# Sustainable Energy Solutions for Rural Electrification (A Comprehensive Study of Microgrid and Distributed Generation Systems)

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## Abstract

Providing power to the people of Afghanistan is a major problem, especially in rural areas where access is severely restricted. Relying on the National Grid is not viable because 75% of people live in these regions and just 9% of people have access to energy. A Micro-Grid system is suggested in this paper as a practical and affordable way to provide rural villages with electricity. The Sayyidabad area of Wardak province's Khwaja Kotgay acts as a case study for assessing the technical feasibility of this Micro-Grid. In addition to having access to local resources, such as biogas produced from the waste of 150 cattle, the region enjoys 220 to 250 sunny days per year. Each day, about 50 cubic meters of biogas are produced. Biogas and solar energy will work together to generate electricity at night. A carefully planned network, consisting of three sections, will distribute the electricity generated to homes. The components of each segment will be determined by the load requirements of each family. The goal of this initiative is to provide dependable and sustainable electricity to rural areas, thus empowering them. At the end of the research, the researchers will present useful results and important recommendations.

**Keywords:** Sustainable Energy, Micro-Grid, Distributed Generation, Rural Electrification, PV syst.

## 1. Introduction

The need for dependable and easily available energy has grown as society develops and becomes essential to sustaining modern living. Everyday necessities like extracting water and regulating the temperature, as well as luxuries like entertainment and communication gadgets, are all made possible by electricity. The fact that electrical appliances are used by everyone shows how important electricity is to raising living standards; without it, many chores would be labor-intensive or nearly impossible, which would have a negative impact on our quality of life.

The difficulty of supplying electricity endures despite its significance, especially in isolated and neglected locations where power plants are frequently situated distant from customers. Because of this separation, a reliable system of distributing electricity—also known as the electrical grid—is required. Solar microgrids are one of the most promising grid designs; they use solar energy to feed individual residences in the vicinity autonomously. These self-sufficient systems offer a practical solution for powering remote areas because they can function independently or in tandem with the main grid.

The purpose of this study is to determine whether it is feasible to use the natural resources of Khwaja Kotgay, Afghanistan, to create a solar microgrid that would provide the local populations with clean, sustainable electricity. There are practical answers to the shortage of electricity, especially in rural regions, thanks to the growing trend toward distributed generation systems. India, for instance, has achieved notable progress in distributed production, obtaining over 13,700 MW of its electricity from renewable sources. (Niwas and others, 2009) By avoiding the drawbacks of centralized power systems, this strategy also lessens the negative environmental effects associated with reliance on fossil fuels.

Numerous studies conducted worldwide highlight the economic and environmental benefits of microgrid systems. The goal of innovations like Sharjah's integration of solar and biomass energy is to lessen the city's dependency on fossil fuels while efficiently handling organic waste.

In 2016, Ghenai and Janajreh Furthermore, using solar power in Kinshasa to improve voltage stability during periods of high demand emphasizes the various advantages of microgrid technology (Ecike,2019). Our goal is to show how a solar microgrid in Khwaja Kotgay may be used as a model for sustainable energy distribution through this research, thereby empowering the local community and encouraging a wider adoption of renewable energy systems in comparable situations.

## 2. Methodology

### 2.1. Site Selection

Our goal was to investigate ways to bring electricity to Afghanistan's remote desert regions. We chose the well-known region of Khwaja Kotgi, which is situated in the southwest of Wardak Province, for this reason. This area is located at latitude 34°11’24.0"N and longitude 68°48’00.0"E in the Saiyidabad district. The majority of the people living in Khwaja Kotgi are farmers and farmers of livestock. The area is flat. This emphasis on agriculture draws attention to the community's reliance on renewable energy sources to improve their standard of living and production. Furthermore, the region's geographic position guarantees that it receives plenty of sunlight all year round, which makes it a prime option for solar energy solutions. Figure 1. Shows the map of the Khwaja Kotgi ((34°11’24.0"N 68°48’00.0"E - Google Maps, n.d.))

**Figure 1.** Map of the Khwaja Kotgi [4]

### 2.2. Data collection

After identifying the location, I visited the area to gather essential data for the study, categorizing the information into primary and secondary sources.

#### 2.2.1. Primary Data:

The information gathered during the site visit or surveys is categorized as primary data, which includes:

- **Number of Houses:** There are 103 houses in the village, along with four nearby mosques.
- **Population:** With an average of 8 individuals per household, the total population is approximately 824 people.

- **Livestock:** Nearly every household owns at least one cow, resulting in about 150 cows in the village.

The renewable resources in Khwaja Kotagi suitable for electricity production include:

- Solar: The area enjoys around 280 to 300 sunny days each year, making it ideal for solar energy.
- Biomass: With 150 cattle producing approximately 17 kilograms of waste each, the region generates about 2,550 kilograms of biomass daily, providing a renewable energy source.

### 2.3. Village's Electrical Demand

We must evaluate each household's maximum electrical requirement as well as the quantity and wattage of its appliances in order to calculate the village's electrical demand. Our initial goal was to sample 10% of the population; but, due to various obstacles, we were only able to obtain data from 8 of the 103 houses. We can determine the average load for the eight households by using this sample, which consists of residences with high, average, and low power consumption. You can use equation (1) (V.K. Mehta & Rohit Mehta, 2016). We find a total load of 21,727 watts by adding up all of their loads.

$$Average\ load\ = \frac{total\ homes\ load}{number\ of\ home} \qquad (1)$$

Equation (2) is used to get the Maximum Demand for the residences after determining the average load. (Mehta, V.K. & Rohit, 2016) After applying a Diversity Factor of 3, which is the average for residential areas, we compute 724.233 as the Maximum Demand.

$$\text{Max Demand } = \frac{\text{average load} \times 0.8}{3} \qquad (2)$$

We calculate the overall electricity need for Khwaja Koti, which consists of 103 houses and 4 mosques, after computing the Diversity Factor. We get 74,595.999 watts total by multiplying the Maximum Demand by the number of dwellings. The village's total electricity use is 85,000 watts, including the mosques' typical demand of 2,500 watts.

### 2.4. Secondary Data

Khwaja Kotgi receives an average of 5.35 hours of sunlight per day, with an average solar radiation of 5.35 kWh/m²×day, suitable for design purposes. This monthly total equates to 1,208,890.2 Wh.

# 3. Design

## 3.1. Solar System Design

Our design of the solar system is based on the 84.575399 kW total load of the hamlet. The design determines the required solar system capacity by taking into account losses associated with wiring, AC and DC electricity, and solar panels.

### 3.1.1. AC Power Loss

Two categories of losses arise in the AC portion, namely inverter losses and AC wiring losses, which are determined by Equation (3) (Kalogirou, n.d.) as follows:

$$\text{AC power output of inverter } = \frac{\text{power fed to load}}{1 - \text{AC power loss}} \qquad (3)$$

Equation (4) (Kalogirou, n.d.) calculates the power losses of the inverter in relation to MPPT tracking and the conversion from DC to AC as follows:

$$\text{Inverter DC power input } = \frac{\text{inverter AC power output}}{1 - \text{inverter power loss}} \qquad (4)$$

### 3.1.2. DC Power Loss

Several losses occur in the DC power wire that connects the inverter and solar panels. These losses are determined using Equation (5) (Kalogirou, n.d.) as follows:

$$PV\ arrary\ DC\ power\ output\ = \frac{\text{inverter DC power input}}{1 - \text{DC cable losses}} \qquad (5)$$

### 3.1.3. Losses in Solar Panels

In solar panels, several losses occur due to factors such as dust or dirt on the surface, reflection of solar radiation, module mismatch loss, and variations in temperature, which we calculate as follows:

- Module soiling loss due to dust = 1% - 2%
- Solar radiation loss = 2% - 4%
- Module mismatch loss = ±3%
- Module temperature losses = 35 - 2 * 0.45%/°C = 14.85%
- Total losses of PV module = 2% + 2.5% + 3% + 14.85% = 22.35%

After calculating the above losses, the total capacity of the system is obtained by Equation (6)(Kalogirou, n.d.) as follows:

$$\text{Total dc power output of array } = \frac{PV\ arrary\ DC\ power\ output}{1 - \text{Total losses of PV module}} \quad (6)$$

### 3.1.4. Number of Solar Panels

For this system, we select 300W panels, which calculated by Equation (7)(Kalogirou, n.d.) as follows:

$$Total\ no\ of\ modules\ required\ = \frac{Total\ PV\ plant\ capacity}{\text{Rated power of one module}} \quad (7)$$

The system requires 400 panels, each with a maximum power of 300W.

### 3.1.5. Inverter Selection

Given the total load of 84.575399 kW, no available inverter matches this capacity. Therefore, we have chosen a 100 kVA inverter from the reputable SMA company for the solar system.(SC 100 Outdoor / SC 100 Indoor SUNNY CENTRAL 100 Powerful and Efficient, n.d.)

### 3.1.6. Finding the number of solar panels in a string

Finding the number of solar panels in a string for this system by Equation (8).(Kalogirou, n.d.)

$$NO\ of\ modules\ in\ string\ = \frac{Vmp\ voltage\ of\ selected\ inverter}{\text{Vmp voltage of selected PV module}} \quad (8)$$

For this system, the number of panels in a string is 25.

### 3.1.7. Finding the number of PV strings in parallel

For obtaining the number of PV strings in parallel Equation (9)(Kalogirou, n.d.) can be used.

$$No.of\ PV\ string\ in\ parallel = \frac{Total\ no.of\ PV\ modules\ in\ system}{No\ of\ \ modules\ in\ \ a\ strings} \quad (9)$$

In this system, there are 16 strings, with each string containing 25 panels.

### 3.1.8. Finding the Shadow Distance Between Two Solar Panels

For obtaining the shadow distance between two solar panels Equation (10) & Equation (11)(Kalogirou, n.d.) can be used the solar Altitude angle is calculated using the following Equation (10).(Kalogirou, n.d.)

$$sin(\alpha) = sin(l) \times sin(\delta) + cos(l) \times cos(h) \times cos(\delta) \quad (10)$$

The known variables in the formula are:

$latitude$ = 34.19, h = -45, $\delta$ = -23.45

### 3.1.9. Distance Between One string of Panels and Another

$$\frac{b}{a} = \frac{sin\beta}{\tan\alpha} + \cos\beta \quad (11)$$

Where b is length of panels, $a$ is altitude angle and $\beta$ is tilt angle

### 3.1.10. Junction Box Selection

For obtaining open circuit voltage & maximum voltage in one string Equations (12) & (13) (Kalogirou, n.d.) can be used.

$one$ string Voc = N × Voc/module (12)

$one$ string Vm = N × Voc/module (13)

With protection and Voc considerations in mind, we selected a junction box with a maximum input voltage of 1500V and a maximum input current of 630A. Additionally, we have 52 lines, each consisting of a positive and negative line, totaling 104 lines. For obtaining number of connected strings in one junction box Equation (144), number of strings for one inverter Equation (15) & number of junction box for one inverter Equation (16)(Kalogirou, n.d.) can be used.

$$No - connected\ string\ in\ one\ junction\ box = \frac{Imax}{Isc\ of\ module} \quad (14)$$

$$No - string\ needed\ for\ 1\ inverter = \frac{Total\ number\ of\ string}{Total\ number\ of\ inverter} \quad (15)$$

$$No - JB\ needed\ for\ 1\ inverter = \frac{No - string\ in\ one\ inverter}{No\ of\ string\ in\ one\ JB} \quad (16)$$

### 3.1.11. line selection

The selection of a line is determined by voltage drop, distance, current, and voltage. One takes into account a 3% voltage decrease for direct current. The voltage and current in our system are 780 volts and 9.63 amps, respectively. To construct the system's line, we utilized the online calculator shown in Table No. 1 of Characteristics of Selected Cable for the Solar System (Cable Cross Sectional Area Calculator | RS, n.d.).

**Table No.1 Characteristics of Selected Cable for the Solar System**

| No. | Usage of Cable | Type | Cross-section ($mm^2$) | Cable Size | Cable Length(m) |
|---|---|---|---|---|---|
| **1** | Characteristics of Cable between String and Junction Box | Copper | 1.5 | 16AWG | 57 |
| | | Copper | 2.5 | 14AWG | 118 |
| | | Copper | 4 | 12AWG | 54 |
| **2** | Characteristics of Cable between Junction Box and Inverter | Copper | 35 | 2 AWG | 4 |

## 3.3. Biomass Design

### 3.3.1. Potential of Biogas from Cattle Manure in the Region

The possibility for producing biogas from animal dung in the area is evaluated in this section. There are 150 cattle, according to our survey, and each one produces 17 kg of manure every day.

### 3.3.2. Parameters of Cattle Manure

In order to ascertain the biogas potential of cattle dung, it is necessary to take into account various criteria, as outlined in Table No. 2, including daily manure production, collection efficiency, dry manure quantity, gas conversion potential, biogas yield, and energy content. The effectiveness of collecting dung in Afghanistan is approximately 80%. (2019, Noori & Fazli)

**Table No.2 criteria of ascertain the biogas potential of cattle dung**

| Parameters | Value |
|---|---|
| Fresh Manure Generation (Kg head-1 day-1) | 17 |
| Fraction Recoverable (%) | 0.80 |
| Proportion Of Dry Matter (%) | 0.237 |
| Fraction Of Volatile solid (Kg VS kg-1 DM) (%) | 0.52 |
| Biogas Yield (m3 Kg-1 VS) | 0.20 |
| Calorific Value of Biogas (MJ m-3) | 20 |

### 3.3.3. Annual Quantity of Collected Dry Manure from the Cattle

Based on the data presented in the above table, one cattle can produce 1,168 kg of dry manure year on average. Fourteen hundred and fifty kg of dry manure may be collected in a year, given the 150 cattle in the community. 83,161,600 megajoules (MJ) of energy can be obtained from this dung.

### 3.3.4. Biogas Potential Generation

The number of cows and other pertinent factors are taken into account when calculating the biogas potential, as shown in table No. 3. Over the course of a day, a cow generates 17 kg of waste material. Of this 17 kg of fresh waste, 13.6 kg can be recovered. 3.2 kg of dry waste are produced after drying, of which 52% can be turned into biogas, yielding 1.67 kg. The 150 cows in the village produce 50 cubic meters of biogas a year.

**Table No.3**

| Parameters | Value |
|---|---|
| No. Of Cows | 150 |
| Manure Generation (Kg head-1 day-1) | 17 |
| Fraction Recoverable (%) | 0.80 |
| Proportion Of Dry Matter (%) | 0.237 |
| Fraction Of Volatile solid (Kg VS kg-1 DM) (%) | 0.52 |
| Biogas Yield (m3 Kg-1 VS) | 0.20 |
| Biogas Potential (m3 year-1) | 18250 |

### 3.3.4. Design of the Biogas Digester

A digester that can create 50 cubic meters of biogas is needed in order to obtain biogas from animal waste. Equation (17) (Capareda, 2013) calculates the amount of livestock manure produced daily in a village with 150 cows kept as follows:

$$\text{Manure generation (m3/day)} = \frac{\left\{\text{NA} \times \text{Manure generation} \left(\frac{\text{kg}}{\text{head} \times \text{day}}\right) \times \text{FR}\right\}}{960} \quad (17)$$

Equation (18) doubles and obtains the resultant waste since the water to waste ratio is 1:1. (Capareda, 2013)

$$\text{Slurry volume} \left(\frac{\text{m3}}{\text{day}}\right) = \text{Cow manure (m3/day) x 2(Manure to water ratio 1: 1)} \quad (18)$$

Biogas plant storage capacity is obtaining by Equation (19)(Capareda, 2013):

$$\text{Digester Volume (m3)} = \text{Slurry volume} \left(\frac{\text{m3}}{\text{day}}\right) \text{x RT (day)} \quad (19)$$

Given that the average temperature in Wardak Province is 20°C, 45 days is the retention period (RT) for garbage storage. With the assumption that the digester is cubic, we can express its length as (L), width as (W), and height as (H). We can then use Equation (20) to get the digester volume. (2019, Noori & Fazli)

$$\text{Digester Volume (m3)} = \text{W x L x H} \qquad (20)$$

The height of the dome above the biogas plant surface is calculated by Equation (21)(Noori & Fazli, 2019) as:

$$\text{F (m)} = \frac{1}{3} \times w \qquad (21)$$

The radius of the biogas plant dome & central angle of the dome arc is calculated by Equation (22) & (23)(Noori & Fazli, 2019) as:

$$\text{R (m)} = \frac{(\text{W}^2 + 4\text{f}^2)}{8\text{f}} \qquad (22)$$

$$\text{Central angle of the dome arc, Ø (degree)} = 2\text{x} \tan^{-1}\{\left[\frac{\frac{\text{w}}{2}}{[\text{R} - \text{f}]}\right\} \qquad (23)$$

For obtaining the storage volume of biogas Equation (24)(Noori & Fazli, 2019) can be used:

$$\text{Biogas storage volume (m3)} = L\ x \left(\frac{R_2}{2}\right) x \left\{\frac{\pi}{180 \text{ x Ø} - \sin(\text{Ø})}\right\} \qquad (24)$$

The inlet storage and pipe dimensions for the biogas plant are calculated by Equation (25), (26) & (27)(Capareda, 2013):

$$\text{Inlet tank volume (m3)} = \text{Slurry volume} \left(\frac{\text{m3}}{\text{day}}\right) \qquad (25)$$

$$\text{Height of inlet pipe and manhole in the digester (m)} = \frac{1}{2} \times \text{H} \qquad (26)$$

$$\text{Width of the manhole (m)} = 0.4 \times \text{W} \qquad (27)$$

The outlet storage volume of the biogas plant is calculated by Equation (28)(Capareda, 2013):

$$\text{Outlet tank volume (m3)} = 1/3 \times \{\text{Digester volume (m3)}\} \qquad (28)$$

## 5. Design of a Distribution Network for Electricity in the Village:

Figure 2 displays the village map created with AutoCAD, which shows the positions of the substations, powerhouse, distribution network system, and dwellings. Figure 3 illustrates how it has been separated into three sections: The main line from the power plant to the second panel board is located in the first segment, designated A. Beginning with the second panel board, the second part, designated B, consists of two mosques and forty-one homes. With 62 homes and two mosques, the third sector, designated C, stretches from the second panel board to the third panel board.

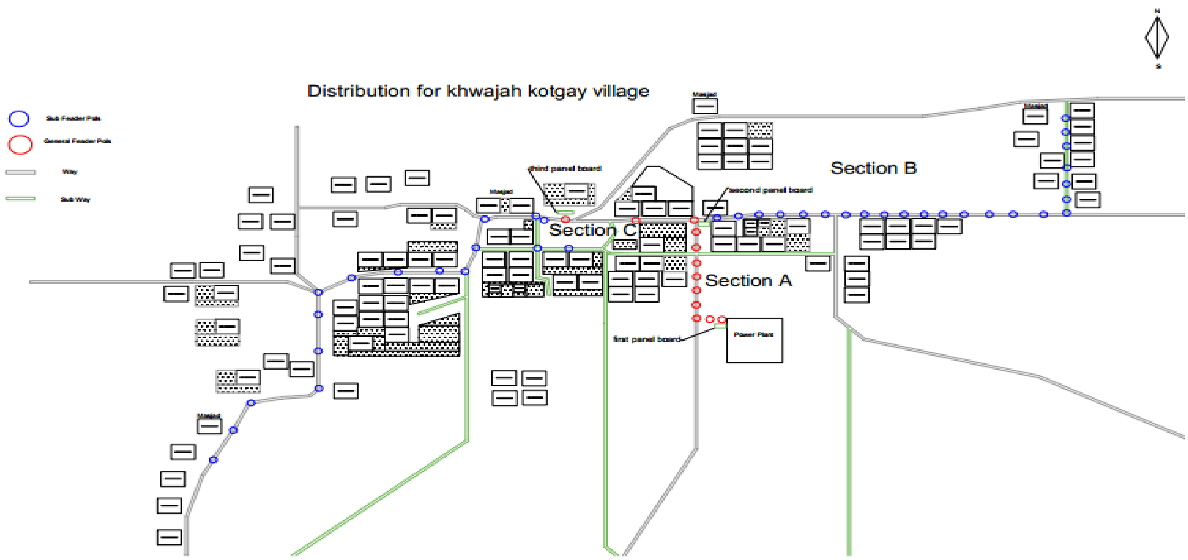


**Figure 2.** Map of the Khwaja Kotgi

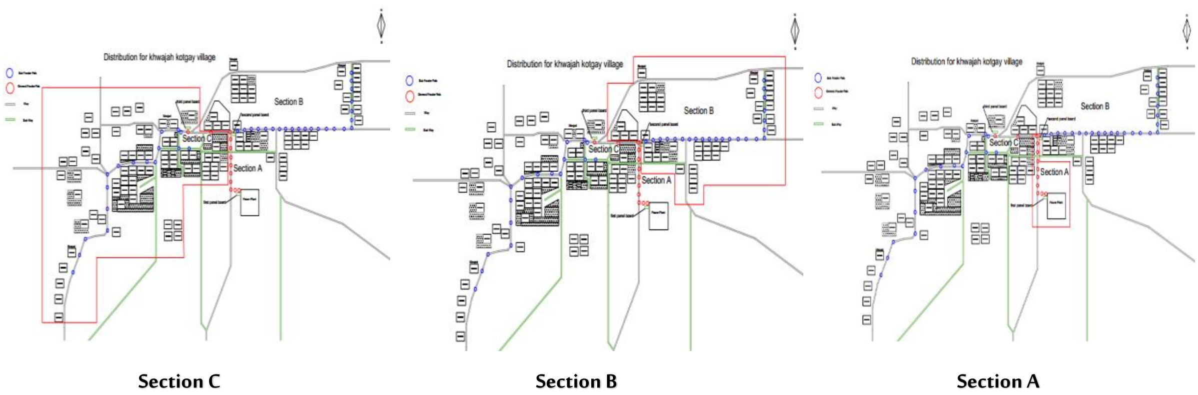


**Figure 3.** Map of the Khwaja Kotgi

With 103 dwellings and an average of eight occupants per house, the community now has 824 people living there. Using Equation (29) (Population, Total - Afghanistan | Data, n.d.) and a growth factor of 1.47% for Wardak Province, one can calculate the population during the next 25 years.

$$\mathrm{Pop_F} = Pop_p \; x \; (1 + i)^N \qquad (29)$$

Therefore, 1,187 individuals are expected to live there in the following 25 years. Equation (30) can be used to calculate the future power demand by dividing the total population by the average size of a household. (Afghanistan Population, Total | Data, n.d.)

$$\text{No. Home} = \frac{\text{Future Population}}{\text{Average Person in Home}} \qquad (30)$$

It is anticipated that 149 new homes will be built. According to V.K. and Rohit Mehta (2016), Equation (31) calculates the load as follows:

$$\begin{aligned}\text{Total future Load} \\ &= \text{Demand load of home} \times \text{Number of homes} \\ &+ \text{Demand load of masjid} \times \text{Number of Masjid} \qquad (31)\end{aligned}$$

The community now has 103 homes with a combined load of 84,575.399 Watts. We will compute an overall future load to current load ratio to ascertain how this will influence each feeder because it is unclear how much additional load each feeder will experience over the next 25 years. You can apply equation (32) (H I R D E D I T I O N Edited & Grigsby, n.d.).

$$\text{Ratio} = \frac{\text{Total Future load}}{\text{Total Present load}} \qquad (32)$$

### 5.1. Section A

A general circuit breaker and a general line that connects the power house to the second panel board are located in this area. Equation (33) (T.A. Short, 2014) is applicable when designing the general circuit breaker for the current load found in the first panel board.

$$\text{Main circuit breaker} = \frac{\text{Present load}}{(\text{Voltage} \times \text{P.F} \times 1.73)} \times \text{Safety factor} \qquad (33)$$

Since a circuit breaker with a rating of 163.3940972 Amps is not readily available, we choose for a 175 Amp circuit breaker, which has a bus bar rating of 163.394 Amps. Line cross-section: We are planning the line cross-section for the anticipated 118 kW load over the next 25 years.

To find the line cross-section area, we can apply Equation (34) (V.K. Mehta & Rohit Mehta, 2016).

$$\text{Cross section area} = \frac{\text{Future load} \times \text{Distance}}{\text{K} \times \text{Voltage drop} \times \text{voltage}} \qquad (34)$$

The system voltage from the power house to the panel board is 413.6 V, with a voltage loss of 6% from 440 V at the point of power generation to the panel board.

Since the 146.8350864 $mm^3$ line size is not readily available, we have opted for the 150 $mm^3$ line since it is readily available.

### 5.2. Section B

With a combined load of 34685.353 Watts from 41 homes and 2 mosques, this section's circuit breaker is found in the second panel board. Since there isn't a circuit breaker on the market that can handle 73.71079777 Amps, we go with a 100 Amp circuit breaker instead, since it can handle that rating and the bus bar rating is 73.71079777 Amps. We use a 185 $mm^2$ line since it is readily available and the voltage in our system can go up to 389.6 volts at the last residence. The line size of 170.2981856 $mm^2$ is not available.

### 5.3. Section C

The second panel board, which has 62 homes and two mosques with a combined load of 49,890.046 watts, is where the cited part begins. The third panel board contains the area's general circuit breaker. Cable Cross Section: From the second panel board to the third, we compute the cable's cross-sectional area. We choose a 150 $mm^2$ cable size since it is readily available and the voltage between the second and third panel boards is 409.6 volts, as opposed to a 131.811769 $mm^2$ cable size that is not readily available in the market. Since a 106.022709 A circuit breaker is not readily available, we have opted to utilize a 125 A circuit breaker instead. and 106.022709 A is the bus bar rating. Two circuits from section C have been routed.

First Circuit: The first circuit has a total load of 13,032.594 watts and consists of 18 houses. We select a 32 A circuit breaker since it is readily available and has a bus bar rating of 27.69592401 A, as there is no 27.69592401 A circuit breaker available in the market.

We use a 50 $mm^2$ cable size since it is readily available, the voltage to the final house can reach up to 397.6 volts, and a 41.325 $mm^2$ cable size is not readily available in the market.

Second Circuit: With a combined load of 36,857.452 watts, the second circuit consists of 44 homes and two mosques. Since a 100-amp circuit breaker is readily available and the bus bar rating is 78.32678511 amps, we will choose it instead of a circuit breaker with a rating of 78.32678511 amps, which is not currently available on the market. Since the 150 $mm^2$ wire size is readily available, we will select it in place of the 128.1692205 $mm^2$ wire size, which is not readily available in the market. Our system's final residence has a voltage of up to 389.6 volts. Table No. 4 presents an overview of the Distribution Network, while Table No. 5 lists the equipment used in the Distribution Network.

**Table No.4**

| No | Circuit Names | Section | Voltage drops (%) | Distance (M) | Cross section area (mm2) | Circuit breaker (A) | Poles | | Pin Insulators | Meter box | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | string | simple | | 6mater box | 4mater box |
| 1 | General Circuit | A | 6 | 477 | 146.8350864 | 163.3940972 | 4 | 6 | 42 | | |
| | | C | 1 | 100 | 131.8117693 | 106.0227091 | 2 | | 12 | | |
| 2 | Tapping | B | 6 | 1115 | 170.2981856 | 73.71079777 | 6 | 17 | 87 | 4 | 5 |
| 3 | First Circuit | C | 1 | 120 | 41.32517079 | 27.69592401 | 2 | 1 | 15 | 3 | |
| 4 | Second Circuit | C | 5 | 658 | 128.1692205 | 78.32678511 | 9 | 5 | 69 | 4 | 6 |
| Total | | | | | | | 23 | 29 | 225 | 11 | 11 |

**Table No.5**

| No. | Equipment | Quantity |
|---|---|---|
| 1 | Panel Board | 3 |
| 2 | bus bar | 5 |
| 3 | Lightning Arrestor | 1 |
| 4 | Fuse Puller | 1 |

## 6. Results and Discussion

The main conclusions drawn from the study are as follows:

- Identification of Resource: According to the study, Khwaja Kotgi can generate electricity from biomass and solar energy. There are 150 cattle in the area that generate 17 kg of waste a day on average, and the area receives solar energy for about 220 to 250 days a year.
- Electricity Demand: 85 kilowatts were determined to be the village's maximum electricity demand. Based on the number of households and their individual electricity demands, this demand was evaluated.
- Design of the Solar System: To supply the community with electricity, a solar system with a 120-kilowatt capacity was suggested. This design effectively harnesses solar energy while accounting for system losses.

- Production of Biogas: Every day, the excrement from the cattle produces around 50 cubic meters of biogas, which may be utilized to run a biogas generator at night to supply power.
- Distribution Network: A distribution network, split into three portions according to distinct load requirements, was created to help with the village's energy distribution. This involves figuring out circuit breakers, line cross-sections, and other essential parts.
- Empowerment of Communities: By supplying sustainable and dependable electricity, the initiative seeks to improve the productivity and quality of life of rural communities.

Overall, the study finds that Khwaja Kotgi can efficiently meet its electrical needs using solar energy and biogas, which encourages the wider use of renewable energy systems in comparable situations.

## 7. Conclusion

The Khwaja Kotgi area of the Wardak province's Syedabad district is the subject of this study. The possible resources for producing power in this hamlet were identified in the first phase, and the technical viability of a microgrid was assessed in the second step, which can be summed up as follows. This study's primary goal was to look at all of Khwaja Kotgi's resources that are now available for producing power. Consequently, two potential sources of electricity generation for this town were determined to be feasible: solar energy and biomass. Sunlight benefits residents on roughly 220 to 250 days a year. In addition, early data shows that the town has 150 animals, with an average of 17 kg of waste produced daily by a single cow. The village's maximum electricity demand, as determined by the microgrid's technical evaluation, is 85 kilowatts. This finding was the subject of the second objective. A solar system with an estimated capacity of about 120 kilowatts, accounting for all waste, was taken into consideration based on this load. The cattle create 2,550 kg of waste per day, which is converted into 50 cubic meters of biogas. The community uses a biogas generator to use the biogas gas to power its lights at night. A distribution network, also designed as part of the project, facilitates the distribution of electricity. The network is broken up into three sections total, and the load needs for each section are determined by taking into account various components such as circuit breakers, line cross-sections, and other elements.

## 8. Research Limitations

The following are the restrictions that were in place when this study was being conducted:

Individuals' lack of cooperation when primary data was being collected.

- Time restrictions.

- The nation lacks pertinent research data.
- Organizations involved in research not cooperating.

## 9. Recommendations

In light of this research, we believe the following suggestions to be advantageous:

1. Although there are numerous chicken farms in the vicinity, the only subject of this investigation was the local cattle. Research ought to be done to ascertain the waste's capacity for energy and to emphasize the advantages of biogas for cooking.
2. Microgrids are a relatively new idea that is being used all over the world to distribute power in rural locations. However, further research is required in some areas to reduce losses that happen during the transmission of electricity and average load times.
3. Although microgrids were used in this study to produce and distribute electricity, they can also be used to address other electrical problems, which merits further investigation.
4. Although AC microgrids were used in the study, DC microgrids are also used in some places. It is necessary to compare the two types economically in order to determine which is more economical.

## 10. References

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