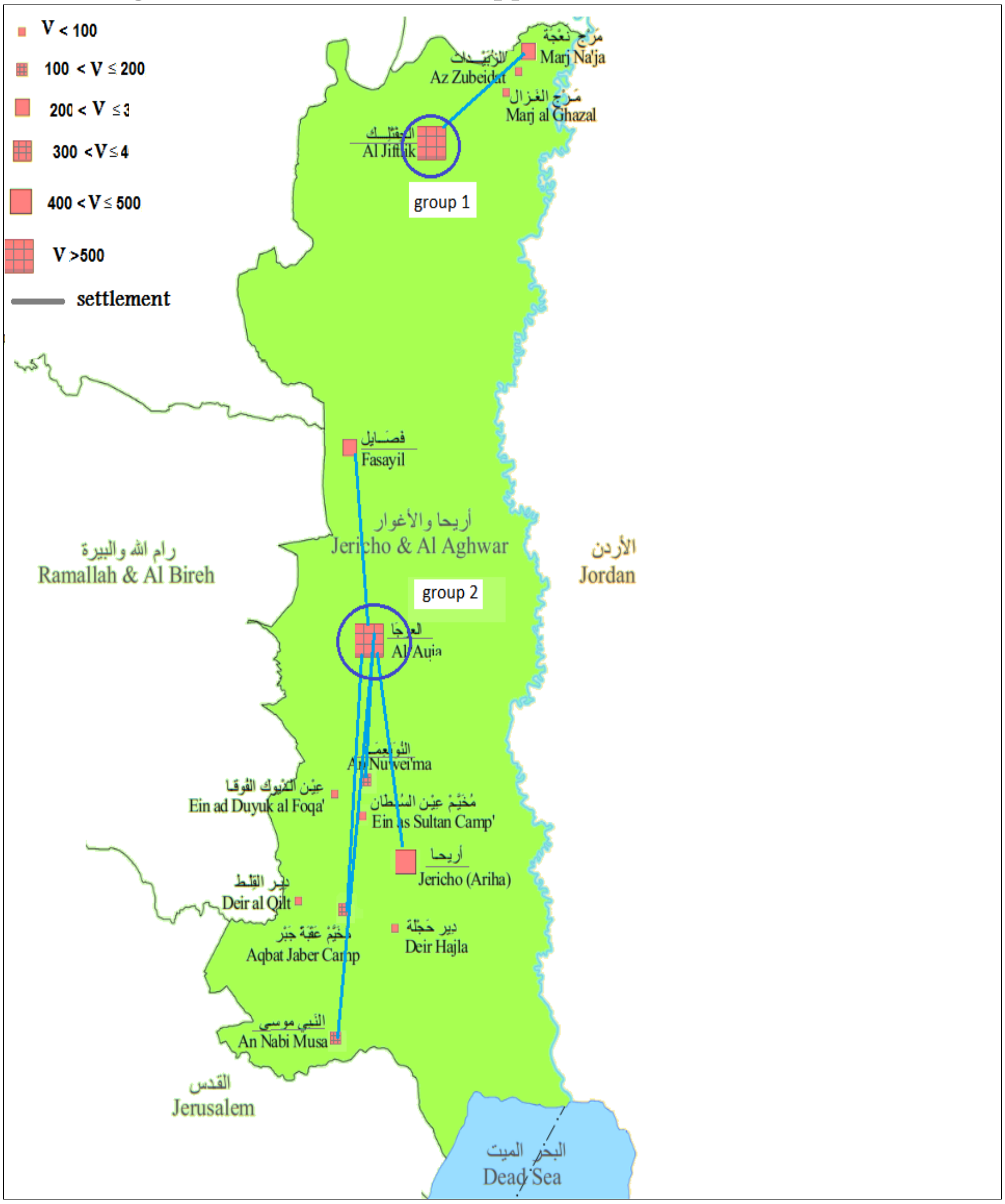


Figure (5. 6): Proposed Centralized biogas power plant for Jericho Governorate

5.10.4 Proposed Centralized Biogas Power Plants for Ramallah Governorate

Ramallah governorate was divided into two clusters the main cities in these cluster are: Beitliqya and Badiw almuarajat as shown in figure (5.7) and Table (5.24).

Table (5. 24): Size and economical summary of proposed centralized biogas plants for Ramallah Governorate

No. of cluster	cluster	NO. Animals	Total dry waste kg/day	Biogas yield (m^3)	E (kWh)	V(m^3)	P (kw)	total cost (NIS)	AW (NIS)	AW with Tran.	P.B.P (Cent.)	P.B.P (Decent)
Group 1	Beitliqya	168,845	8,554	3,043	1,919,493	770	219	695,422	123,658	217,346	0.61	1.52
Group 2	Badiw al Mu'arrajat	36,814	7,785	2,770	1,746,930	701	199	646,138	114,894	567,191	0.59	1.39

It is noted that the livestock is rare at Ramallah Governorate and the clusters for centralized biogas plant are feasible.

Beitliqya cluster has the biggest amount of biogas, volume of digester and total cost of plant but the Badiw al Mu'arrajat has the shorter P.B.P than other Summary of Potential Biogas Production and Economic Analysis for Ramallah governorate is shown in appendix D.

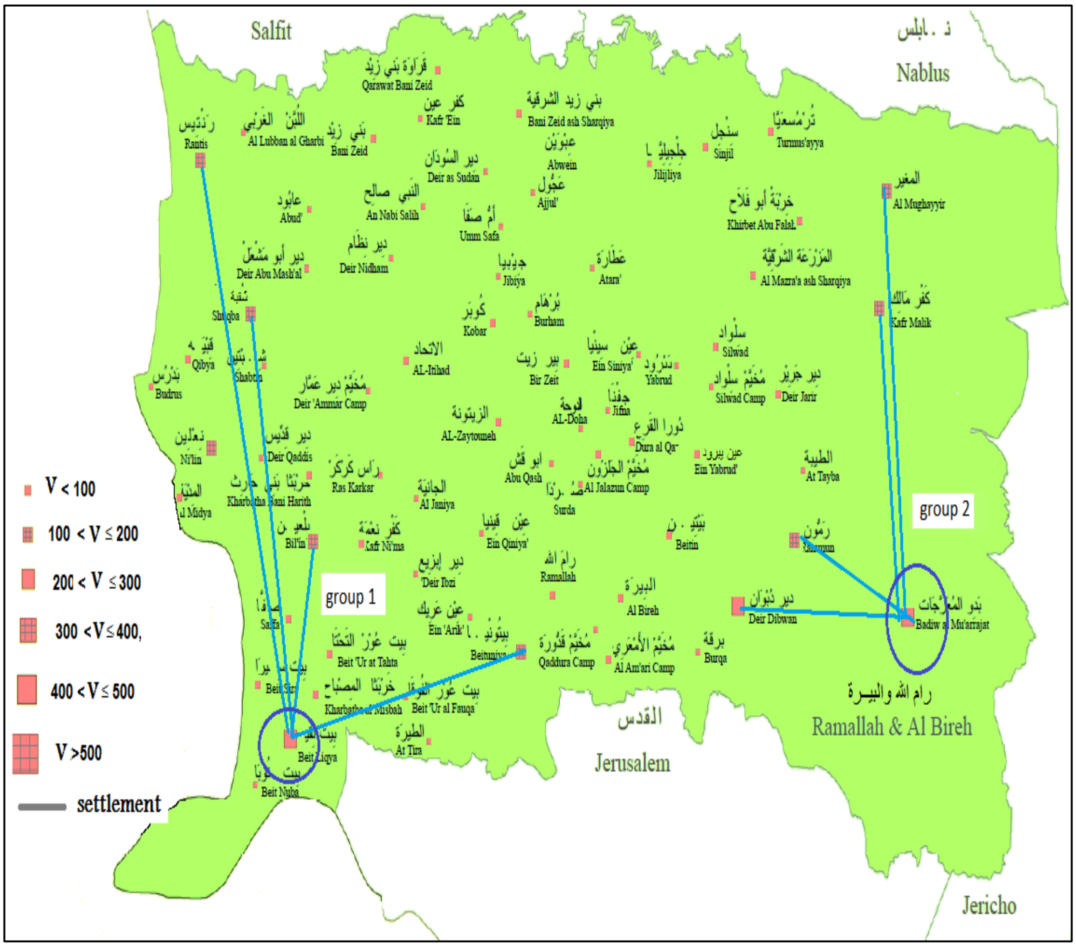


Figure (5. 7): Proposed Centralized biogas power plant for Ramallah Governorate

5.10.5 Proposed Centralized Biogas Power Plants for Nablus Governorate

Nablus governorate was divided into four clusters the main cities in these cluster are: Zawata, Beitforik, Furush Beitdajan and Aqraba as shown in figure (5.8) and Table (5.25).

The highest biogas production, volume of digester and total cost were in (group 1: Zawata) in Nablus Governorate, but the Aqraba cluster is lowest biogas production and volume digester and total cost and all plants were feasible economically stage in the centralized and decentralized biogas plants.

The shortest payback period of centralized and decentralized biogas plants were in (group 2: Beitforek).

Summary of Potential Biogas Production and Economic Analysis for Nablus governorate is shown in appendix E.

Table (5. 25): Size and economical summary of proposed centralized biogas plants for Nablus Governorate

No. of cluster	Cluster	No.of Animals	Total dry waste kg/day	Biogas yield (m^3)	E (kWh)	V (m^3)	P (kw)	Total cost (NIS)	AW (NIS)	AW with Tran.	P.B.P (Cent.)	P.B.P (Decent)
Group 1	Zawata	223,286	19,244	6,847	4,318,465	1,732	493	1,380,563	701,073	327,586	0.34	2.4
Group 2	Beitforek	130,140	11,451	4,074	2,569,653	1,031	293	881,106	553,173	227,746	0.42	1.9
Group 3	Furush BeitDajan	50,877	11,050	3,932	2,479,835	995	283	855,454	562,732	225,739	0.44	2.2
Group 4	Aqraba	126,524	9,694	3,449	2,175,448	872	248	768,522	520,917	204,374	0.46	2.0

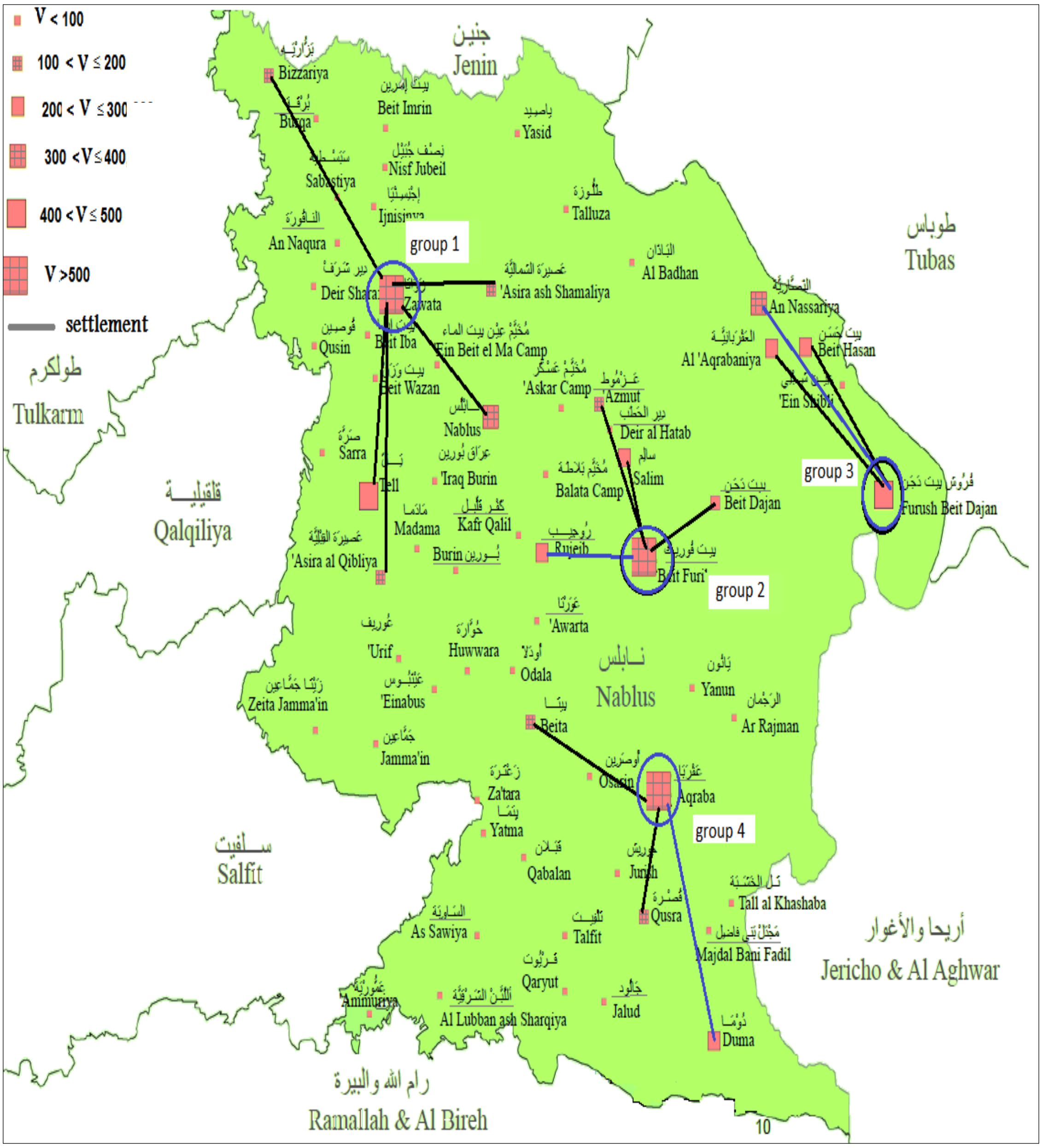


Figure (5. 8): Proposed Centralized biogas power plant for Nablus Governorate

5.10.6 Proposed Centralized Biogas Power Plants for Qalqilya Governorate

Qalqilya governorate was divided into two clusters the main cities in these cluster are: Kuferqadom and Qalqulia as shown in figure (5.9) and Table (5.26).

Table (5. 26): Size and economical summary of proposed centralized biogas plants for Qalqilya Governorate

No. of cluster	Cluster	NO. of Animal	Total dry waste kg/day	Biogas yield (m^3)	E (kWh)	V (m^3)	P (kw)	Total cost (NIS)	AW (NIS)	AW with Tran.	P.B.P (Cent.)	P.B.P (Decent)
Group 1	Kuferqadom	155,331	5,343	1,901	1199080	481	137	489,673	87,072	154684	0.754	1.6
Group 2	Qalqulia	366,964	16,779	5,970	3765314	1,510	430	1,222,584	217,396	287728	0.342	2.24

We note that the livestock at Qalqilya Governorate is few and the Qalqilya cluster has the biggest amount of biogas, volume of digester, total cost of plant but and the shorter P.B.P than other.

Summary of Potential Biogas Production and Economic Analysis for Qalqilya governorate is shown in appendix F.

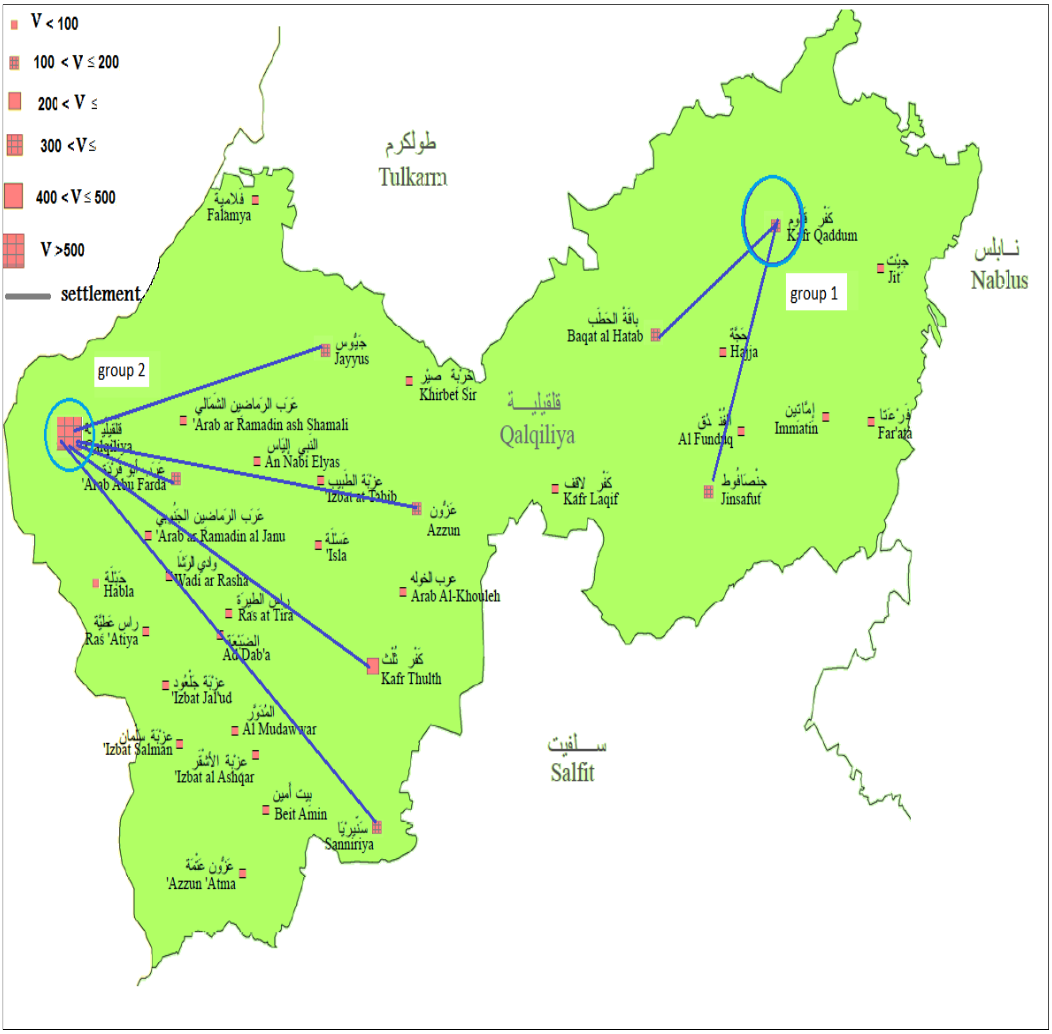


Figure (5. 9): Proposed Centralized biogas power plant for Qalqilya Governorate

5.10.7 Proposed Centralized Biogas Power Plants for jenin Governorate

Jenin governorate was divided into four clusters the main cities in these cluster are: jenin ,arba, seltaldaher and qabatia as shown in figure (5.10) and Table (5.27).

Table (5. 27): Size and economical summary of proposed centralized biogas plants for jenin governorate

No. of cluster	Location	NO. of Animal	Total dry waste kg/day	Biogas yield (m^3)	E (kWh)	V (m^3)	P (kw)	Total cost (NIS)	AW (NIS)	AW with Tran.	P.B.P (Cent.)	P.B.P (Decent)
Group 1	Jenin	152,364	15,989	5,689	3,588,203	1,439	410	1,172,002	688,922	293279	0.37	2.17
Group 2	araba	238,430	10,230	3,640	2,295,770	921	262	802,885	564,281	217415	0.46	1.78
Group 3	Seltaldaher	202,468	19,917	7,087	4,469,673	1,793	510	1,423,748	666,053	326514	0.32	2.75
Group 4	qabatia	302,554	13,807	4,912	3,098,362	1,243	354	1,032,104	627,330	263318	0.40	2.22

Seltadher cluster has the biggest amount of biogas, volume of digester, total cost of plant and the shorter P.B.P of centralized plant than other, but araba cluster has shortest P.B.P. Also, all of the proposed centralized biogas plants are feasible.

Summary of Potential Biogas Production and Economic Analysis for jenin governorate is shown in appendix G.

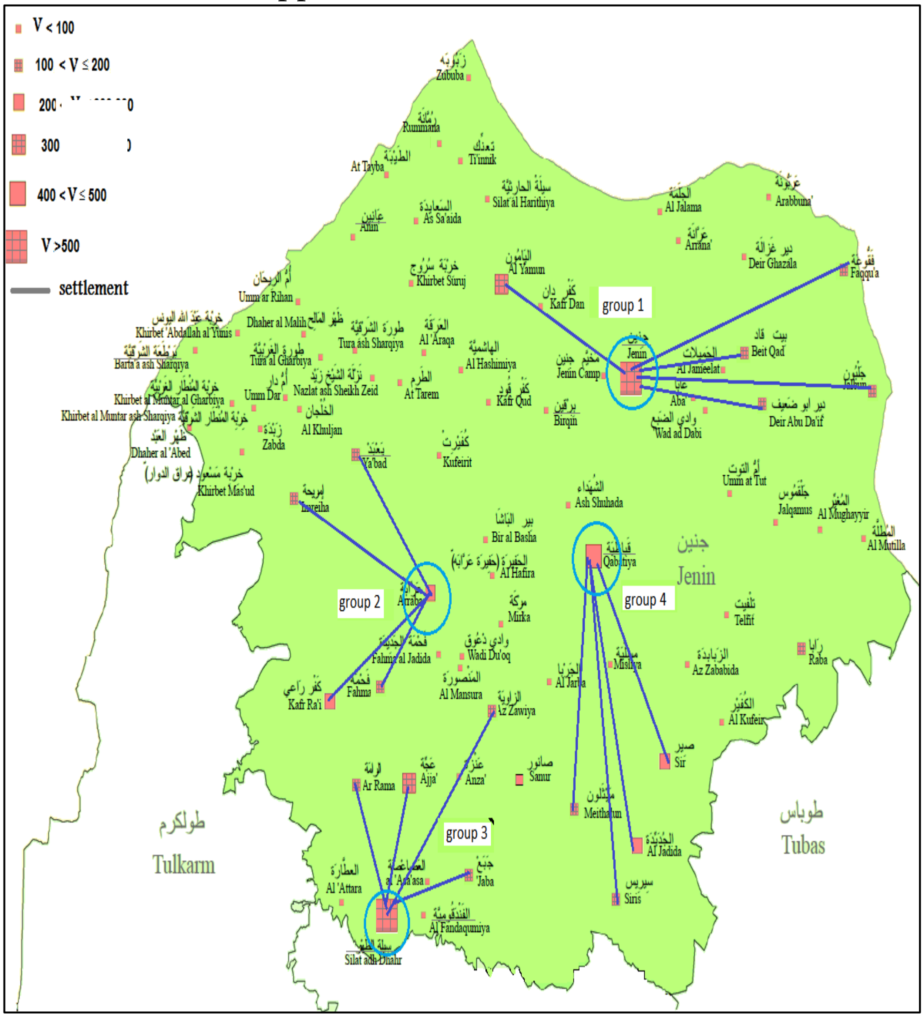


Figure (5. 10): ProposedCentralized biogas power plant for Jenin Governorate

5.10.8 Proposed Centralized Biogas Power Plants for Tulkarem Governorate

Tulkarem governorate is consisted of one cluster the main city of this cluster is: Bal'a as shown in figure (5.11) and Table (5.28).

Table (5. 28): Size and economical summary of proposed centralized biogas plants for Tulkarem Governorate

No. of cluster	Cluster	NO. of Animal	Total dry waste kg/day	Biogas yield (m^3)	E (kWh)	V (m^3)	P (kw)	Total cost (NIS)	AW (NIS)	AW with Tran. (NIS)	P.B.P (Cent.)	P.B.P (Decent)
Group 1	Bal'a	418,710	18,804	6,690	4,219,759	1,692	482	1,352,373	240,474	333105	0.34	2.1

Bal’a cluster is the only cluster in tulkarem governorate which has a large amount of biogas comparing with the other governorate clusters, and the P.B.P in centralized and decentralized are feasible.

Summary of Potential Biogas Production and Economic Analysis for Tulkarem governorate is shown in appendix H.

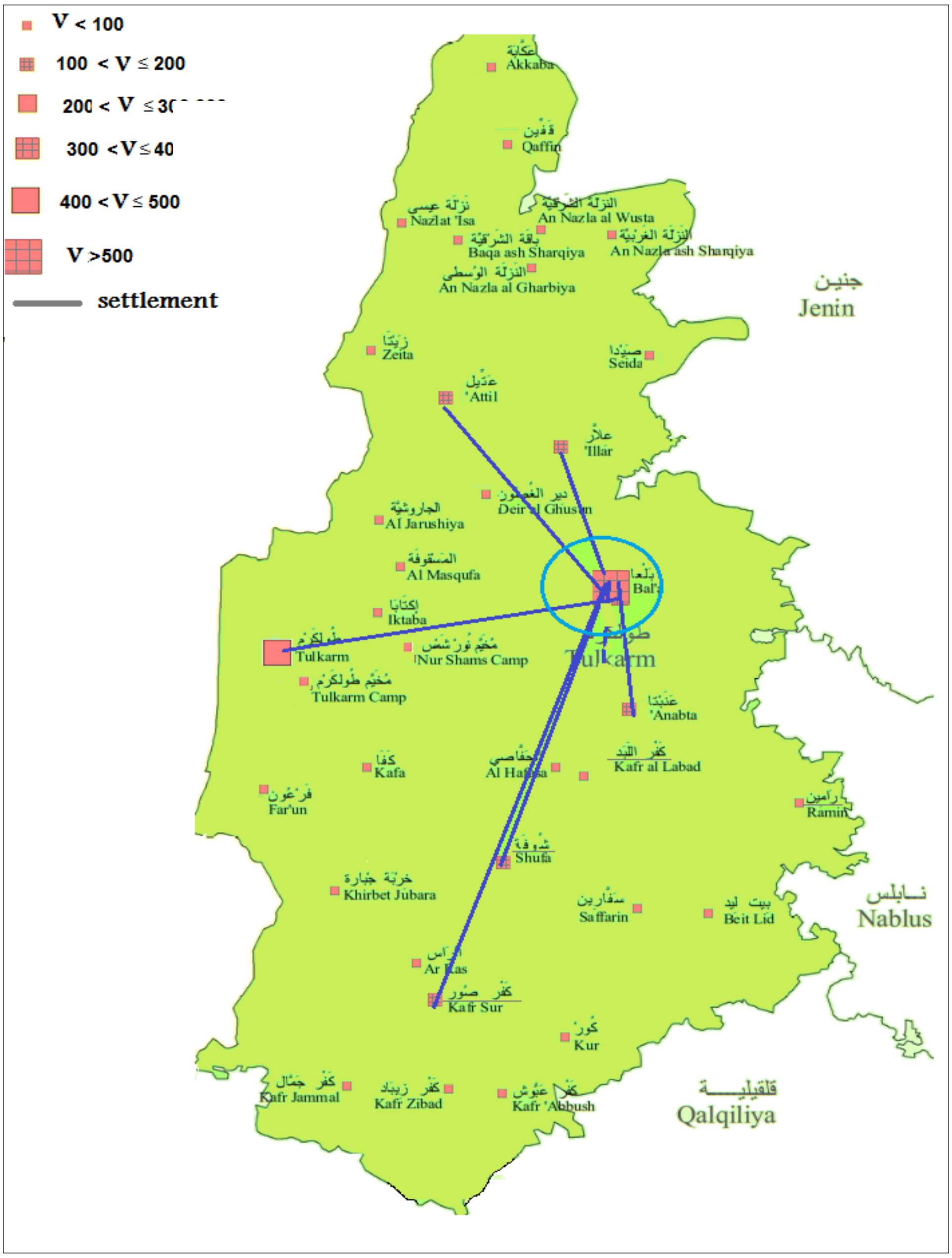


Figure (5. 11): Proposed Centralized biogas power plant for Tulkarem Governorate

5.10.9 Proposed Decentralized Biogas Power Plants Salfeet Governorate

It is noted that proposed centralized biogas plants couldn't be for Salfeet Governorate, because the volume of the digester is less than 100 m^3 and all the plants can be decentralized biogas plant as shown in figure (5.13).

Summary of Potential Biogas Production and Economic Analysis for Salfeet governorate is shown in appendix I.

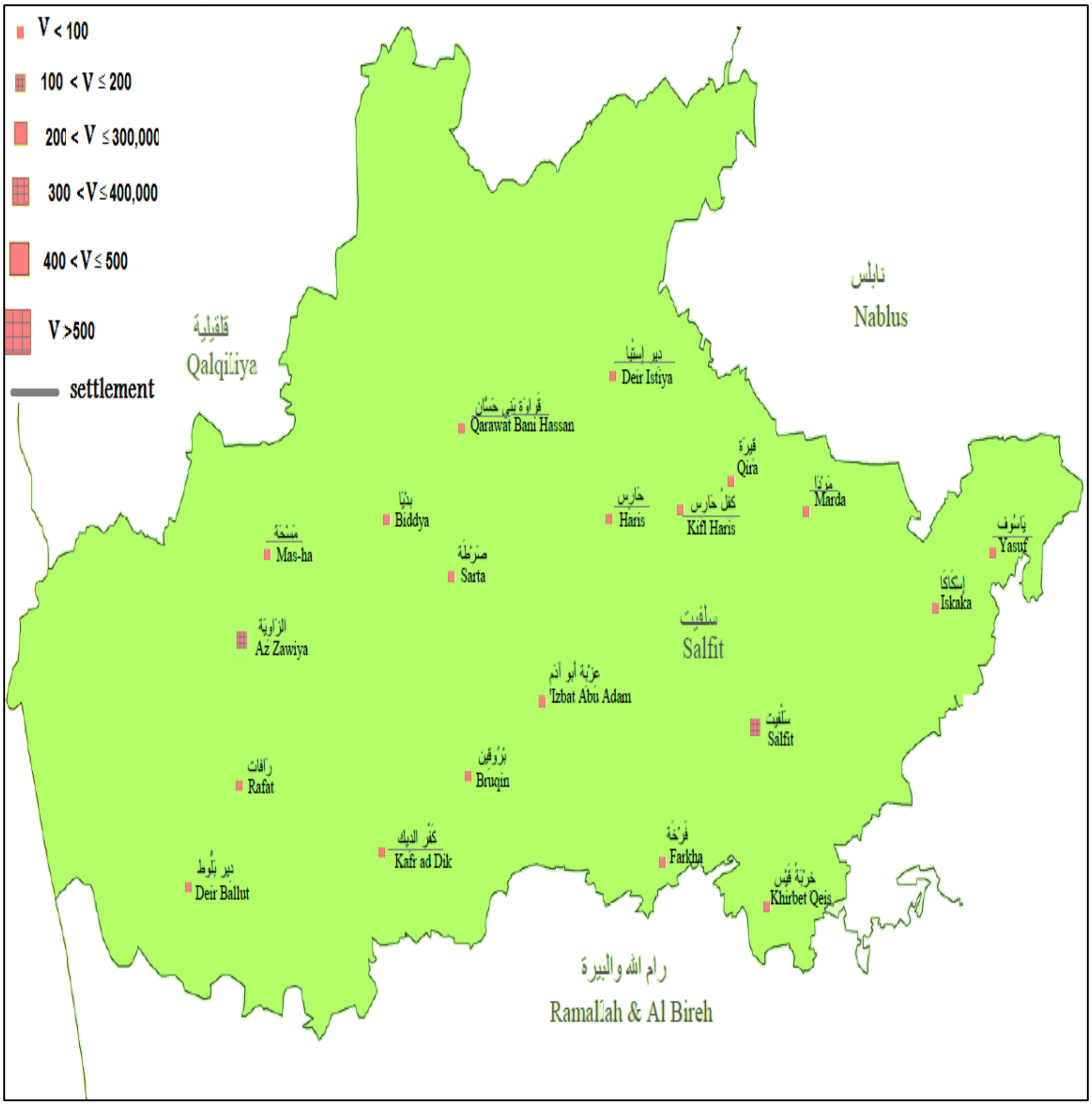


Figure (5. 12): Proposed Centralized biogas power plant for Salfeet Governorate

Chapter six

Conclusions and recommendations

Chapter six

Conclusions and recommendations

6.1 Conclusions

Based on this study the following conclusions can be drawn:

- Under ideal conditions temperature 35C°, pH value of 6-7, and retention time 40 days, it is possible to produce about 0.36m^3 of biogas per kg dry waste at atmospheric pressure.
- In this study it is obvious that to construct a feasible biogas power plant, the minimum required digester volume is more than 100 m^3. This can be obtained by: 200 cattle, 3000 sheep or goat, 10000 broilers, 40000 layers, 12000 turkeys.
- The potential of biogas production from 100 m^3 digester is about 400 m^3/day, which is equivalent to 30kW and annually electricity production is about 236, 52 MWh.
- Based on the local selling price, the 0.3NIS/ kWh is considered as the selling price of electricity to compete the municipality of Israel Electric Corporation (IEC).
- The amount of yearly energy production for all proposed biogas power plant in all governorate is about 104.8 GWh which is equivalent 2% of Palestinian energy consumption, resulting in enough power to supply 33,590 home in West bank according to the Average Household Consumption of Energy is about 260 kWh.
- It is obvious from analysis, the proposed Hebron governorate biogas power plant has the biggest amount of biogas production from all

governorates, which has 45,670 m^3 daily biogas production which equivalent to 28.8GWh yearly electrical energy production, and the biggest proposed biogas power plant in Hebron governorate is Qalqas biogas power plant with 6,776 m^3daily biogas production. The least biogas production in Salfeet governorate, with 2,860 m^3daily biogas production which is equivalent to 2 GWh yearly electrical energy production.

- Centralized biogas power plants were found to be more viable than decentralized plants as the payback period is shorter, and the social and environmental impacts were better. Centralized biogas power plants need less land, it produces less noise, lower emission & pollution on nearest residents in addition to more ease for obtaining permission, monitoring, and control of operation.
- (95 %) of total waste can be utilized in case of using Centralized plant in Tubas and Jericho governorates were only (50 %) can be utilized in Ramallah governorate.
- Furthermore, the negative potential environmental impact in centralized biogas power plant is less than decentralized biogas power plant. The environmental analysis shows that using such a biogas power plant preserves the environment of production 100,000 ton of CO_2 per year if produced by coal.
- One of the advantages of biogas plants is the value of digestion residues which may be used as liquid or solid fertilizer.

6.2 Recommendations:

The main recommendations that can be suggested from this study can be listed as below

1- It is recommended to conduct a detailed study for the calculation of the cost of construction a biogas digester. The study should be based on the labor and construction material cost in the local market.

2- Since the biodigester volume was found to be the critical point in determining wither the system is feasible or not, the effect of solid/ water ratio should be investigated for their relation with the retention time.

3- Shortening the retention time has a big effect on the system volume, as a rule of thumb, most bidigesters are designed based on 40 days retention time, but the biogas production rate may be very low after 20 days. Thus optimal retention time based on the thermophilic condition (37 ^{o}C) is open for further tests. This of interest for most of biogas power plants that use CO-generators offer a lot of thermal energy for heating the biodigester.

4- The cost and environmental impacts of transportation in centralized biogas power plants was taken based on the scales on the map. Actual distances could be considered for more accurate results.

5- The products from biodigestion are solid waste and liquid phase supernatant. The solid waste is considered as a good fertilizer, but the liquid phase is not well defined whether to be used as fertilizer or to be recycled to the system to decrease the dependence on fresh water. In case of adequate calculation, considering these valuable material could decrease the cost of biogas power plants and as well the PBP.

6- Co- digestion has many advantages in balancing the C/N ratio. Since most of digester are proposed to be built in farms, the agricultural residues could be considered in future studies.

7- In Palestine, the biogas power plants and utilization of biomass still foreign phrases. Awareness campaign to the farmers and stack holders could be held to disseminate these technologies.

References

[1] Antonio Rota, Karan Sehgal, Onyekachi Nwankwo , Romain Gellee, Silvia Sperandini,2012,***’Livestock and renewable energy’***,Thematic Papers, the International Fund for Agricultural Development **(IFAD)**,

[2] Peter McKendry,2001,***’Energy production from biomass (part1): overview of biomass’*, Bioresource Technology**,vol.83, pp.37–46, last accessed on 6 July, 2015, http://www.sciencedirect.com/science/article/pii/S0960852401.htm

[3] Julia Bramley , Lum Fobi , Cammy Peterson, Lydia Rainville Jeft Cheng-Hao Shih , Axum Teferra , Rose Yuan Wang,2011,***Agriculture biogas in the united state, A Market Assessment,***Tufts University .

[4] Dr.Imad Ibrik, 2012,‘Potential of Renewable Energy in Palestine and our regional needs’, *in the energy conference***,** An-Najah National University,Palestine,pp.14-20

[5] Medyan Adel Mustaffa Hassan,2004,**’The Feasibility of Biogas Production from Mixed Organic Wastes in Palestinian Rural areas’,** MSc.Thesis, An Najah National university, Nablus, Palestine.

[6] Eng. Fahad A.Rafai, 2006, **‘Biomass as an Alternative Fuel for Generating Electricity’**, pp.1-6, viewed Sep, 2014.

[7] T. Abbasi ,2012,’Biogas Energy,**’ Springer Briefs in Environmental Science’**,pp.11-24viewed 2014, http://www.springer.com/978-1-4614-1039-3>

[8] Uli Werner, Ulrich Stohr, and Nicolai Hees, 1989, **Biogas *Plant in Animal Husbandry*,Friedr**. Vieweg & Sohn erlagsgesellschaft mbH, Braunschweig

[9] Yunus A. Cengel, Michael A. Boles McGraw-Hill, 2008, ***Thermodynamics An Engineering Approach***,7 th Edition

[10] Peyruze Özmen, Solmaz Aslanzadeh , 2009,' Biogas production from municipal wastemixed with different portions of orange peel ', MSc.Thesis, University of Borås.

[11] ARTI,Rich Dana NCAT Energy Specialist,2010, '**Micro-scale Biogas Production'**, A beginner's guide',viewed dec,2014.www.attra.ncat.org/attra-pub/biogas.html>

[12] Anaerobic digestion reference sheet ,2007,viewed, sep,2015 http:/ / www. waste. nl/ content/ download/ 472/ 3779/ file/ WB89 InfoSheet (Anaerobic Digestion).pdf

[13] Mohammad Shariful Islam, Asif Islam, Dipendra Shah, Enamul Basher,***'Impact of Different Factors on Biogas Production in Poultry Dropping Based Biogas Plants of Bangladesh'***, **Journal of Energy and Natural Resources**,Vol. 2, No. 4, 2013, pp. 25-32.

[14] Teodorita Al Seadi, DominikRutz, Heinz Prassl, Michael Köttner, TobiasFinsterwalder,Silke Volk, Rainer Janssen,2008,***Biogas handbook.*** University of Southern Denmark Esbjerg, Niels Bohrs , Esbjerg, Denmark.

[15] Ortega Angella,2013, Type Of Energy cources,Echnologygreen *energy-E-Online*, viewed sep 2015.<http://technologygreenenergy-e-online.blogspot.com>

[16] ChrishKavuma,2013,**'Variation of Methane and Carbon dioxide Yield in abiogas plant',**MSc.Thesis, Presented to Department of Energy Technology, Royal Institute of Technology, Stockholm, Sweden

[17] Teodorita Al Seadi, 2007***, the future of biogas in europe,*** University of Southern Denmark, Department of Bioenergy.

[18] Ortega Angella, 2013, **Type of Energy cources, Echnologygreen *energy-E-Online*,** viewed Sep 2015.<http://technologygreenenergy-e-online.blogspot.com>.

[19] Thomas Hoerz, Pedro Krämer, B. Klingler, C. Kellner, Thomas Wittur, F. v. Klopotek, A.Krieg, H. Euler, Werner Kossmann, UtaPönitz, Stefan Habermehl,1999,**'Biogas Digest Volume II Biogas Application and Product Development'.**

[20] KarthikRajendran, SolmazAslanzadeh and Mohammad J. herzadeh, 2013,'Household Biogas Digestersk', *Energies,* pp. 2911-2942. <http://www.mdpi.com/journal/energies>

[21] Palestinian Central Bureau of Statistics (PCBS), http://www. pcbs.gov.ps/,[Access date 2 Jan 2015.

[22] Deublein, D., & Steinhauser, A. (2008). **'Biogas from Waste and Renewable Resources an Introduction (first ed.)'**, The Federal Republic of Germany: Wiley-VCH.

[23] Gregor D. Zupančič and Viktor Grilc (2012).’ ***Anaerobic Treatment and Biogas Production from Organic Waste’,*** ISBN: 978-953-307-925-7.<http://www.intechopen.com/books/management-of-organic-waste/anaerobic-treatment-and-biogas-productionfrom-organic-wastes>

[24] Abo Omar, J. M., & Ishtayeh, M. S. (1996),**’Estimate of wastes produces from cattles, goats, sheep, and poultry in west bank and utilization of these waste’**, islamic university journal , Palestine.

[25] Al Asaad, A.,Mohammad, U.,& Jenad, O,2011,**’Animal wealth and Manure production’**, *General Commission for Scientific Agricultural Research,* Damascus University, Syria.

[26] Tricase, C., &Lombardi, 2009,’ **State of the art and prospects of Italian biogas production from animal sewage: Technical-economic considerations’**, Elsevier, Italy, P. 481.

[27] Adawi,O,2008**,‘Design, Building and Techno-Economic Evaluation of Biogas Digester thesis’**, MSc. Thesis, An Najah National university, Nablus, Palestine.

[28] Uli Werner, Ulrich Stohr, and Nicolai Hees iogizs,1987,***Plants in Animal husbandry***, germany.

[29] Silvia Schulz, Federico Garcia, Frederic Sonnek , 2007, ***Biogas Technology***, GmbH.

[30] leland blank and anthony tarquin,2012,***engineering economy***, *MC Graw Hill* ,seventh edition ,pp 3-33.

[31] AM.EL-Hamouz "**Logistical management and private sector involvement in reducing the cost of municipal solid waste collection service in the Tubas area of the West Bank**" Waste Management 28(2), 260-271 (2008).

[32] Nicole Labutong, Janet Mosley, Ryan Smith, John Willard, 2012,**'Life Cycle Modeling and Environmental Impact of Commercial scale biogas production'**, MSc. Thesis, University of Michigan.

[33] Pacifica F. Achieng Ogola,2007,'**environmental impact assessment general procedures'**, Presented at Short Course II on Surface Exploration for Geothermal Resources, organized by UNU-GTP and KenGen, Kenya, 2-17 November.

[34] The Palestinian Environmental Assessment Policy, 1999, viewed 5 April 2016 <http://environment.pna.ps/ar/files/Environment_Impact_Assessment_Policy_en.pdf>

[35] Food and Agriculture Organization of the united station (FAO), viewed 5 June 2016,**'Environmental Impact Assessment (EIA) and Environmental Auditing (EA)'**. <http://www.fao.org/home/en>

[36] UNDP/PAPP, 2009, 'Environmental Impact Assessment Khan Younis Wastewater Treatment Plant'.

[37] Palestinian water authority,2013,**'North Gaza Emergency Sewage Treatment Project (NGESTP) Effluent Recovery and Reuse System and Remediation works**', Supplementary Environmental and Social Impact Assessment (SESIA)',pp.1-35.

[38] Bosko Josimovic1, Jasna Petric1 & Sasa Milijic1,2014**,'The Use of the Leopold Matrix in Carrying Out the EIA for WindFarms in Serbia'**,***Energy and Environment Research,***Vol. 4, No. 1; 2014

[39] ERKAS Valduse OÜ,2011,' **Feasibility and profitability study Construction of a biogas plant to produce fuel for Tartu city buses'**,*Baltic biogas bus.*

[40] Environmental Cost Management (ECM) Centre Limited,2013,***environmental impact assessment (EIA) reported for biojule KENYA LTD for proposed (AD) biogas plant***,Kenya

[41] Hjort-Gregersen ,1999,**'Centralised Biogas Plants -Integrated Energy Production and waste treatment and nutrient redistribution facilities',***Danish Institute of Agricultural and Fisheries Economics.*

[42] International Energy Agency (IAE), 2015, ***CO2 EMISSIONSFROM FUEL COMBUSTION***, Fran.

Appendix A

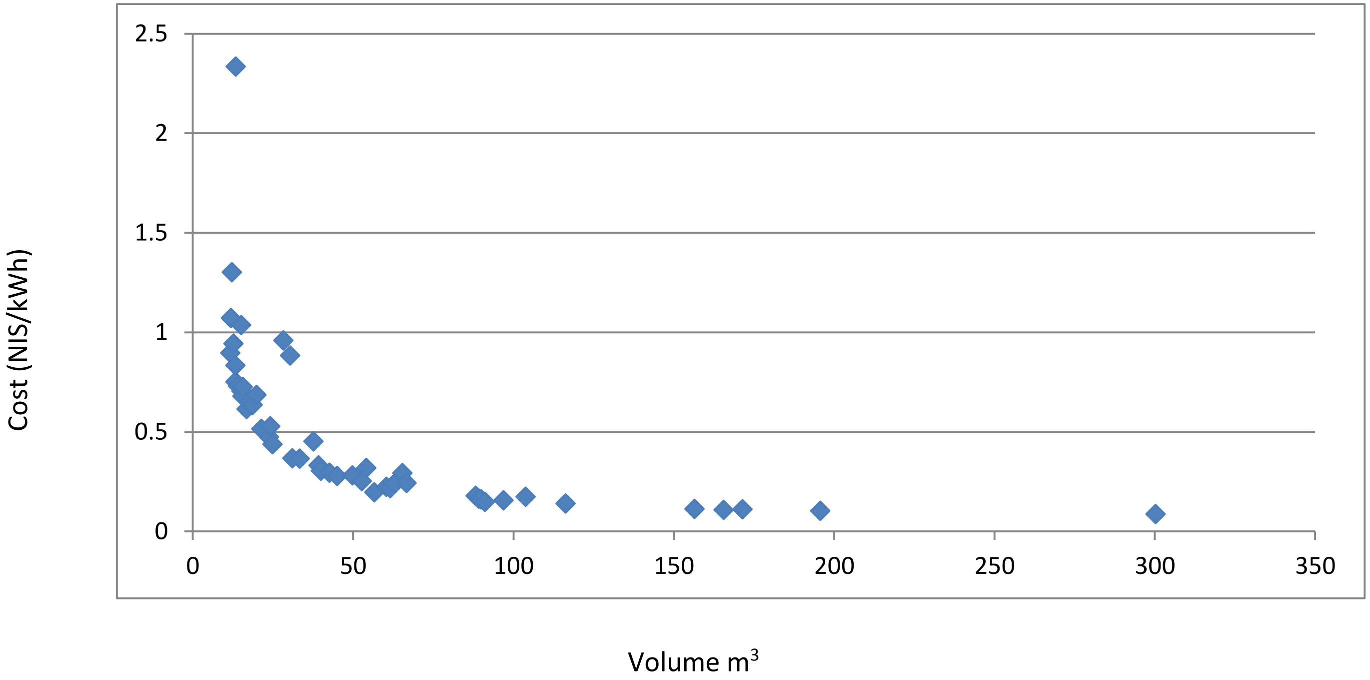
Appendix A1: Summary of Potential Biogas Production and Economic Analysis for Hebron governorate

Location	NO. Of Animals	Total waste wet g/day	Total waste dry for kg/day	Biogas yield-m3/kg.TS	Electricity kWh	Volume (m^3)	Power (kW)	Cost of plant (€)	Cost of generator (€)	Total cost (€)	Tolal cost (NIS)	Cost (NIS)/kWh	AW (€)	AW (NIS)	P.B.P
Surif	37,831	5,458	1,098	391	246,489	99	28	31,980	19,833	51,813	217,615	1.48	9,213	38,696	1.10
Al 'Arrub Camp	6,142	1,047	211	75	47,287	19	5	24,870	13,398	38,267	160,723	0.19	6,805	28,579	1.99-
Beit Ummar	24,694	7,681	1,546	550	346,888	139	40	35,564	23,077	58,640	246,289	0.77	10,427	43,794	0.73
Jala	263	426	86	31	19,242	8	2	23,869	12,492	36,360	152,714	0.13	6,465	27,155	1.27-
Hitta	842	1,284	258	92	57,994	23	7	25,252	13,744	38,996	163,781	1.32	6,934	29,123	2.48-
Shuyukh al 'Arrub	1,499	669	135	48	30,231	12	3	24,261	12,847	37,108	155,852	0.47	6,598	27,713	1.49-
Kharas	14,861	5,691	1,145	408	257,031	103	29	32,356	20,174	52,530	220,626	0.87	9,341	39,231	1.04
Umm al Butm	122	198	40	14	8,926	4	1	23,501	12,158	35,659	149,768	0.15	6,341	26,631	1.11-
Hamrush	243	394	79	28	17,779	7	2	23,817	12,444	36,261	152,296	2.79	6,448	27,081	1.25-
Nuba	1,890	815	164	58	36,827	15	4	24,497	13,060	37,556	157,736	1.43	6,678	28,048	1.65-
Beit Ula	23,309	10,896	2,193	780	492,100	197	56	40,747	27,768	68,515	287,761	0.69	12,183	51,169	0.53
Sa'ir	31,800	10,187	2,050	729	460,072	185	53	39,604	26,733	66,337	278,614	0.09	11,796	49,542	0.56
Halhul	35,446	9,685	1,949	694	437,418	175	50	38,795	26,001	64,796	272,144	0.11	11,522	48,392	0.58
Ash Shuyukh	17,687	7,737	1,557	554	349,438	140	40	35,655	23,159	58,814	247,017	0.12	10,458	43,924	0.72
Tarqumiya	18,667	17,081	3,438	1,223	771,431	309	88	50,717	36,792	87,509	367,537	0.12	15,561	65,354	0.39
Beit Kahil	410	664	134	48	29,997	12	3	24,253	12,839	37,092	155,785	0.07	6,596	27,701	1.48-
Beit 'Einun	95	154	31	11	6,951	3	1	23,430	12,095	35,525	149,203	0.87	6,317	26,531	1.09-
Qla'a Zeta	108	175	35	13	7,902	3	1	23,464	12,125	35,589	149,475	3.58	6,328	26,579	1.10-
Idhna	36,210	18,644	3,752	1,335	842,013	338	96	53,236	39,072	92,308	387,695	3.15	16,414	68,939	0.38
Taffuh	16,031	3,901	785	279	176,176	71	20	29,470	17,562	47,032	197,534	0.07	8,363	35,125	1.98
Beit Maqdum	10,094	15,981	3,216	1,144	721,741	289	82	48,944	35,187	84,130	353,346	0.22	14,960	62,831	0.41
Al Baqa	205	385	77	28	17,376	7	2	23,802	12,431	36,234	152,181	0.07	6,443	27,060	1.24-
Hebron (Al Khalil)	103,906	40,643	8,179	2,910	1,835,558	736	210	88,700	71,169	159,869	671,450	1.40	28,427	119,395	0.28

Al Bowereh (Aqabat Injeleh)	130	395	79	28	17,834	7	2	23,819	12,446	36,265	152,312	0.06	6,448	27,084	1.25-
Khallet Edar	12,010	1,438	289	103	64,923	26	7	25,499	13,967	39,467	165,760	1.24	7,018	29,475	2.95-
Deir Samit	23,077	14,444	2,907	1,034	652,342	262	74	46,466	32,945	79,411	333,526	0.79	14,121	59,306	0.43
Bani Na'im	48,870	30,770	6,192	2,203	1,389,653	557	159	72,784	56,764	129,548	544,100	0.08	23,036	96,750	0.30
Khallet Al Masafer	30,155	7,248	1,459	519	327,342	131	37	34,866	22,445	57,311	240,707	0.07	10,191	42,802	0.77
Beit 'Awwa	21,783	5,718	1,151	409	258,246	104	29	32,400	20,213	52,613	220,973	0.16	9,355	39,293	1.03
Dura	72,507	22,512	4,530	1,612	1,016,690	408	116	59,471	44,715	104,186	437,583	0.17	18,526	77,810	0.34
Qalqas	16,175	94,634	19,045	6,776	4,273,926	1,714	488	175,734	149,943	325,677	1,367,843	0.07	57,911	243,225	0.23
Sikka	3,418	1,059	213	76	47,819	19	5	24,889	13,415	38,304	160,875	0.04	6,811	28,606	2.01-
Khirbet Salama	5,100	756	152	54	34,141	14	4	24,401	12,973	37,374	156,969	0.66	6,646	27,912	1.58-
Wadi 'Ubeid	1,051	148	30	11	6,672	3	1	23,420	12,086	35,506	149,124	1.14	6,314	26,517	1.08-
Fuqeiqis	175	310	62	22	13,992	6	2	23,681	12,322	36,003	151,215	6.09	6,402	26,888	1.18-
Khursa	17,082	3,082	620	221	139,212	56	16	28,151	16,367	44,518	186,977	1.75	7,916	33,248	3.90
Tarrama	2,426	970	195	69	43,829	18	5	24,746	13,286	38,032	159,736	0.30	6,763	28,404	1.86-
Al Fawwar Camp	1,224	442	89	32	19,973	8	2	23,895	12,515	36,410	152,923	0.65	6,474	27,192	1.28-
Al Majd	13,602	3,075	619	220	138,875	56	16	28,139	16,356	44,495	186,881	1.28	7,912	33,231	3.94
Marah al Baqqar	1,580	1,006	203	72	45,446	18	5	24,804	13,338	38,142	160,198	0.28	6,782	28,486	1.92-
Hadab al Fawwar	12,427	1,492	300	107	67,371	27	8	25,587	14,046	39,633	166,459	0.62	7,047	29,599	3.15-
Deir al 'Asal at Tahta	329	559	113	40	25,260	10	3	24,084	12,686	36,770	154,433	0.76	6,538	27,461	1.38-
Al Heila	2,303	2,765	556	198	124,868	50	14	27,639	15,904	43,543	182,881	1.00	7,743	32,519	6.58
Wadi ash Shajina	2,115	782	157	56	35,295	14	4	24,442	13,010	37,452	157,299	0.21	6,660	27,970	1.61-
As Sura	14,690	5,313	1,069	380	239,955	96	27	31,747	19,622	51,369	215,749	0.80	9,134	38,364	1.14
Deir Razih	12,647	2,107	424	151	95,163	38	11	26,579	14,944	41,523	174,397	0.17	7,383	31,011	12.60-
Ar Rihiya	4,759	5,069	1,020	363	228,930	92	26	31,353	19,266	50,619	212,600	0.41	9,001	37,804	1.22
Zif	360	583	117	42	26,339	11	3	24,122	12,721	36,843	154,741	0.14	6,551	27,515	1.40-
Deir al 'Asal al Fauqa	4,135	2,194	442	157	99,088	40	11	26,719	15,071	41,790	175,518	0.98	7,431	31,210	21.04-
Khallet al 'Aqed	633	1,052	212	75	47,501	19	5	24,877	13,405	38,282	160,785	0.32	6,807	28,590	1.99-
Imreish	7,010	2,192	441	157	98,975	40	11	26,715	15,067	41,782	175,486	0.56	7,430	31,204	20.64-
Al Buweib	20,740	7,969	1,604	571	359,891	144	41	36,028	23,497	59,524	250,003	0.35	10,584	44,455	0.70
Beit ar Rush at Tahta	1,346	385	77	28	17,368	7	2	23,802	12,431	36,233	152,179	0.13	6,443	27,060	1.24-
Hadab al 'Alaqa	13,639	1,908	384	137	86,161	35	10	26,257	14,654	40,911	171,826	1.66	7,275	30,554	6.49-
Beit Mirsim	6,184	844	170	60	38,114	15	4	24,542	13,101	37,644	158,104	0.57	6,694	28,113	1.69-
Beit ar Rush al Fauqa	6,986	2,148	432	154	97,008	39	11	26,645	15,004	41,649	174,924	1.12	7,406	31,104	15.54-
Karma	450	729	147	52	32,923	13	4	24,357	12,934	37,291	156,621	0.35	6,631	27,850	1.55-
Beit 'Amra	4,134	4,168	839	298	188,240	75	21	29,901	17,951	47,852	200,979	0.79	8,509	35,737	1.72
Om Adaraj (Arab Al Ka’abneh)	3,291	5,331	1,073	382	240,781	97	27	31,776	19,649	51,425	215,985	0.16	9,144	38,406	1.14

Wadi al Kilab	21,654	18,168	3,656	1,301	820,514	329	94	52,469	38,377	90,847	381,556	0.15	16,154	67,847	0.38
Om Ashoqhan	120	194	39	14	8,780	4	1	23,495	12,154	35,649	149,726	0.07	6,339	26,624	1.11-
Khallet al Maiyya	533	969	195	69	43,752	18	5	24,744	13,283	38,027	159,714	2.84	6,762	28,400	1.86-
Kheroshewesh Wal Hadedeyah	3,107	971	195	70	43,841	18	5	24,747	13,286	38,033	159,739	0.59	6,763	28,404	1.86-
Om Al Amad (Sahel Wadi Elma)	55	89	18	6	4,024	2	0	23,326	12,000	35,326	148,368	0.65	6,281	26,382	1.05-
Yatta	36,019	25,056	5,042	1,794	1,131,578	454	129	63,572	48,427	111,999	470,395	6.14	19,915	83,644	0.33
Ad Deirat	1,023	2,490	501	178	112,434	45	13	27,195	15,502	42,697	179,329	0.07	7,592	31,888	17.31
Khashem Adaraj (Al-Hathaleen)	2,929	4,745	955	340	214,295	86	24	30,831	18,793	49,624	208,421	0.24	8,824	37,061	1.36
Kurza	3,177	468	94	33	21,121	8	2	23,936	12,552	36,488	153,251	0.16	6,488	27,251	1.30-
Rabud	4,607	2,284	460	164	103,144	41	12	26,864	15,202	42,066	176,676	1.87	7,480	31,416	66.45-
Umm Lasafa	1,814	2,965	597	212	133,907	54	15	27,962	16,196	44,158	185,462	0.31	7,852	32,978	4.58
Al Burj	35,853	12,473	2,510	893	563,295	226	64	43,288	30,068	73,356	308,094	0.23	13,044	54,784	0.48
Al Faqir	16	26	5	2	1,171	0	0	23,224	11,908	35,132	147,553	0.10	6,247	26,237	1.01-
Um Al-Khair	1,307	2,117	426	152	95,624	38	11	26,595	14,959	41,554	174,529	20.98	7,389	31,034	13.22-
Al Karmil	9,839	14,652	2,949	1,049	661,701	265	76	46,800	33,247	80,047	336,199	0.31	14,234	59,782	0.43
Khallet Salih	1,146	2,303	463	165	104,007	42	12	26,894	15,230	42,124	176,923	0.08	7,490	31,460	122.12-
Adh Dhahiriya	65,534	41,653	8,383	2,983	1,881,173	754	215	90,328	72,643	162,971	684,477	0.25	28,979	121,711	0.27
At Tuwani	4,399	7,153	1,439	512	323,034	130	37	34,712	22,306	57,018	239,476	0.06	10,139	42,583	0.78
Ma'in	557	929	187	66	41,941	17	5	24,679	13,225	37,904	159,197	0.13	6,740	28,308	1.80-
An Najada	2,370	3,918	789	281	176,964	71	20	29,498	17,587	47,085	197,759	0.63	8,373	35,165	1.96
'Anab al Kabir	7,073	5,866	1,181	420	264,935	106	30	32,638	20,429	53,067	222,883	0.19	9,436	39,632	0.99
Khirbet Asafi	1,461	2,367	476	169	106,892	43	12	26,997	15,323	42,321	177,746	0.15	7,525	31,606	68.53
Mantiqat Shi'b al Batin	2,080	3,370	678	241	152,180	61	17	28,614	16,786	45,400	190,681	0.28	8,073	33,906	2.89
As Samu'	164,644	40,647	8,180	2,911	1,835,722	736	210	88,705	71,175	159,880	671,497	0.21	28,429	119,403	0.28
Wadi Al Amayer	301	488	98	35	22,022	9	3	23,968	12,581	36,549	153,508	0.09	6,499	27,296	1.32-
Khirbet Tawil ash Shih	7,134	3,168	637	227	143,054	57	16	28,288	16,491	44,780	188,074	1.16	7,963	33,443	3.53
Ar Ramadin	5,372	8,883	1,788	636	401,191	161	46	37,502	24,831	62,333	261,798	0.24	11,084	46,552	0.63
Maghayir al 'Abeed	464	752	151	54	33,948	14	4	24,394	12,967	37,360	156,914	0.11	6,643	27,902	1.57-
Khirbet al Fakheit	6,462	10,468	2,107	750	472,781	190	54	40,057	27,144	67,201	282,244	0.77	11,949	50,188	0.55
Khirbet Bir al 'Idd	2,867	4,645	935	333	209,759	84	24	30,669	18,646	49,316	207,125	0.10	8,769	36,830	1.41
Khirbet Zanuta	3,415	5,024	1,011	360	226,880	91	26	31,280	19,200	50,480	212,015	0.17	8,976	37,700	1.24
Imneizil	2,833	4,695	945	336	212,027	85	24	30,750	18,720	49,470	207,773	0.16	8,797	36,945	1.39
'Arab al Fureijat	5,201	8,426	1,696	603	380,522	153	43	36,764	24,163	60,927	255,895	0.16	10,834	45,502	0.66

Appendix A2: Relationship between Volume of Biodigester and Cost of kWh (NIS) for Hebron Governorate



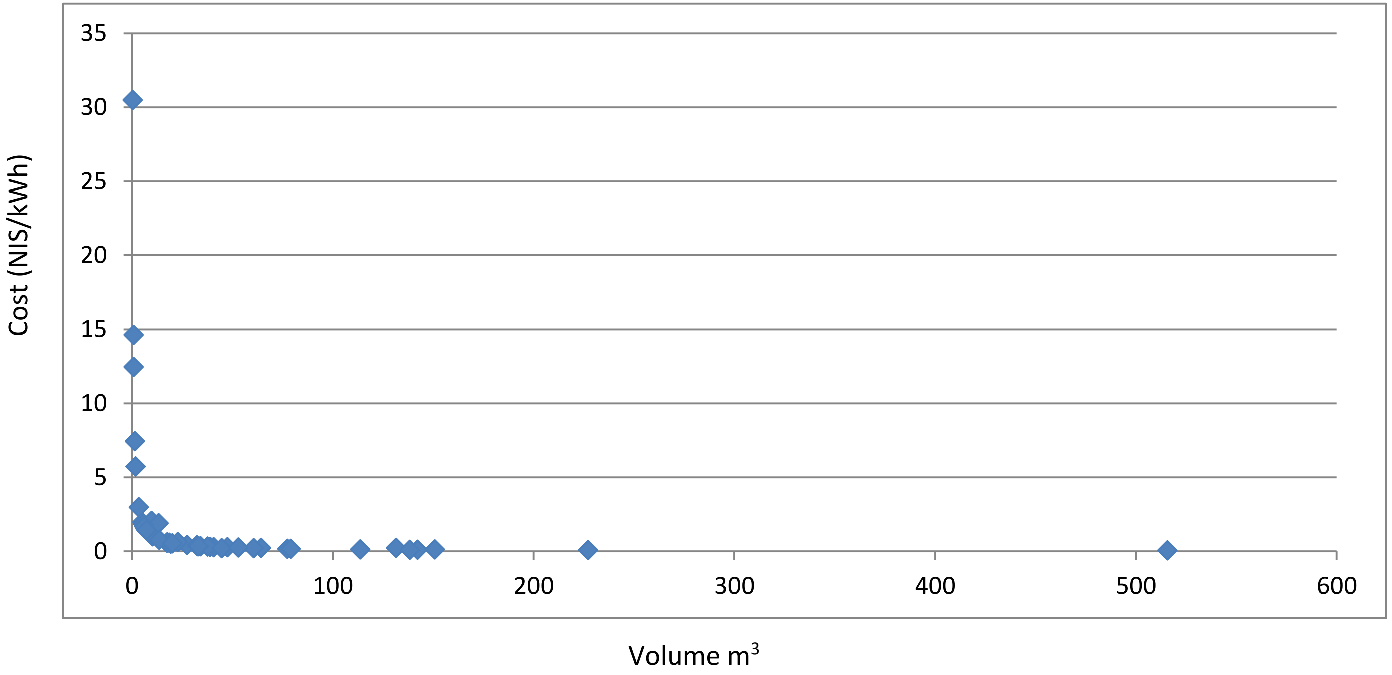
Appendix B

Appendix B1: Summary of Potential Biogas Production and Economic Analysis for Bethlehem Governorate

Location	NO. Of Animals	Total waste wet g/day	Total waste dry for kg/day	Biogas yield- m3/kg.TS	Electricity kWh	Volume (m^3)	Power (kW)	Cost of plant (€)	Cost of generator (€)	Total cost (€)	Tolal cost (NIS)	Cost (NIS)/kWh	AW (€)	AW (NIS)	P.B.P
Al Walaja	2,908	1,509	304	108	68,148	27	8	25,614	14,072	39,686	166,681	0.104	7,057	29,639	-3.2
Battir	6,081	1,884	379	135	85,096	34	10	26,219	14,619	40,838	171,522	0.084	7,262	30,499	-6.1
Al 'Ubeidiya	9,908	7,846	1,579	562	354,326	142	40	35,829	23,317	59,146	248,413	0.030	10,517	44,172	0.7
'Ayda Camp	23	37	7	3	1,683	1	0	23,242	11,924	35,166	147,699	3.479	6,253	26,263	-1.0
Khallet an Nu'man	59	96	19	7	4,317	2	0	23,336	12,009	35,346	148,451	1.364	6,285	26,397	-1.1
Al 'Aza Camp	-	-	-	-	-	-	-	23,182	11,870	35,052	147,218	#DIV/0!	6,233	26,178	#DIV/0!
Al Khas	59	96	19	7	4,317	2	0	23,336	12,009	35,346	148,451	1.364	6,285	26,397	-1.1
Al Haddadiya	11	18	4	1	805	0	0	23,211	11,896	35,107	147,448	7.261	6,243	26,219	-1.0
Khallet Hamameh	597	967	195	69	43,679	18	5	24,741	13,281	38,022	159,693	0.146	6,761	28,396	-1.9
Bir Onah	136	75	15	5	3,387	1	0	23,303	11,979	35,282	148,186	1.771	6,274	26,350	-1.0
Beit Jala	970	956	192	68	43,191	17	5	24,724	13,265	37,989	159,554	0.142	6,755	28,371	-1.8
Dar Salah	1,745	2,246	452	161	101,416	41	12	26,802	15,146	41,948	176,182	0.070	7,459	31,328	-34.7
Husan	174	282	57	20	12,730	5	1	23,636	12,281	35,918	150,854	0.471	6,387	26,824	-1.2
Wadi Fukin	13,440	2,619	527	188	118,302	47	14	27,405	15,692	43,096	181,005	0.068	7,663	32,186	9.7
Bethlehem (Beit Lahm)	4,610	6,271	1,262	449	283,234	114	32	33,292	21,020	54,312	228,109	0.030	9,658	40,562	0.9
Beit Sahur	612	1,018	205	73	45,965	18	5	24,823	13,355	38,178	160,346	0.139	6,789	28,512	-1.9
Ad Doha	469	556	112	40	25,125	10	3	24,079	12,682	36,760	154,394	0.246	6,537	27,454	-1.4
Al Khadr	17,467	4,270	859	306	192,850	77	22	30,066	18,100	48,166	202,296	0.045	8,565	35,972	1.6
Ad Duheisha Camp	114	185	37	13	8,341	3	1	23,480	12,139	35,619	149,600	0.712	6,334	26,601	-1.1
Hindaza	2,695	4,366	879	313	197,175	79	23	30,220	18,240	48,460	203,531	0.042	8,617	36,191	1.6
Ash Shawawra	11,529	3,544	713	254	160,067	64	18	28,895	17,041	45,936	192,933	0.057	8,168	34,307	2.5
Artas	1,354	1,064	214	76	48,060	19	5	24,897	13,423	38,320	160,944	0.126	6,814	28,619	-2.0
Nahhalin	2,488	2,141	431	153	96,703	39	11	26,634	14,994	41,628	174,837	0.074	7,402	31,089	-15.0
Beit Ta'mir	2,912	2,077	418	149	93,792	38	11	26,530	14,900	41,430	174,005	0.078	7,367	30,941	-11.0
Khallet al Louza	6,049	1,256	253	90	56,726	23	6	25,207	13,703	38,909	163,419	0.153	6,919	29,059	-2.4
Al Jab'a	4,646	537	108	38	24,231	10	3	24,047	12,653	36,700	154,139	0.489	6,526	27,408	-1.4

Za'tara	34,330	8,327	1,676	596	376,066	151	43	36,605	24,019	60,624	254,622	0.033	10,780	45,276	0.7
Jannatah	70,367	7,257	1,460	520	327,739	131	37	34,880	22,458	57,338	240,820	0.058	10,196	42,822	0.8
Wadi Rahhal	11,061	3,340	672	239	150,821	60	17	28,565	16,742	45,308	190,293	0.056	8,056	33,837	3.0
Jubbet adh Dhib	7,545	728	147	52	32,889	13	4	24,356	12,933	37,288	156,611	0.456	6,631	27,848	-1.5
Khallet Sakariya	381	2,464	496	176	111,281	45	13	27,154	15,465	42,619	179,000	0.055	7,578	31,829	20.5
Khallet al Haddad	187	303	61	22	13,682	5	2	23,670	12,312	35,982	151,126	0.439	6,398	26,873	-1.2
Al Ma'sara	1,659	1,793	361	128	80,998	32	9	26,073	14,487	40,560	170,351	0.085	7,212	30,291	-5.1
Wadi an Nis	225	365	73	26	16,462	7	2	23,770	12,402	36,171	151,920	0.367	6,432	27,014	-1.2
Jurat ash Sham'a	923	749	151	54	33,808	14	4	24,389	12,962	37,351	156,874	0.189	6,642	27,895	-1.6
Khallet 'Afana	27	44	9	3	1,975	1	0	23,253	11,934	35,186	147,783	2.966	6,257	26,278	-1.0
Marah Ma'alla	205	332	67	24	14,998	6	2	23,717	12,355	36,072	151,502	0.402	6,414	26,940	-1.2
Umm Salamuna	242	392	79	28	17,706	7	2	23,814	12,442	36,256	152,275	0.342	6,447	27,077	-1.2
Al Manshiya	684	1,108	223	79	50,044	20	6	24,968	13,487	38,455	161,511	0.129	6,838	28,719	-2.1
Tuqu'	7,724	12,536	2,523	898	566,138	227	65	43,389	30,160	73,549	308,906	0.023	13,078	54,929	0.5
Marah Rabah	8,327	7,633	1,536	547	344,729	138	39	35,487	23,007	58,493	245,672	0.027	10,401	43,685	0.7
Beit Fajjar	5,750	1,781	358	128	80,450	32	9	26,054	14,469	40,523	170,195	0.100	7,206	30,263	-4.9
Al Maniya	7,862	2,916	587	209	131,685	53	15	27,882	16,124	44,007	184,827	0.064	7,825	32,865	4.9
Kisan	1,800	1,829	368	131	82,587	33	9	26,130	14,538	40,668	170,805	0.085	7,231	30,372	-5.4
'Arab ar Rashayida	19,780	28,471	5,730	2,039	1,285,820	516	147	69,078	53,410	122,487	514,446	0.017	21,780	91,477	0.3

Appendix A2: Relationship between Volume of Biodigester and Cost of kWh (NIS) for Bethlehem Governorate

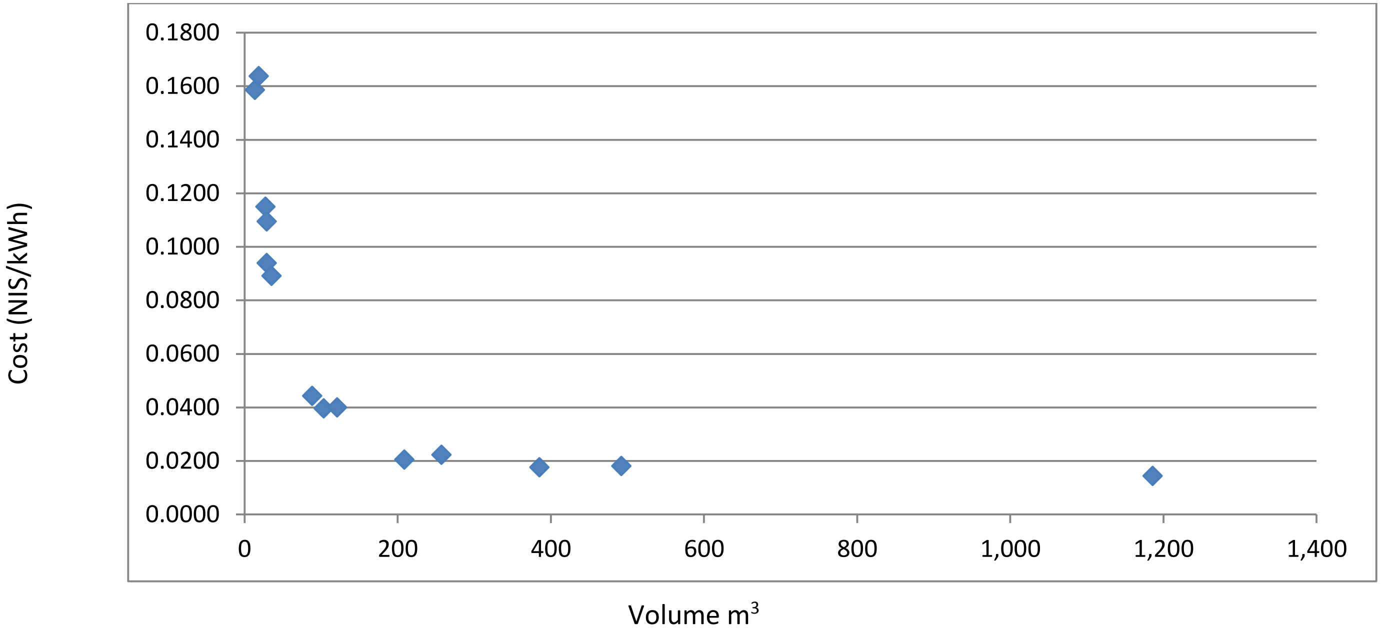


Appendix C

Appendix C1: Summary of Potential Biogas Production and Economic Analysis for Jericho Governorate

Location	NO. Of Animals	Total waste wet g/day	Total waste dry kg/day	Biogas yield-m3/kg.TS	Electricity kWh	Volume (m^3)	Power (kW)	Cost of plant (€)	Cost of generator (€)	Total cost (€)	Tolal cost (NIS)	Cost (NIS)/kWh	AW (€)	AW (NIS)	P.B.P
Marj Na'ja	2,176	10,990	2,212	786.94	496,340	199	56.7	40,898	27,905	68,803	288,972	0.0205	12,234	51,384.0	0.5
Az Zubeidat	595	1,423	286	101.91	64,274	26	7.3	25,476	13,946	39,423	165,575	0.0939	7,010	29,442.0	-2.9
Marj al Ghazal	780	1,264	254	90.48	57,067	23	6.5	25,219	13,714	38,933	163,517	0.1150	6,923	29,076.0	-2.4
Al Jiftlik	13,339	23,152	4,659	1,657.81	1,045,614	419	119.4	60,504	45,650	106,153	445,843	0.0180	18,876	79,278.4	0.3
Fasayil	6,411	12,282	2,472	879.42	554,669	222	63.3	42,980	29,789	72,769	305,631	0.0223	12,940	54,346.2	0.5
Al 'Auja	189,344	62,577	12,594	4,480.83	2,826,149	1,133	322.6	124,057	103,171	227,229	954,361	0.0144	40,405	169,701.2	0.3
An Nuwei'ma	2,969	4,810	968	344.40	217,222	87	24.8	30,935	18,888	49,823	209,257	0.0396	8,859	37,209.3	1.3
'Ein ad Duyuk al Fauqa	875	1,340	270	95.94	60,510	24	6.9	25,342	13,825	39,167	164,500	0.1094	6,964	29,250.8	-2.6
'Ein as Sultan Camp	1,286	1,664	335	119.15	75,151	30	8.6	25,864	14,298	40,162	168,681	0.0891	7,142	29,994.4	-4.0
Jericho (Ariha)	37,969	20,241	4,073	1,449.35	914,133	367	104.4	55,811	41,402	97,213	408,293	0.0176	17,286	72,601.3	0.4
Deir al Qilt	528	855	172	61.25	38,630	15	4.4	24,561	13,118	37,679	158,251	0.1638	6,700	28,139.7	-1.7
Aqbat Jaber Camp	25,158	6,107	1,229	437.31	275,819	111	31.5	33,027	20,781	53,808	225,992	0.0400	9,568	40,185.1	0.9
Deir Hajla	130	712	143	50.95	32,137	13	3.7	24,329	12,908	37,237	156,397	0.1586	6,621	27,809.9	-1.5
An Nabi Musa	2,537	4,110	827	294.29	185,615	74	21.2	29,807	17,866	47,674	200,230	0.0442	8,477	35,604.2	1.8

Appendix C2: Relationship between Volume of Biodigester and Cost of kWh (NIS) for Jericho Governorate



Appendix D

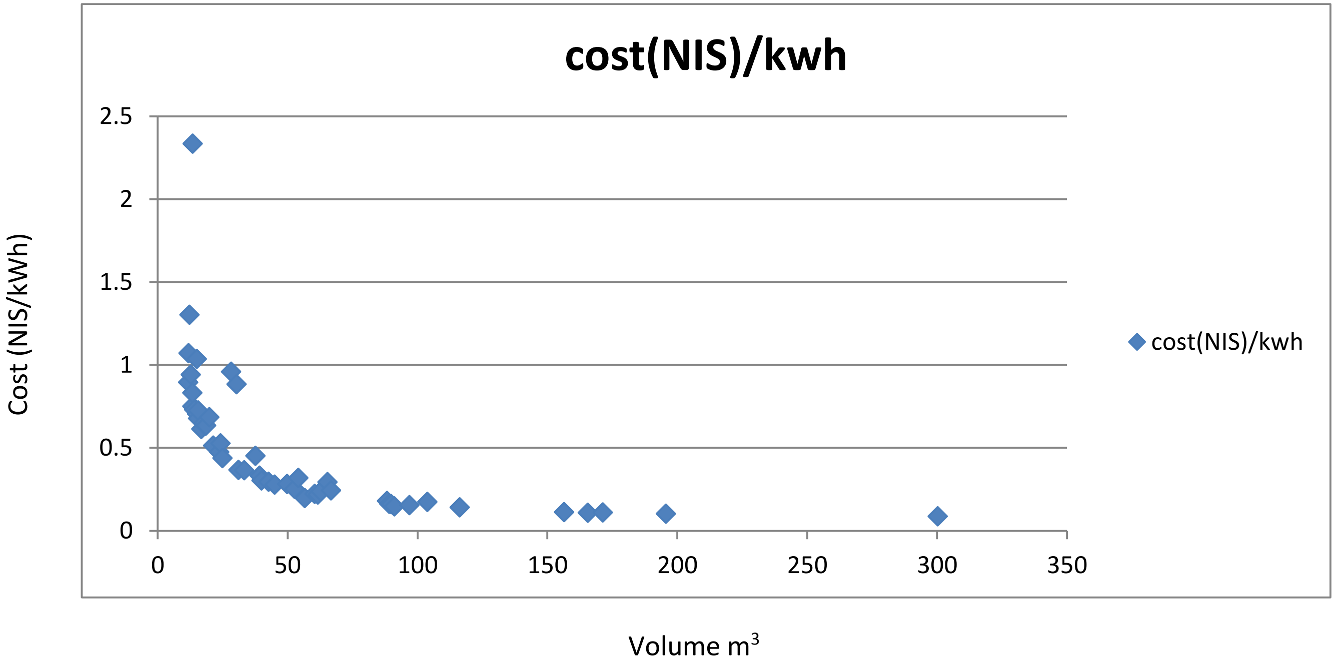
Appendix D1: Summary of Potential Biogas Production and Economic Analysis for Ramallah Governorate

Location	NO. Of Animals	Total waste wet g/day	Total waste dry for kg/day	Biogas yield-m3/kg.TS	Electricity kWh	Volume (m^3)	Power (kW)	Cost of plant (€)	Cost of generator (€)	Total cost (€)	Tolal cost (NIS)	Cost (NIS)/kWh	AW (€)	AW (NIS)	P.B.P
Qarawat Bani Zeid	1,051	731	147	52	33,028	13	4	24,361	12,937	37,298	156,651	0.18	6,632	27,855	-1.6
Bani Zeid ash Sharqiya	5,205	1,330	268	95	60,074	24	7	25,326	13,811	39,137	164,375	0.13	6,959	29,229	-2.6
Kafr 'Ein	1,540	217	44	16	9,821	4	1	23,533	12,187	35,720	150,023	0.89	6,352	26,677	-1.1
Bani Zeid	36,706	5,729	1,153	410	258,745	104	30	32,418	20,229	52,647	221,116	0.04	9,361	39,318	1.0
'Abwein	0	0	0	0	0	0	0	23,182	11,870	35,052	147,218	#DIV/0!	6,233	26,178	------
Turmus'ayya	307	497	100	36	22,461	9	3	23,984	12,596	36,579	153,633	0.27	6,504	27,319	-1.3
Al Lubban al Gharbi	4,213	983	198	70	44,413	18	5	24,767	13,305	38,072	159,903	0.16	6,770	28,433	-1.9
Sinjil	781	1,371	276	98	61,896	25	7	25,391	13,870	39,261	164,896	0.10	6,981	29,321	-2.7
Deir as Sudan	74	256	52	18	11,560	5	1	23,595	12,243	35,838	150,520	0.44	6,373	26,765	-1.1
Rantis	6,886	5,347	1,076	383	241,497	97	28	31,802	19,672	51,474	216,189	0.04	9,153	38,442	1.1
Jilijliya	10	16	3	1	732	0	0	23,208	11,894	35,102	147,427	7.99	6,242	26,215	-1.0
'Ajjul	5,018	562	113	40	25,404	10	3	24,089	12,691	36,779	154,474	0.38	6,540	27,468	-1.4
Al Mughayyir	10,444	8,634	1,738	618	389,950	156	45	37,101	24,468	61,568	258,587	0.03	10,948	45,981	0.6
'Abud	6,214	828	167	59	37,410	15	4	24,517	13,079	37,596	157,902	0.25	6,685	28,078	-1.7
An Nabi Salih	4,250	672	135	48	30,334	12	3	24,265	12,850	37,115	155,882	0.31	6,600	27,718	-1.5
Khirbet Abu Falah	1,837	2,199	443	157	99,325	40	11	26,727	15,079	41,806	175,585	0.07	7,434	31,222	-21.9
Umm Safa	192	311	63	22	14,047	6	2	23,683	12,324	36,007	151,230	0.43	6,403	26,891	-1.2
Al Mazra'a ash Sharqiya	161	460	93	33	20,797	8	2	23,924	12,542	36,466	153,158	0.26	6,484	27,234	-1.3
Deir Nidham	726	1,176	237	84	53,117	21	6	25,078	13,586	38,664	162,388	0.12	6,875	28,875	-2.2
'Atara	17,509	1,674	337	120	75,583	30	9	25,880	14,312	40,192	168,805	0.21	7,147	30,016	-4.1
Deir Abu Mash'al	10,079	3,462	697	248	156,336	63	18	28,762	16,921	45,683	191,868	0.06	8,123	34,117	2.7
Jibiya	0	0	0	0	0	0	0	23,182	11,870	35,052	147,218	#DIV/0!	6,233	26,178	-------
Burham	434	558	112	40	25,189	10	3	24,081	12,684	36,765	154,412	0.24	6,537	27,457	-1.4
Kafr Malik	3,048	4,921	990	352	222,230	89	25	31,114	19,049	50,164	210,687	0.04	8,920	37,464	1.3
Shuqba	4,038	5,030	1,012	360	227,146	91	26	31,290	19,208	50,498	212,091	0.04	8,979	37,713	1.2
Kobar	645	476	96	34	21,507	9	2	23,950	12,565	36,514	153,361	0.29	6,493	27,270	-1.3
Qibya	5,226	2,480	499	178	112,008	45	13	27,180	15,489	42,668	179,208	0.07	7,587	31,866	18.4

Silwad	2,245	1,009	203	72	45,582	18	5	24,809	13,343	38,152	160,237	0.15	6,784	28,493	-1.9
Yabrud	214	347	70	25	15,657	6	2	23,741	12,376	36,117	151,690	0.39	6,422	26,973	-1.2
AL-Itihad	16,609	1,559	314	112	70,390	28	8	25,694	14,144	39,838	167,322	0.23	7,084	29,753	-3.4
Shabtin	1,389	459	92	33	20,722	8	2	23,922	12,539	36,461	153,137	0.33	6,483	27,230	-1.3
Bir Zeit	9,525	2,351	473	168	106,155	43	12	26,971	15,299	42,270	177,536	0.07	7,516	31,569	113.7
AL-Doha	0	0	0	0	0	0	0	23,182	11,870	35,052	147,218	#DIV/0!	6,233	26,178	---------
'Ein Siniya	514	833	168	60	37,606	15	4	24,524	13,085	37,609	157,959	0.17	6,688	28,088	-1.7
Silwad Camp	0	0	0	0	0	0	0	23,182	11,870	35,052	147,218	#DIV/0!	6,233	26,178	--------
Deir Jarir	6,786	2,905	585	208	131,212	53	15	27,865	16,109	43,974	184,692	0.06	7,819	32,841	5.0
Deir 'Ammar Camp	4,041	412	83	30	18,610	7	2	23,846	12,471	36,317	152,533	0.65	6,458	27,123	-1.3
Budrus	5,643	1,092	220	78	49,316	20	6	24,942	13,463	38,405	161,303	0.16	6,829	28,682	-2.1
AL-Zaytouneh	397	643	129	46	29,046	12	3	24,219	12,808	37,027	155,514	0.21	6,584	27,653	-1.5
Jifna	429	774	156	55	34,954	14	4	24,430	12,999	37,429	157,201	0.17	6,655	27,953	-1.6
Dura al Qar'	6,104	539	109	39	24,361	10	3	24,052	12,657	36,709	154,176	0.71	6,527	27,415	-1.4
At Tayba	16,129	2,984	601	214	134,779	54	15	27,993	16,224	44,217	185,711	0.08	7,863	33,023	4.5
Al Jalazun Camp	128	260	52	19	11,743	5	1	23,601	12,249	35,850	150,572	0.48	6,375	26,774	-1.2
Abu Qash	1,027	732	147	52	33,047	13	4	24,362	12,938	37,299	156,657	0.20	6,632	27,856	-1.6
Deir Qaddis	1,472	858	173	61	38,733	16	4	24,565	13,121	37,686	158,280	0.17	6,701	28,145	-1.7
Ni'lin	16,132	4,959	998	355	223,973	90	26	31,176	19,106	50,282	211,185	0.04	8,941	37,552	1.3
'Ein Yabrud	1,158	1,711	344	122	77,256	31	9	25,940	14,366	40,305	169,282	0.09	7,167	30,101	-4.3
Kharbatha Bani Harith	11,287	2,161	435	155	97,593	39	11	26,665	15,023	41,688	175,091	0.08	7,413	31,134	-16.8
Ras Karkar	2,320	652	131	47	29,434	12	3	24,233	12,821	37,053	155,625	0.26	6,589	27,673	-1.5
Surda	14	75	15	5	3,402	1	0	23,303	11,980	35,283	148,190	1.41	6,274	26,351	-1.0
Al Janiya	3,556	527	106	38	23,787	10	3	24,031	12,638	36,670	154,012	0.33	6,520	27,386	-1.4
Al Midya	16,266	2,073	417	148	93,618	38	11	26,524	14,894	41,418	173,956	0.11	7,365	30,932	-10.9
Rammun	10,964	4,869	980	349	219,897	88	25	31,031	18,974	50,005	210,021	0.04	8,892	37,345	1.3
Kafr Ni'ma	31,819	3,606	726	258	162,861	65	19	28,995	17,131	46,126	193,731	0.07	8,202	34,449	2.4
Bil'in	37,153	6,415	1,291	459	289,696	116	33	33,522	21,229	54,751	229,955	0.03	9,736	40,890	0.9
Beitin	2,063	1,307	263	94	59,045	24	7	25,290	13,778	39,067	164,082	0.11	6,947	29,176	-2.5
'Ein Qiniya	1,870	699	141	50	31,587	13	4	24,309	12,890	37,200	156,239	0.22	6,615	27,782	-1.5
Badiw al Mu'arrajat	5,839	9,459	1,904	677	427,201	171	49	38,430	25,671	64,101	269,226	0.03	11,398	47,873	0.6
Deir Ibzi'	13,061	2,745	553	197	123,991	50	14	27,608	15,876	43,483	182,630	0.07	7,732	32,475	6.9
Deir Dibwan	6,519	10,798	2,173	773	487,652	196	56	40,588	27,624	68,212	286,491	0.02	12,129	50,943	0.5
Al Bireh	726	926	186	66	41,831	17	5	24,675	13,221	37,896	159,165	0.15	6,739	28,302	-1.8
'Ein 'Arik	487	168	34	12	7,570	3	1	23,452	12,115	35,567	149,380	0.91	6,324	26,562	-1.1
Saffa	25,680	3,677	740	263	166,060	67	19	29,109	17,235	46,344	194,645	0.06	8,241	34,611	2.3
Ramallah	13,718	3,330	670	238	150,383	60	17	28,550	16,728	45,278	190,168	0.05	8,051	33,815	3.0
Burqa	969	3,119	628	223	140,876	56	16	28,210	16,421	44,631	187,452	0.05	7,936	33,332	3.7

Beit 'Ur at Tahta	927	853	172	61	38,526	15	4	24,557	13,115	37,672	158,221	0.16	6,699	28,134	-1.7
Beituniya	24,570	9,136	1,839	654	412,626	165	47	37,910	25,200	63,110	265,064	0.03	11,222	47,133	0.6
Al Am'ari Camp	0	0	0	0	0	0	0	23,182	11,870	35,052	147,218	#DIV/0!	6,233	26,178	-------
Qaddura Camp	20	32	7	2	1,463	1	0	23,234	11,917	35,152	147,636	4.00	6,251	26,252	-1.0
Beit Sira	251	407	82	29	18,364	7	2	23,837	12,463	36,301	152,463	0.33	6,455	27,110	-1.3
Kharbatha al Misbah	10,530	3,397	684	243	153,429	62	18	28,658	16,827	45,485	191,037	0.05	8,088	33,970	2.8
Beit 'Ur al Fauqa	8,610	1,836	369	131	82,919	33	9	26,142	14,549	40,690	170,900	0.09	7,235	30,389	-5.5
At Tira	9,214	736	148	53	33,240	13	4	24,368	12,944	37,312	156,712	0.56	6,635	27,866	-1.6
Beit Liqya	96,198	16,574	3,336	1,187	748,528	300	85	49,900	36,052	85,952	360,996	0.02	15,284	64,191	0.4
Beit Nuba	3,356	1,026	207	73	46,346	19	5	24,836	13,367	38,203	160,455	0.15	6,793	28,532	-2.0

Appendix D2: Relationship between Volume of Biodigester and Cost for Ramallah Governorate



Appendix E

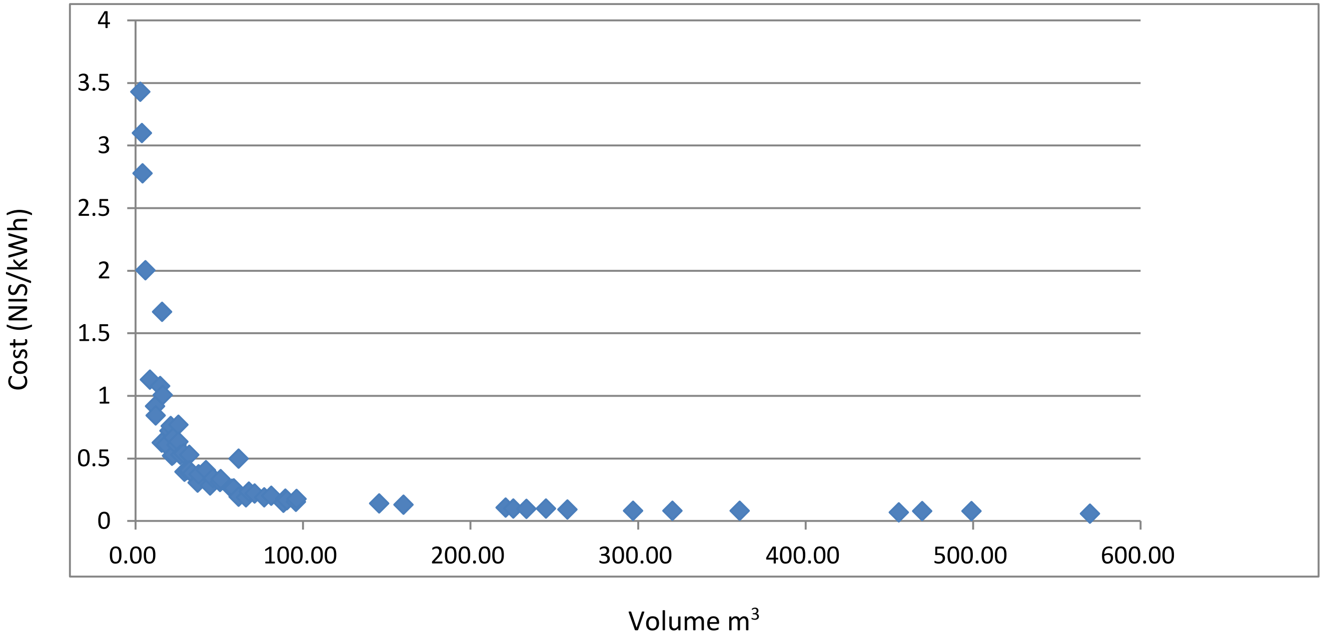
Appendix E1: Summary of Potential Biogas Production and Economic Analysis for Nablus Governorate

Location	NO. Of Animals	Total waste wet g/day	Total waste dry for kg/day	Biogas yield-m3/kg.TS	Electricity kWh	Volume (m^3)	Power (kW)	Cost of plant (€)	Cost of generator (€)	Total cost (€)	Tolal cost (NIS)	Cost (NIS)/kWh	AW (NIS)	P.B.P
Bizzariya	10,561	6,896	1,388	494	311,456	125	36	34,299	21,932	56,231	236,170	9,999	41,995	1
Burqa	4,839	1,860	374	133	83,999	34	10	26,180	14,584	40,764	171,208	7,249	30,444	-5.81
Yasid	11,268	1,716	345	123	77,507	31	9	25,949	14,374	40,322	169,354	7,170	30,114	-4.39
Beit Imrin	3,588	3,355	675	240	151,508	61	17	28,590	16,765	45,354	190,489	8,065	33,872	2.92
Nisf Jubeil	3,489	992	200	71	44,809	18	5	24,781	13,318	38,099	160,016	6,775	28,453	-1.90
Sabastiya	2,508	1,516	305	109	68,463	27	8	25,626	14,082	39,707	166,771	7,061	29,655	-3.25
Ijnisinya	10,155	918	185	66	41,449	17	5	24,661	13,209	37,870	159,056	6,734	28,283	-1.78
Talluza	19,465	4,317	869	309	194,952	78	22	30,141	18,168	48,309	202,896	8,590	36,078	1.61
An Naqura	7,858	1,341	270	96	60,545	24	7	25,343	13,826	39,169	164,510	6,965	29,253	-2.64
Al Badhan	6,326	3,257	655	233	147,099	59	17	28,432	16,622	45,055	189,229	8,011	33,648	3.21
Deir Sharaf	1,831	1,539	310	110	69,515	28	8	25,663	14,116	39,779	167,072	7,073	29,708	-3.36
'Asira ash Shamaliya	49,023	8,905	1,792	638	402,166	161	46	37,537	24,862	62,399	262,076	11,096	46,602	0.63
An Nassariya	15,338	15,196	3,058	1,088	686,274	275	78	47,678	34,041	81,718	343,217	14,531	61,030	0.42
Zawata	17,480	31,764	6,393	2,274	1,434,552	575	164	74,386	58,215	132,601	556,923	23,579	99,030	0.30
Al 'Aqrabaniya	12,964	10,519	2,117	753	475,070	191	54	40,139	27,218	67,357	282,898	11,977	50,304	0.55
Qusin	10,534	2,566	516	184	115,904	46	13	27,319	15,614	42,933	180,320	7,634	32,064	11.84
Beit Iba	10,206	3,477	700	249	157,027	63	18	28,787	16,943	45,730	192,065	8,132	34,152	2.64
Beit Hasan	13,792	11,888	2,392	851	536,887	215	61	42,345	29,215	71,560	300,552	12,725	53,443	0.50
Beit Wazan	6,220	881	177	63	39,776	16	5	24,602	13,155	37,757	158,578	6,714	28,198	-1.73
'Ein Beit el Ma Camp	0	0	0	0	0	0	0	23,182	11,870	35,052	147,218	6,233	26,178	#DIV/0!
'Ein Shibli	1,650	2,673	538	191	120,719	48	14	27,491	15,770	43,261	181,696	7,693	32,309	8.27
'Azmut	7,546	4,837	974	346	218,471	88	25	30,980	18,928	49,908	209,613	8,874	37,273	1.32

Nablus	50,178	17,421	3,506	1,247	786,764	316	90	51,264	37,287	88,552	371,917	15,746	66,133	0.39
'Askar Camp	172	279	56	20	12,584	5	1	23,631	12,277	35,908	150,812	6,385	26,817	-1.16
Deir al Hatab	558	1,081	218	77	48,818	20	6	24,924	13,447	38,372	161,161	6,823	28,657	-2.05
Sarra	24,128	2,966	597	212	133,968	54	15	27,964	16,198	44,162	185,480	7,853	32,981	4.57
Salim	21,307	11,453	2,305	820	517,262	207	59	41,645	28,581	70,226	294,947	12,487	52,447	0.51
Balata Camp	147	438	88	31	19,772	8	2	23,888	12,509	36,397	152,865	6,472	27,182	-1.28
'Iraq Burin	4,291	1,204	242	86	54,380	22	6	25,123	13,627	38,750	162,749	6,890	28,939	-2.29
Tell	81,743	25,805	5,193	1,848	1,165,426	467	133	64,780	49,520	114,300	480,062	20,325	85,363	0.32
Beit Dajan	13,538	4,831	972	346	218,199	88	25	30,970	18,919	49,889	209,536	8,871	37,259	1.32
Rujeib	36,624	12,379	2,491	886	559,071	224	64	43,137	29,931	73,069	306,888	12,993	54,570	0.48
Kafr Qallil	8,454	1,515	305	109	68,438	27	8	25,625	14,081	39,706	166,764	7,060	29,653	-3.25
Furush Beit Dajan	8,783	17,306	3,483	1,239	781,604	313	89	51,080	37,120	88,201	370,443	15,684	65,871	0.39
Madama	7,009	1,811	364	130	81,768	33	9	26,101	14,512	40,612	170,571	7,222	30,330	-5.23
Burin	5,748	3,517	708	252	158,833	64	18	28,851	17,001	45,853	192,581	8,153	34,244	2.55
Beit Furik	51,125	23,397	4,709	1,675	1,056,651	424	121	60,898	46,006	106,904	448,996	19,009	79,839	0.34
'Asira al Qibliya	14,301	4,829	972	346	218,101	87	25	30,967	18,916	49,883	209,508	8,870	37,254	1.32
'Awarta	899	827	166	59	37,349	15	4	24,515	13,077	37,592	157,885	6,684	28,075	-1.66
'Urif	500	1,065	214	76	48,092	19	5	24,899	13,424	38,322	160,953	6,814	28,620	-2.02
Odala	11,001	1,379	278	99	62,278	25	7	25,405	13,882	39,287	165,005	6,986	29,341	-2.75
Huwwara	1,936	940	189	67	42,442	17	5	24,697	13,241	37,938	159,340	6,746	28,333	-1.82
'Einabus	222	605	122	43	27,308	11	3	24,157	12,752	36,909	155,018	6,563	27,565	-1.42
Yanun	3,655	1,306	263	94	59,003	24	7	25,288	13,776	39,064	164,070	6,946	29,174	-2.54
Beita	30,354	5,097	1,026	365	230,212	92	26	31,399	19,307	50,706	212,967	9,016	37,869	1.21
Ar Rajman	123	199	40	14	8,999	4	1	23,503	12,161	35,664	149,789	6,342	26,635	-1.11
Zeita Jamma'in	43,015	3,674	739	263	165,913	67	19	29,104	17,230	46,334	194,603	8,239	34,604	2.28
Jamma'in	12,709	2,449	493	175	110,592	44	13	27,129	15,443	42,572	178,803	7,570	31,794	22.98
Osarin	12,717	2,223	447	159	100,397	40	11	26,766	15,113	41,879	175,891	7,447	31,276	-27.02
Aqraba	41,796	24,202	4,871	1,733	1,093,046	438	125	62,197	47,182	109,379	459,390	19,449	81,687	0.33
Za'tara	0	0	0	0	0	0	0	23,182	11,870	35,052	147,218	6,233	26,178	#DIV/0!

Tall al Khashaba	1,790	3,712	747	266	167,654	67	19	29,166	17,286	46,452	195,100	8,260	34,692	2.22
Yatma	656	584	118	42	26,372	11	3	24,123	12,722	36,845	154,750	6,552	27,517	-1.40
Qabalan	15,227	3,161	636	226	142,765	57	16	28,278	16,482	44,760	187,992	7,959	33,428	3.56
Jurish	4,939	779	157	56	35,204	14	4	24,439	13,007	37,446	157,272	6,658	27,966	-1.61
Qusra	19,030	5,309	1,068	380	239,753	96	27	31,740	19,615	51,355	215,691	9,132	38,353	1.14
Talfit	6,187	1,091	220	78	49,263	20	6	24,940	13,461	38,402	161,288	6,828	28,680	-2.06
As Sawiya	4,870	1,574	317	113	71,089	29	8	25,719	14,167	39,886	167,521	7,092	29,788	-3.52
Majdal Bani Fadil	4,633	2,286	460	164	103,251	41	12	26,867	15,206	42,073	176,707	7,481	31,421	-70.45
Al Lubban ash Sharqiya	6,847	1,202	242	86	54,305	22	6	25,120	13,624	38,745	162,728	6,889	28,936	-2.29
Qaryut	18,318	2,389	481	171	107,879	43	12	27,033	15,355	42,388	178,028	7,537	31,656	44.76
Jalud	76	145	29	10	6,535	3	1	23,415	12,081	35,496	149,085	6,312	26,510	-1.08
'Ammuriya	110	178	36	13	8,048	3	1	23,469	12,130	35,599	149,517	6,330	26,587	-1.10
Duma	35,344	13,561	2,729	971	612,437	246	70	45,042	31,655	76,697	322,129	13,638	57,280	0.45

Appendix E2: Relationship between Volume of Biodigester and Cost of kWh (NIS) for Nablus Governorate



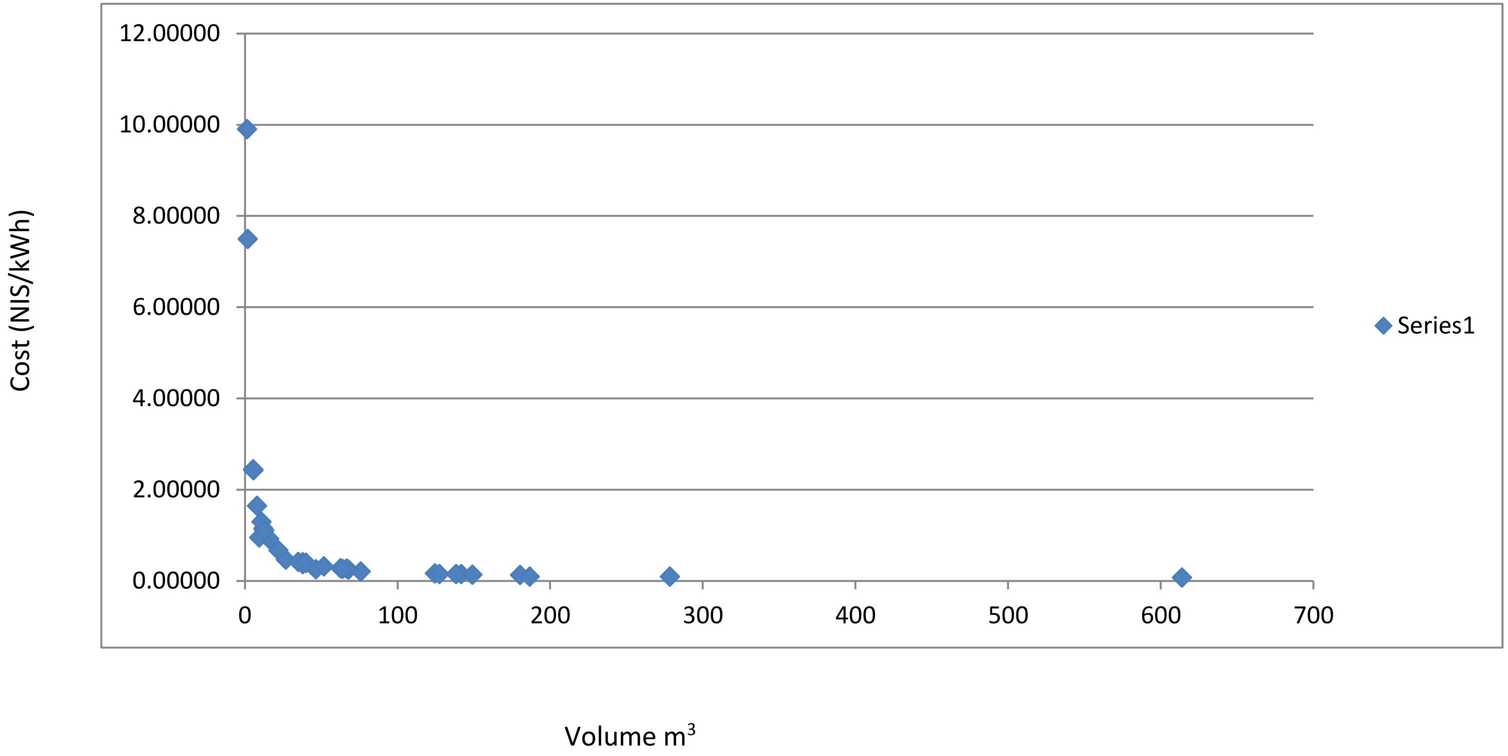
Appendix F

Appendix F1: Summary of Potential Biogas Production and Economic Analysis for Qalqilya governorate

Location	NO. Of Animals	Total waste wet g/day	Total waste dry for g/day	Biogas yield- m3/kg.TS	Electricity kWh	Volume (m^3)	Power (kW)	Cost of plant (€)	Cost of generator (€)	Total cost (€)	Tolal cost (NIS)	Cost (NIS)/kWh	AW (€)	AW (NIS)	PBP
Falamya	5,711	875	176	62.68	39,532	16	4.5	24,593	13,147	37,740	158,509	0.92514	6,711	28,185	-1.7
Kafr Qaddum	53,991	7,919	1,594	567.01	357,627	143	40.8	35,947	23,423	59,370	249,356	0.15441	10,557	44,340	0.7
Jit	5,201	1,533	309	109.79	69,249	28	7.9	25,654	14,107	39,761	166,996	0.46585	7,070	29,695	-3.3
Baqat al Hatab	67,606	10,250	2,063	733.92	462,901	186	52.8	39,705	26,824	66,529	279,422	0.12771	11,830	49,686	0.6
Hajja	9,550	4,181	841	299.40	188,840	76	21.6	29,922	17,971	47,893	201,151	0.20790	8,516	35,768	1.7
Jayyus	24,401	6,680	1,344	478.34	301,701	121	34.4	33,951	21,617	55,568	233,384	0.16417	9,881	41,499	0.8
Khirbet Sir	7,988	2,039	410	146.03	92,101	37	10.5	26,469	14,845	41,315	173,522	0.40969	7,346	30,855	-9.6
'Arab ar Ramadin ash Shamali	1,754	3,508	706	251.19	158,430	64	18.1	28,837	16,988	45,825	192,466	0.24794	8,148	34,224	2.6
Far'ata	8,343	1,230	248	88.07	55,548	22	6.3	25,165	13,665	38,829	163,083	0.67266	6,904	28,999	-2.4
Immatin	4,971	2,073	417	148.46	93,637	38	10.7	26,524	14,895	41,419	173,961	0.36902	7,365	30,933	-10.9
Al Funduq	807	296	60	21.17	13,353	5	1.5	23,659	12,301	35,960	151,032	2.42513	6,394	26,856	-1.2
Qalqiliya	217,144	35,041	7,052	2,509.09	1,582,533	635	180.7	79,668	62,995	142,663	599,187	0.07613	25,368	106,545	0.3
An Nabi Elyas	363	726	146	51.99	32,788	13	3.7	24,352	12,929	37,282	156,583	0.97951	6,629	27,843	-1.5
Kafr Laqif	29,090	3,752	755	268.64	169,435	68	19.3	29,230	17,344	46,573	195,609	0.26696	8,282	34,782	2.2
'Arab Abu Farda	1,036	11,227	2,259	803.91	507,040	203	57.9	41,280	28,250	69,530	292,028	0.09367	12,364	51,927	0.5
'Izbat at Tabib	45	90	18	6.44	4,065	2	0.5	23,327	12,001	35,328	148,379	7.49834	6,282	26,384	-1.0
Jinsafut	33,734	8,382	1,687	600.19	378,552	152	43.2	36,694	24,099	60,793	255,332	0.13378	10,810	45,402	0.7
'Azzun	38,497	7,244	1,458	518.70	327,157	131	37.3	34,859	22,439	57,299	240,654	0.15040	10,189	42,792	0.8
'Arab ar Ramadin al Janubi	189	411	83	29.39	18,539	7	2.1	23,844	12,469	36,313	152,513	1.64652	6,457	27,119	-1.3
'Isla	24,332	3,497	704	250.37	157,911	63	18.0	28,818	16,971	45,790	192,317	0.27701	8,142	34,197	2.6
Arab Al-Khouleh	501	2,688	541	192.44	121,374	49	13.9	27,514	15,791	43,305	181,883	0.25570	7,700	32,342	7.9
Wadi ar Rasha	33	574	115	41.07	25,901	10	3.0	24,106	12,707	36,813	154,616	0.95272	6,546	27,493	-1.4
Habla	22,235	3,574	719	255.95	161,431	65	18.4	28,944	17,085	46,029	193,323	0.26446	8,185	34,376	2.4
Ras at Tira	14,394	2,223	447	159.15	100,381	40	11.5	26,765	15,113	41,878	175,887	0.39556	7,447	31,276	-26.9
Ras 'Atiya	2,924	1,849	372	132.41	83,513	33	9.5	26,163	14,568	40,731	171,070	0.41687	7,243	30,419	-5.7

Ad Dab'a	140	280	56	20.05	12,646	5	1.4	23,633	12,279	35,912	150,830	2.44888	6,386	26,820	-1.2
Kafr Thulth	43,174	15,479	3,115	1,108.37	699,071	280	79.8	48,134	34,454	82,588	346,872	0.09559	14,686	61,680	0.4
'Izbat Jal'ud	34	68	14	4.87	3,071	1	0.4	23,292	11,969	35,261	148,095	9.90583	6,270	26,334	-1.0
Al Mudawwar	3,329	664	134	47.53	29,980	12	3.4	24,252	12,839	37,091	155,781	1.14484	6,595	27,700	-1.5
'Izbat Salman	11,941	2,789	561	199.68	125,943	51	14.4	27,677	15,939	43,616	183,188	0.31726	7,756	32,574	6.3
'Izbat al Ashqar	1,792	571	115	40.86	25,773	10	2.9	24,102	12,703	36,805	154,579	1.29467	6,544	27,487	-1.4
Beit Amin	2,981	689	139	49.31	31,102	12	3.6	24,292	12,875	37,167	156,101	1.10860	6,609	27,757	-1.5
Sanniriya	42,712	7,701	1,550	551.45	347,812	139	39.7	35,597	23,106	58,703	246,553	0.15076	10,438	43,841	0.7
'Azzun 'Atma	13,333	2,215	446	158.62	100,043	40	11.4	26,753	15,102	41,855	175,790	0.39520	7,442	31,258	-25.1

Appendix F2: Relationship between Volume of Biodigester and Cost of kWh (NIS) for Qalqilya governorate



Appendix G

Appendix G1: Summary of Potential Biogas Production and Economic Analysis for Jenin Governorate

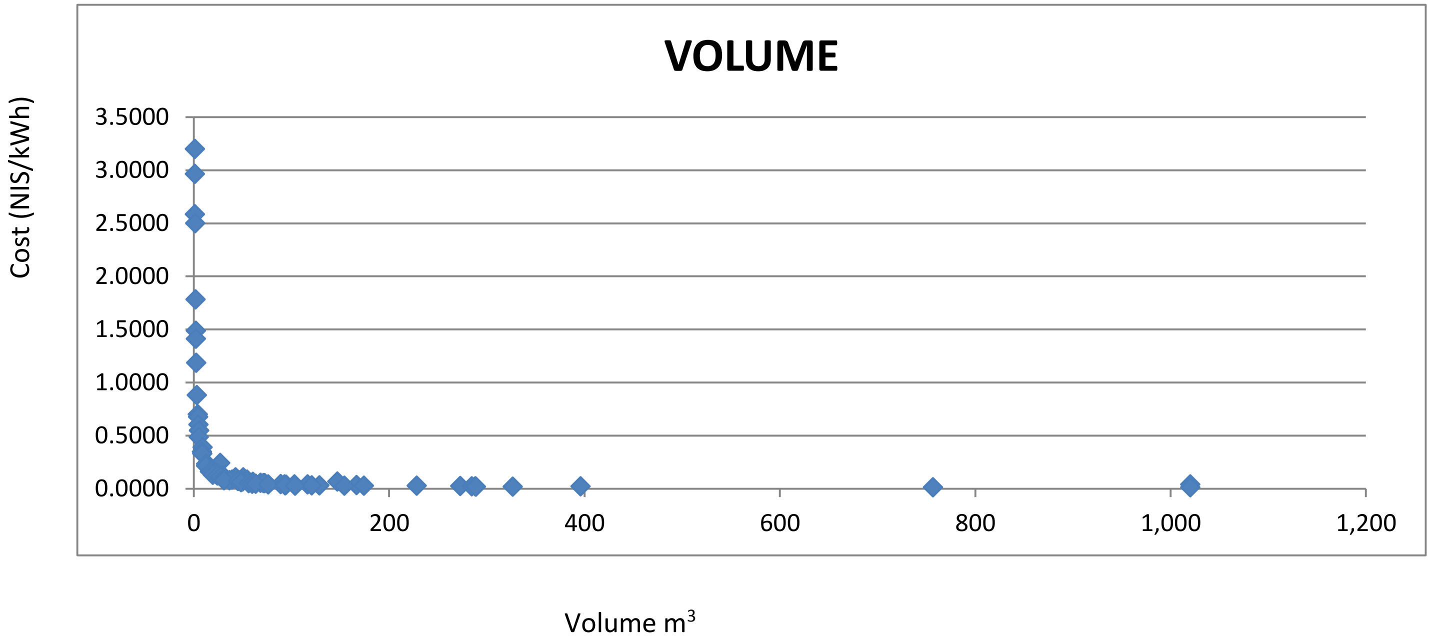
Location	NO. Of Animals	Total waste wet g/day	Total waste dry kg/day	Biogas yield- m3/kg.TS	Electricity kWh	Volume (m^3)	Power (kW)	Cost of plant (€)	Cost of generator (€)	Total cost (€)	Tolal cost (NIS)	Cost (NIS)/kWh	AW (€)	AW (NIS)	P.B.P
Zububa	2,003	449	90	32	20,272	8	2	23,906	12,525	36,430	153,008	1.638	6,478	27,207	-1.3
Rummana	12,771	4,208	847	301	190,050	76	22	29,966	18,010	47,975	201,496	0.173	8,531	35,829	1.7
Ti'innik	11,402	2,162	435	155	97,647	39	11	26,667	15,025	41,692	175,106	0.359	7,414	31,137	-16.9
At Tayba	16,985	1,546	311	111	69,838	28	8	25,675	14,126	39,801	167,164	1.015	7,077	29,725	-3.4
'Arabbuna	8,225	3,290	662	236	148,585	60	17	28,486	16,670	45,156	189,654	0.266	8,029	33,724	3.1
Al Jalama	6,444	2,974	599	213	134,310	54	15	27,976	16,209	44,185	185,577	0.222	7,857	32,999	4.5
Silat al Harithiya	4,113	1,551	312	111	70,063	28	8	25,683	14,133	39,816	167,228	0.411	7,080	29,736	-3.4
As Sa'aida	120	194	39	14	8,780	4	1	23,495	12,154	35,649	149,726	2.844	6,339	26,624	-1.1
'Anin	12,866	3,688	742	264	166,553	67	19	29,127	17,251	46,378	194,786	0.217	8,247	34,636	2.3
'Arrana	3,581	1,232	248	88	55,662	22	6	25,169	13,668	38,837	163,115	0.530	6,906	29,005	-2.4
Deir Ghazala	12,940	3,474	699	249	156,916	63	18	28,783	16,939	45,722	192,033	0.239	8,130	34,147	2.6
Faqqu'a	26,210	5,905	1,188	423	266,675	107	30	32,701	20,485	53,186	223,380	0.175	9,457	39,721	1.0
Khirbet Suruj	366	796	160	57	35,960	14	4	24,466	13,032	37,497	157,488	0.680	6,668	28,004	-1.6
Al Yamun	28,784	14,609	2,940	1,046	659,801	265	75	46,733	33,185	79,918	335,656	0.097	14,211	59,685	0.4
Umm ar Rihan	6,375	1,172	236	84	52,908	21	6	25,070	13,579	38,650	162,329	0.554	6,873	28,865	-2.2
Kafr Dan	16,040	2,816	567	202	127,197	51	15	27,722	15,979	43,701	183,546	0.335	7,771	32,637	5.9
Khirbet 'Abdallah al Yunis	68	110	22	8	4,975	2	1	23,360	12,031	35,390	148,639	4.978	6,293	26,431	-1.1
Dhaher al Malih	238	386	78	28	17,413	7	2	23,804	12,433	36,236	152,191	1.461	6,443	27,062	-1.2

Barta'a ash Sharqiya	24,000	4,000	805	286	180,650	72	21	29,630	17,706	47,336	198,812	0.198	8,417	35,352	1.9
Al 'Araqa	7,612	1,993	401	143	90,021	36	10	26,395	14,778	41,173	172,928	0.337	7,321	30,750	-8.2
Al Jameelat	27	44	9	3	1,975	1	0	23,253	11,934	35,186	147,783	12.456	6,257	26,278	-1.0
Beit Qad	13,908	5,068	1,020	363	228,874	92	26	31,351	19,264	50,615	212,584	0.156	9,000	37,801	1.2
Tura al Gharbiya	340	577	116	41	26,064	10	3	24,112	12,712	36,824	154,662	0.979	6,548	27,502	-1.4
Tura ash Sharqiya	148	240	48	17	10,828	4	1	23,568	12,220	35,788	150,311	2.316	6,364	26,728	-1.1
Al Hashimiya	2,327	665	134	48	30,018	12	3	24,253	12,840	37,093	155,791	0.902	6,596	27,702	-1.5
Nazlat ash Sheikh Zeid	8,146	1,196	241	86	54,021	22	6	25,110	13,615	38,725	162,647	0.618	6,886	28,921	-2.3
At Tarem	149	241	49	17	10,901	4	1	23,571	12,222	35,793	150,332	2.301	6,365	26,731	-1.1
Khirbet al Muntar al Gharbiya	45	73	15	5	3,292	1	0	23,300	11,976	35,276	148,159	7.495	6,273	26,345	-1.0
Jenin	26,148	39,971	8,044	2,862	1,805,175	724	206	87,615	70,188	157,803	662,773	0.059	28,060	117,852	0.3
Jenin Camp	31	50	10	4	2,268	1	0	23,263	11,943	35,206	147,866	10.856	6,260	26,293	-1.0
Jalbun	41,106	8,725	1,756	625	394,032	158	45	37,246	24,600	61,846	259,753	0.121	10,997	46,188	0.6
'Aba	4,218	986	198	71	44,519	18	5	24,771	13,308	38,079	159,933	0.712	6,771	28,439	-1.9
Khirbet Mas'ud	116	188	38	13	8,487	3	1	23,485	12,144	35,629	149,642	2.940	6,335	26,609	-1.1
Khirbet al Muntar ash Sharqiya	54	87	18	6	3,951	2	0	23,323	11,998	35,321	148,347	6.255	6,281	26,379	-1.0
Kafr Qud	20,156	2,910	586	208	131,437	53	15	27,873	16,116	43,990	184,757	0.356	7,822	32,853	5.0
Deir Abu Da'if	16,208	5,173	1,041	370	233,647	94	27	31,522	19,418	50,940	213,947	0.172	9,058	38,043	1.2
Birqin	6,460	3,498	704	250	157,986	63	18	28,821	16,974	45,795	192,339	0.218	8,143	34,201	2.6
Umm Dar	1,304	2,112	425	151	95,405	38	11	26,587	14,952	41,539	174,466	0.311	7,386	31,023	-12.9
Al Khuljan	1,768	1,000	201	72	45,170	18	5	24,794	13,329	38,124	160,119	0.639	6,779	28,472	-1.9
Wad ad Dabi'	5,871	1,142	230	82	51,597	21	6	25,024	13,537	38,561	161,954	0.663	6,857	28,798	-2.2
Dhaher al 'Abed	57	92	19	7	4,170	2	0	23,331	12,005	35,336	148,409	5.928	6,283	26,390	-1.0
Zabda	1,883	720	145	52	32,538	13	4	24,343	12,921	37,265	156,511	0.914	6,626	27,830	-1.5

Ya'bad	21,420	5,101	1,027	365	230,381	92	26	31,405	19,313	50,718	213,015	0.167	9,018	37,878	1.2
Kufeirit	17,202	2,319	467	166	104,724	42	12	26,920	15,253	42,173	177,127	0.446	7,499	31,496	-399.2
Imreiha	1,610	4,919	990	352	222,174	89	25	31,112	19,048	50,160	210,671	0.137	8,919	37,461	1.3
Umm at Tut	7,048	1,481	298	106	66,869	27	8	25,569	14,030	39,599	166,316	0.492	7,041	29,574	-3.1
Ash Shuhada	3,678	1,143	230	82	51,622	21	6	25,025	13,538	38,562	161,962	0.622	6,857	28,799	-2.2
Jalqamus	15,184	2,501	503	179	112,953	45	13	27,214	15,519	42,733	179,478	0.345	7,599	31,914	16.2
Al Mughayyir	5,889	1,463	294	105	66,066	26	8	25,540	14,004	39,544	166,087	0.527	7,032	29,533	-3.0
Al Mutilla	103	246	49	18	11,103	4	1	23,578	12,229	35,807	150,389	2.048	6,367	26,742	-1.1
Bir al Basha	442	848	171	61	38,283	15	4	24,548	13,107	37,655	158,152	0.661	6,696	28,122	-1.7
Al Hafira	508	73	15	5	3,280	1	0	23,299	11,976	35,275	148,155	10.503	6,272	26,344	-1.0
Qabatiya	82,639	21,685	4,364	1,553	979,343	393	112	58,138	43,509	101,647	426,917	0.093	18,075	75,913	0.3
Arraba	49,442	15,394	3,098	1,102	695,213	279	79	47,997	34,329	82,326	345,770	0.088	14,639	61,484	0.4
Telfit	2,525	2,414	486	173	109,020	44	12	27,073	15,392	42,465	178,354	0.260	7,551	31,714	32.0
Mirka	1,691	2,117	426	152	95,612	38	11	26,595	14,959	41,554	174,525	0.307	7,389	31,033	-13.2
Wadi Du'oq	206	142	29	10	6,415	3	1	23,411	12,077	35,488	149,051	3.710	6,310	26,504	-1.1
Fahma al Jadida	25	41	8	3	1,829	1	0	23,247	11,929	35,176	147,741	13.448	6,255	26,271	-1.0
Raba	4,830	4,246	854	304	191,746	77	22	30,026	18,065	48,091	201,981	0.181	8,551	35,916	1.7
Al Mansura	302	399	80	29	18,033	7	2	23,826	12,453	36,278	152,369	1.387	6,451	27,094	-1.2
Misliya	650	1,132	228	81	51,123	21	6	25,007	13,522	38,528	161,819	0.521	6,851	28,774	-2.1
Al Jarba	495	828	167	59	37,405	15	4	24,517	13,078	37,596	157,901	0.702	6,685	28,077	-1.7
Az Zababida	6,341	2,366	476	169	106,852	43	12	26,996	15,322	42,318	177,735	0.319	7,525	31,604	70.0
Fahma	80,035	8,799	1,771	630	397,402	159	45	37,367	24,708	62,075	260,716	0.281	11,038	46,360	0.6
Az Zawiya	1,635	5,612	1,129	402	253,467	102	29	32,229	20,058	52,288	219,608	0.122	9,298	39,050	1.1
Kafr Ra'i	85,923	16,620	3,345	1,190	750,599	301	86	49,974	36,119	86,092	361,588	0.103	15,309	64,296	0.4
Al Kufeir	5,318	3,015	607	216	136,172	55	16	28,042	16,269	44,312	186,109	0.447	7,879	33,093	4.3
Sir	114,274	17,794	3,581	1,274	803,641	322	92	51,867	37,832	89,699	376,737	0.093	15,950	66,990	0.4
'Ajja	97,745	19,453	3,915	1,393	878,553	352	100	54,541	40,252	94,793	398,131	0.079	16,856	70,794	0.4

'Anza	14,995	2,809	565	201	126,870	51	14	27,710	15,969	43,679	183,452	0.283	7,767	32,621	6.0
Sanur	1,283	2,914	586	209	131,584	53	15	27,879	16,121	44,000	184,799	0.220	7,824	32,860	5.0
Ar Rama	33,999	7,174	1,444	514	324,008	130	37	34,747	22,337	57,084	239,755	0.138	10,151	42,632	0.8
Meithalun	11,271	6,260	1,260	448	282,725	113	32	33,273	21,004	54,277	227,964	0.132	9,651	40,536	0.9
Al Judeida	72,136	13,474	2,712	965	608,519	244	69	44,902	31,529	76,431	321,010	0.115	13,591	57,081	0.5
al 'Asa'asa	135	219	44	16	9,877	4	1	23,535	12,189	35,724	150,039	2.534	6,352	26,679	-1.1
Al 'Attara	8,652	3,299	664	236	149,006	60	17	28,501	16,684	45,184	189,774	0.202	8,035	33,745	3.1
Siris	22,234	9,391	1,890	672	424,134	170	48	38,321	25,572	63,893	268,350	0.149	11,361	47,717	0.6
Jaba'	14,043	8,558	1,722	613	386,512	155	44	36,978	24,357	61,335	257,605	0.119	10,906	45,807	0.7
Al Fandaqumiya	809	1,602	322	115	72,356	29	8	25,765	14,208	39,972	167,883	0.336	7,108	29,852	-3.7
Silat adh Dhahr	22,682	56,609	11,392	4,053	2,556,591	1,025	292	114,436	94,463	208,899	877,375	0.051	37,146	156,012	0.3

Appendix G2: Relationship between Volume of Biodigester and Cost of kWh (NIS) for Jenin Governorate



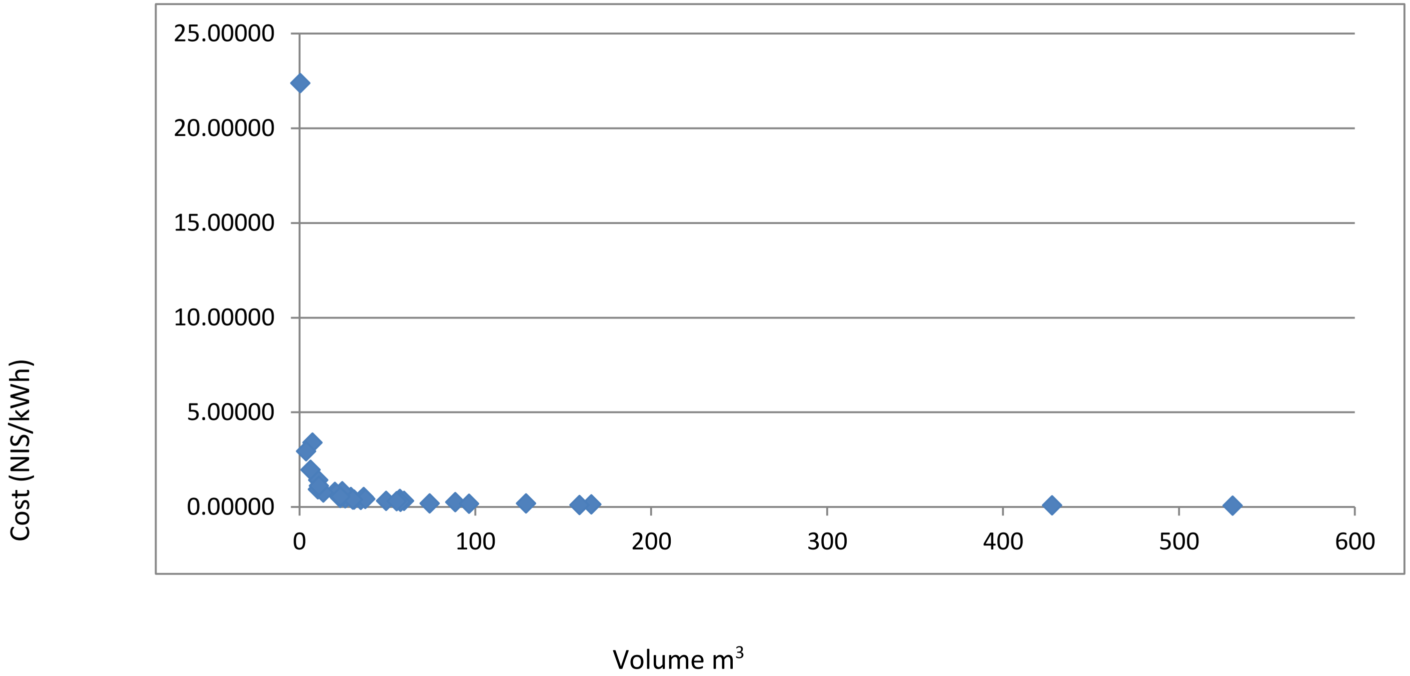
Appendix H

Appendix H1: Summary of Potential Biogas Production and Economic Analysis for Tulkarem Governorate

Location	NO. Of Animals	Total waste wet g/day	Total waste dry for kg/day	Biogas yield- m3/kg.TS	Electricity kWh	Volume (m^3)	Power (kW)	Cost of plant (€)	Cost of generator (€)	Total cost (€)	Tolal cost (NIS)	Cost (NIS)/kWh	AW (€)	AW (NIS)	P.B.P
'Akkaba	27,824	3,135	631	224.47	141,579	57	16.2	28,235	16,444	44,679	187,653	0.42	7,945	33,368	3.66
Qaffin	11,920	2,786	561	199.49	125,825	50	14.4	27,673	15,935	43,608	183,154	0.33	7,754	32,568	6.29
Nazlat 'Isa	2,911	548	110	39.25	24,756	10	2.8	24,066	12,670	36,735	154,289	1.42	6,532	27,435	1.37
An Nazla ash Sharqiya	4,714	1,384	279	99.12	62,519	25	7.1	25,414	13,890	39,303	165,074	0.47	6,989	29,353	2.77
Baqa ash Sharqiya	6,941	1,861	375	133.25	84,046	34	9.6	26,182	14,585	40,767	171,222	0.37	7,249	30,446	5.82
An Nazla al Wusta	4,379	415	83	29.69	18,726	8	2.1	23,850	12,475	36,325	152,567	3.40	6,459	27,129	1.26
An Nazla al Gharbiya	6,837	1,079	217	77.28	48,743	20	5.6	24,922	13,445	38,366	161,139	0.79	6,822	28,653	2.04
Zeita	18,407	2,098	422	150.23	94,751	38	10.8	26,564	14,931	41,495	174,279	0.53	7,379	30,990	12.08
Seida	22,734	3,364	677	240.85	151,912	61	17.3	28,604	16,778	45,382	190,604	0.32	8,070	33,893	2.90
'Illar	28,611	5,012	1,009	358.90	226,363	91	25.8	31,262	19,183	50,445	211,867	0.25	8,970	37,674	1.25
'Attil	59,562	9,471	1,906	678.15	427,721	172	48.8	38,449	25,688	64,137	269,375	0.14	11,405	47,899	0.60
Deir al Ghusun	9,168	1,570	316	112.42	70,908	28	8.1	25,713	14,161	39,874	167,470	0.53	7,090	29,779	3.50
Al Jarushiya	11,212	1,636	329	117.15	73,891	30	8.4	25,819	14,257	40,077	168,321	0.45	7,126	29,930	3.86
Al Masqufa	569	195	39	13.97	8,812	4	1.0	23,497	12,155	35,651	149,735	2.95	6,339	26,625	1.11
Bal'a	174,280	33,097	6,661	2,369.89	1,494,738	599	170.6	76,535	60,159	136,693	574,112	0.07	24,306	102,087	0.29
Iktaba	7,565	1,692	340	121.13	76,397	31	8.7	25,909	14,338	40,247	169,037	0.41	7,157	30,058	4.21
Nur Shams Camp	3,685	1,426	287	102.11	64,403	26	7.4	25,481	13,951	39,431	165,612	0.82	7,012	29,449	2.91
Tulkarm Camp	15	24	5	1.74	1,097	0	0.1	23,221	11,905	35,127	147,532	22.38	6,246	26,234	1.01
Tulkarm	71,202	24,232	4,877	1,735.15	1,094,394	439	124.9	62,245	47,225	109,470	459,775	0.08	19,466	81,756	0.33
Anabta	18,612	5,272	1,061	377.47	238,080	95	27.2	31,680	19,561	51,241	215,214	0.16	9,112	38,269	1.15
Kafr al Labad	13,587	3,973	800	284.51	179,444	72	20.5	29,587	17,667	47,254	198,467	0.19	8,403	35,291	1.90
Kafa	9,729	1,822	367	130.44	82,270	33	9.4	26,119	14,528	40,646	170,715	0.39	7,228	30,356	5.35
Al Haffasi	167	534	107	38.22	24,107	10	2.8	24,042	12,649	36,691	154,103	0.92	6,524	27,402	1.36
Ramin	7,750	1,879	378	134.56	84,872	34	9.7	26,211	14,612	40,823	171,458	0.42	7,259	30,488	6.07
Far'un	9,222	1,213	244	86.86	54,787	22	6.3	25,138	13,640	38,778	162,866	0.71	6,895	28,960	2.31
Shufa	62,199	7,409	1,491	530.55	334,629	134	38.2	35,126	22,681	57,807	242,788	0.19	10,279	43,172	0.75

Khirbet Jubara	7,137	1,389	279	99.43	62,713	25	7.2	25,420	13,896	39,316	165,129	0.47	6,991	29,363	2.78
Saffarin	5,148	1,626	327	116.44	73,440	29	8.4	25,803	14,243	40,046	168,193	0.39	7,121	29,907	3.80
Beit Lid	7,861	2,837	571	203.13	128,117	51	14.6	27,755	16,009	43,764	183,808	0.27	7,782	32,684	5.68
Ar Ras	651	304	61	21.79	13,742	6	1.6	23,673	12,314	35,986	151,143	1.97	6,399	26,876	1.18
Kafr Sur	4,244	8,942	1,800	640.27	403,833	162	46.1	37,596	24,916	62,512	262,552	0.10	11,116	46,686	0.63
Kur	530	682	137	48.85	30,809	12	3.5	24,282	12,865	37,147	156,017	0.76	6,605	27,742	1.50
Kafr Zibad	317	514	103	36.77	23,193	9	2.6	24,010	12,619	36,629	153,842	1.11	6,513	27,356	1.34
Kafr Jammal	759	1,098	221	78.64	49,599	20	5.7	24,952	13,472	38,425	161,384	0.54	6,833	28,697	2.08
Kafr 'Abbush	10,828	2,750	553	196.92	124,203	50	14.2	27,615	15,883	43,498	182,691	0.30	7,735	32,485	6.80

Appendix H2: Relationship between Volume of Biodigester and Cost of kWh (NIS) for Tulkarem Governorate

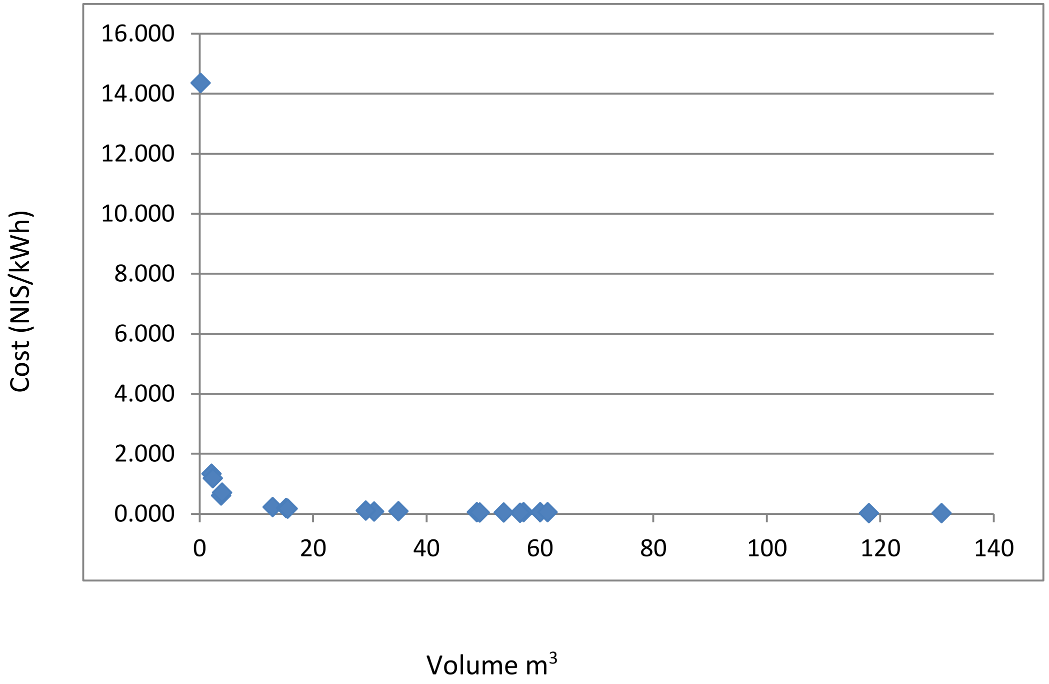


Appendix I

Appendix I1: Summary of Potential Biogas Production and Economic Analysis for Salfeet Governorate

Location	NO. Of Animals	Total waste dry for g/day	Biogas yield- m3/kg.TS	Volume (m^3)	Electricity kWh	Power (kW)	Cost of plant (€)	Cost of generator (€)	Total cost (€)	Tolal cost (NIS)	Cost (NIS)/kWh	AW (€)	AW (NIS)	PBP
Deir Istiya	4,746.0	543.1	63,084.2	48.9	120,911.5	13.8	27,531.8	15,776.2	43,308.0	173,232.0	0.27	7,700.9	32,343.7	8.2
Qarawat Bani Hassan	7,209.0	634.7	74,009.2	57.1	141,851.0	16.2	28,266.2	16,452.6	44,718.8	178,875.3	0.24	7,951.7	33,397.3	3.6
Qira	54.0	23.2	2,447.2	2.1	4,690.5	0.5	23,368.0	12,021.5	35,389.5	141,558.1	5.63	6,292.8	26,430.0	1.1-
Kifl Haris	399.0	548.9	81,863.5	49.4	156,905.1	17.9	27,578.3	16,939.0	44,517.3	178,069.0	0.21	7,915.9	33,246.8	2.4
Marda	63.0	42.0	5,379.6	3.8	10,311.0	1.2	23,518.4	12,203.1	35,721.5	142,886.1	2.59	6,351.9	26,677.9	1.1-
Biddya	5,397.0	389.5	38,566.9	35.1	73,919.9	8.4	26,301.8	14,258.1	40,559.9	162,239.5	0.41	7,212.2	30,291.3	3.7-
Haris	61.0	26.2	2,764.5	2.4	5,298.6	0.6	23,392.1	12,041.2	35,433.3	141,733.1	4.99	6,300.6	26,462.6	1.1-
Yasuf	673.0	143.0	14,719.2	12.9	28,211.8	3.2	24,327.3	12,781.4	37,108.7	148,434.9	0.98	6,598.5	27,713.9	1.4-
Mas-ha	4,344.0	342.2	42,899.8	30.8	82,224.6	9.4	25,923.1	14,526.3	40,449.5	161,797.9	0.37	7,192.6	30,208.9	5.5-
Iskaka	4,112.0	169.8	17,746.5	15.3	34,014.1	3.9	24,542.4	12,968.9	37,511.3	150,045.1	0.82	6,670.1	28,014.5	1.6-
Sarta	1,980.0	325.9	33,445.5	29.3	64,103.8	7.3	25,792.8	13,940.9	39,733.7	158,934.8	0.46	7,065.3	29,674.3	2.8-
'Izbat Abu Adam	5.0	2.2	226.6	0.2	434.3	0.0	23,199.2	11,884.0	35,083.3	140,333.0	60.33	6,238.4	26,201.2	1.0-
Az Zawiya	17,250.0	1,453.7	174,606.4	130.8	334,662.4	38.2	34,826.2	22,681.6	57,507.8	230,031.1	0.13	10,225.8	42,948.5	0.7
Salfit	12,943.0	1,311.2	151,825.1	118.0	290,998.1	33.2	33,684.7	21,271.0	54,955.7	219,822.7	0.14	9,772.0	41,042.5	0.9
Rafat	3,194.0	667.3	68,942.4	60.1	132,139.6	15.1	28,526.9	16,138.9	44,665.8	178,663.2	0.25	7,942.3	33,357.8	5.3
Bruqin	328.0	627.8	97,202.4	56.5	186,304.6	21.3	28,210.4	17,888.7	46,099.2	184,396.7	0.18	8,197.2	34,428.2	1.6
Farkha	2,754.0	595.6	76,294.2	53.6	146,230.5	16.7	27,952.5	16,594.1	44,546.6	178,186.4	0.23	7,921.1	33,268.7	3.1
Kafr ad Dik	3,239.0	173.0	19,518.6	15.6	37,410.6	4.3	24,567.5	13,078.6	37,646.1	150,584.3	0.75	6,694.1	28,115.2	1.7-
Deir Ballut	5,296.0	682.0	73,844.4	61.4	141,535.0	16.2	28,644.6	16,442.4	45,087.0	180,348.0	0.24	8,017.2	33,672.3	3.8
Khirbet Qeis	103.0	44.3	4,667.9	4.0	8,946.8	1.0	23,536.8	12,159.0	35,695.8	142,783.2	2.98	6,347.3	26,658.7	1.1-

Appendix I2: Relationship between Volume of Biodigester and Cost of kWh (NIS) for Salfeet Governorate



Appendix J

As to the Palestinian Environmental Assessment Policy (PEAP), the EIA is a perquisite for the approval of any project in Palestine. The EIA is the project document informing the relevant permitting authorities and the Environmental Quality Authority (EQA) that a project is being considered. It is the document used by the EQA to screen the project for its disposition under the EIA Policy, and to consider permitting conditions. The EIA should list what environmental and other permits must be obtained and complied, it indicates how the expected conditions of these permits will be fulfilled, and it includes a signed statement by the proponent that these conditions will be fulfilled. [35]

Appendix J1: Environmental Law

The Environment law identifies waste, hazardous materials, and hazardous waste. It is also based on the polluter pays principle. Although the law does not indicate that culled animals due to an infectious disease and their waste as hazardous waste directly, it however implies that these wastes are considered hazardous. Culled animals due to an infectious disease and their waste are biologically infectious material, therefore are regulated under the environmental law, and the disposal method of this waste should be approved by EQA. Also, this law identifies (Article 12) that handling hazardous waste, should be in accordance to terms, regulations, instructions and norms specified by EQA in coordination with specialized agencies. Therefore, transport, storage, use, treatment and disposal of culled animals and their waste, should be according to these norms and regulations. However, these norms and regulations are not issued yet, therefore, it is subjective to the opinion of the EQA employees. [35]

Appendix J2: Ministry of Energy and Natural Resources (MENR)

The objectives of the Ministry of Energy and Natural Resources are to develop current electricity sources and develop sustainable and cost-effective new sources and to minimize the emission of air pollutants. This can be achieved by full adoption of the actions specified in the National Environmental Action Plan (NEAP) to protect health and the environment from the effects of air pollution.

The following table (J2.1) is a summary of the laws and regulations [37]

Table (J2.1): Summary of the laws and regulations

Name of Law	Law Summary	Year
Environmental laws and regulations		
Law7/1999	Palestinian Environmental Law	1999
Law3/2002	Palestinian Water Law	2002
	Regulations for Ground water Pollution Control	
	Guide lines for Waste water Reuse in the Gaza Strip ,Palestine	2002
	Water Pollution Control System	
DecreeNo.90/1995	Regarding The establishment of Palestinian Water Authority(PWA)	1995
DecreeNo.6/2002	TheEnvironmentQualityAuthoritywasestablishedbyPresidentialdecreeNo6/2002	2002
TS34/2012	The Palestinian Treated Waste water Standard(Technical Specification)	2012
Solid Waste regulations	Solid Waste Management Regulations	2004
Social laws and regulations		
Law7/2000	PalestinianLaborLaws7/2000	2000
	Health and safety	
Law3/2011	Land Ownership	2011
Law2/1953	Expropriation Law(Istmlak)	1953
AntiquitiesLaw1966	Palestinian Antiquities Law	1966
Basic laws	Basic Laws declaration for Palestinian Human Right	2003
Law21	Consumer protection laws	2005
Other laws and regulations		
JSC Regulations	Joint Service Council(JSC)Regulations	2006
PRDP	Palestinian Reform and Development Plan(2008-2010)	2008-2010
Law1/1997	Local Council Law	1997

جامعة النجاح الوطنية
كلية الدراسات العليا

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إعداد
ربا أحمد حسن عليا

إشراف
د. عبد الرحيم أبو الصفا
أ.د. عامر الهموز

قدمت هذه الأطروحة استكمالاً لمتطلبات الحصول على درجة الماجستير في هندسةالطاقة النظيفة وترشيد الاستهلاك ،كلية الدراسات العليا في جامعة النجاح الوطنية في نابلس، فلسطين

2017

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إعداد

ربا احمد حسن عليا

إشراف

د. عبد الرحيم أبو الصفا

أ.د. عامر الهموز

الملخص

إنتاج الغاز الحيوي بالتخمر يعتبر من الطرق المهمه لانتاج الطاقة المتجددة، من أهم طرق استغلال الغاز الحيوي هي توليد الطاقة الكهربائية من خلال مولدات خاصة. يوجد في فلسطين عدد كبير من الحيوانات مثل : الأبقار، الماعز، الخراف والطيور وتنتج كمية كبيرة من الروث والذي يصلح لعمليات التخمر اللاهوائي وإنتاج مايسمى بالغاز الحيوي.

في محاولة لتقدير كمية الطاقة الكهربائية الممكن توليدها من الغاز الحيوي الناتج من تخمر روث الحيوانات، تم جمع بيانات عن عدد الحيوانات وانواعها وكميات الروث المنتجه بشكل يومي في جميع قرى محافظات الضفة الغربية.

يهدف هذا البحث الى دراسة الجدوى الاقتصادية وتقييم الاثر البيئي لمحطات انتاج الطاقة الكهربائية من الغاز الحيوي حيث تم حساب كميات الروث الناتجة من الحيوانات في كل قرية وحساب حجم الهاضم الحيوي اللازم وحساب قدرة المولد الكهربائي وتقدير كمية الكهرباء الممكن انتاجها سنوياً ومن ثم تم حساب القيمة السنوية(AW) والتي من خلالها تم حساب كلفة موازنة لتوليد الكهرباء(LCOE) ولعملية حساب الربح المتوقع تم أخذ سعر بيع الكيلواط ساعة الواحدة من الكهرباء 30 أغورة لضمان منافسة الشركة القطرية والتي تبيع للشبكات المحلية بسعر 40 أغورة لكل كيلواط ساعة.

ولغاية الربح وضمان فترة قصيرة لاسترداد رأس المال قد تبين عدم جدوى إنشاء أي هاضم حيوي بحجم أقل من 100 متر مكعب .

وحيث أن كلفة موازنة التوليد تعتمد بشكل مباشر على حجم الهاضم وحجم إنتاج الغاز الحيوي فقد تم دراسة عمل محطات مركزية يتم من خلالها تجميع الروث الناتج في عنقود من القرى المتجاورة آخذاً بعين الاعتبار الأثر البيئي لعملية التجميع وقد تبين أن جميع المحطات المركزيه المقترحة مجدية من الناحية الإقتصادية وفترة استرداد رأس مال أقل من المحطات اللامركزيه. وقد تبين من خلال تقييم الاثر البيئي أن المحطات المركزية هي أفضل من الناحية الإجتماعية والناحية البيئية.

بالنظر الى أهم النتائج تبين أن محافظة الخليل لها القدرة على إنتاج أكبر كمية من الغاز الحيوي بمعدل 45670 م^3 يوميا والذي يعادل طاقة كهربائية تساوي 28.8 جيجا واط ساعة سنوياً. وكانت محافظة سلفيت هي الأقل انتاجا حيث قدرت كمية الغاز المتوقع انتاجها يوميا 2860م^3 والتي تعادل 2جيجا واط ساعة من الطاقة الكهربائية سنوياُ.

وقد أظهرت الدراسة الحالية أن كمية الطاقة الكهربائية المتوقع انتاجها تعادل 2% من الطاقة المستهلكة في الضفة الغربية.

في حالة الإستخدام الامثل للطاقة الحيوية في الأنظمة المذكورة فإنه يتوقع تقليل كمية انبعاث الغازات الدفيئة بما يعادل تقريباً مئة ألف طن من غاز ثاني أكسيد الكربون الناتج عن توليد نفس الكمية من الطاقة الكهربائية باستخدام الفحم الحجري سنوياً.