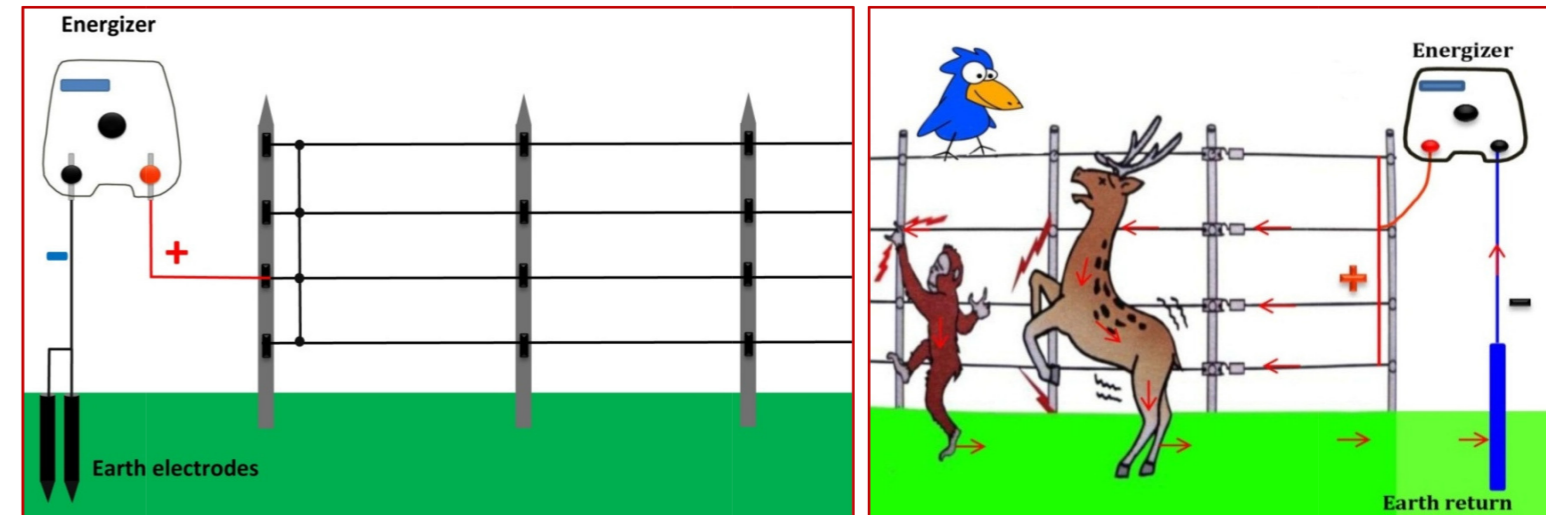


# Technical Reference Manual for installation and maintenance of Electric fence



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ཉོན་བརྟོ

མཇུག་ཐག་རྩི་ལུ་ཉོན་མེ་ཤུགས་ཚད་མར་ཕབ་འབད་མི་འབྲུལ་ཚམ་ (Energizer) ལུ་ལས་མ་གཏོགས་གཞན་ལ་ལས་ཉོན་ཐག་སྒྲིང་པ་ཅིན་  
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**WARNING**

**Use of electricity directly from the main line for electric fence without use of energizer is illegal and fatal.**

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## **1. Introduction**

Crop depredation by wild animals is one the biggest human wildlife conflict (HWC) in Bhutan especially for the farming communities in the rural areas. The conflict directly impacts on socio economic development in rural areas. Some of these include high cost of agriculture production (a lot of time spend in crop guarding), increasing rate of fallowing agricultural land and rural urban migration. With the increasing intensity of the conflict, farmers are now resorting to use of illegal and fatal methods of electric fencing by tapping electricity directly from the main line and taking to the agricultural fields as evident from several incidents reported in media. The issue has been discussed and deliberated in many forums at all levels, and methods like snaring, culling, trapping of wild animal, use of sound and light repellent including imported standard electric fence system have been experimented in the field on pilot scale.

Although various options for crop protection are available, most are not effective or not opted as it involves killing of animals. The model of electric fencing which includes imported IEC certified energizer and locally fabricated fencing materials has proven to be successful after it has been tested for more than 5 years in different locations targeting different problem species of animals. This technology is not only found to be an effective control but also cost effective and socially acceptable for the Bhutanese farmers.

Bhutan Electricity Authority (BEA), Bhutan Power Cooperation (BPC), Bhutan Standard Bureau (BSB) and the Ministry of Agriculture and Forests (MoAF) recently approved the use of electric fencing method for crop protection from wild animals (provided safety standards and recommended accessories are used).

Therefore, this technical manual is developed for those who promote this technology to provide standard guideline on electric fence installation and maintenance mainly focusing on the fabricated fencing materials in order to ensure safety from use of electric fencing.

## **2. How an electric fence works?**

The mechanisms in electric circuit that creates light is shown in Figure 1A in which the electric bulb will light only when the electric circuit is completed between a positive and negative terminal of the battery. Likewise, in electric fence system shown in Figure 1 B, the positive terminal of the energizer is connected to the fence wires supported on the wooden poles via insulator and the negative (earth) terminal is connected to the ground. The circuit is called open circuit and no electric current flows in the circuit if the fence is not touched by an external connection. So, when human or animals touch the fence wires, the electrical circuit completes by passing current through their body to earth and return to the energizer. As a result the animal or human will receive an electric shock. On the other hand, a bird sitting on the fence wire without touching the ground will not receive any electric shock. The energizer unlike batteries do not produce continuous current, instead produce current in pulse form (1-

2 pulses per second) and each pulse has pulse width (less than 100 micro seconds) and pulse energy (<5 joules). This characteristic of the energizer makes electric fence system safe for human and animals.

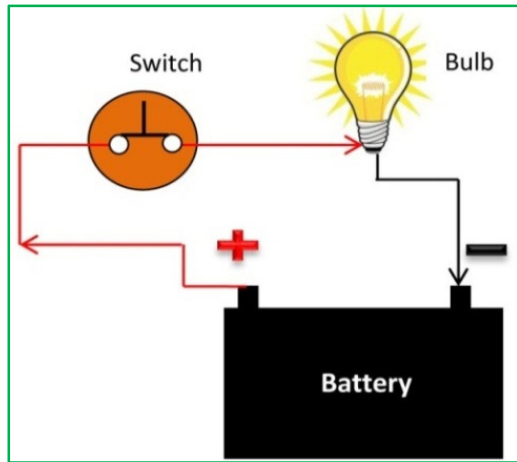


Figure 1A.

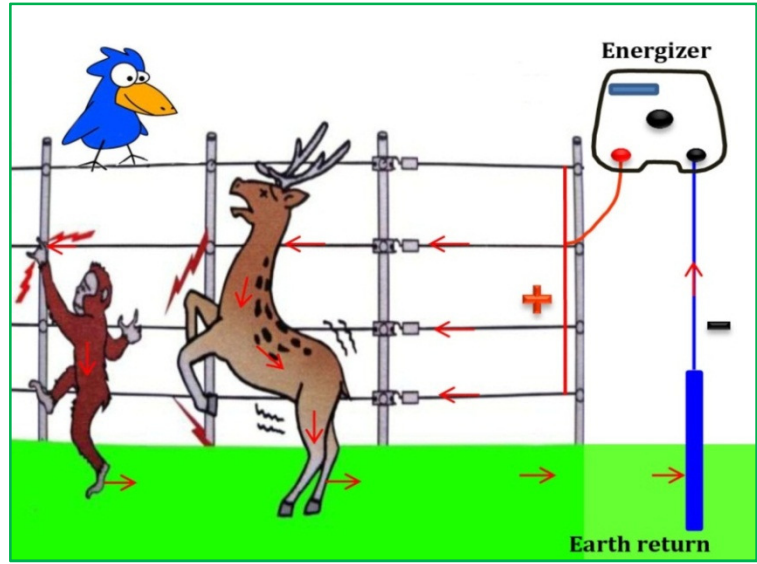


Figure 1B.

The advantages and disadvantages of an electric fence are shown in Table 1.

Table 1. Advantages and disadvantages of electric fence

Advantages	Disadvantages
<ul style="list-style-type: none"><li>• Aside from repulsive electric shock, it does not harm the animal</li><li>• Electric fences are economical and relatively easy to build compared to other fence e.g barbed wire, wire mesh etc.</li><li>• The animals learn to respect the electric fence after few initial shocks and never challenge the fence again</li><li>• Electric fences are not subjected to the same physical pressure from animals, and can therefore be expected to have a greatly extended service life.</li><li>• Fences are versatile with a variety of design possibilities.</li><li>• Can control wide range of wild animals including domestic cattle</li></ul>	<ul style="list-style-type: none"><li>• Ineffective if the power is off or grounded</li><li>• Required frequent inspections and maintenance</li><li>• Required technically trained personnel during installation</li></ul>

### 3. Knowing the electric fence equipment

There are wide ranges of electric fence equipments available in the market produced by different manufacturers with different terms and units. Sometimes these terms and units used to specify electric fences are difficult to understand. This section provides general guideline to understand the basic component of the electric fence system. (also see Annexure 2 and 3 for the tools and accessories required for installing electric fence system)

#### 3.1 Energizer:

The energizer is the center of any electric fence system. It is sometimes called fence charger or fence controller. The main function of energizer is to produce high voltage (9-12Kilo Volt) of pulse electricity which is delivered along the fence wires. The pulse rate of energizer will depend upon the different manufacturers. Some manufacturers produce energizers with fixed pulse rate normally 1-1.2 pulse/second while some produce energizer where users can select the desired pulse rates for controlling specific animals.



Lanstar Energizer

**Types of energizers:** There are mainly two types of energizers that can be used for fencing and they are:

- **Electric powered energizer:** These energizers that can be directly plugged in into the home power supply. They are less expensive and require no battery maintenance.
- **Solar and Battery powered energizers:** A solar panel charges a lead acidic battery by converting light into electricity. The battery stores this electricity to operate the energizer. It is used in areas where there is no mains power.

**Capacity of the energizers:** Most energizer's capacity is rated in either of these two terms:

- **Stored energy and output energy in Joules:** Stored Joules is a measure of the amount of electrical energy stored in the main capacitor just before output. Output Joules is a measure of the actual amount of electrical energy that is transferred to the fence line. The energizer with higher the output joules can cover greater fencing area at the same time pose greater risk to human and animal life than low joule energizers. Therefore, some countries do not allow using energizers with an output more than 5 Joules.
- **Kilometer or miles of effective fence length:** Some manufacturers also rate their energizers based on the maximum length of fence wire that it can power effectively. The length of fence, for multi-strand fences, is the total length of conductor wire used. For example, energizer capacity rated 2 km for 2 strains of wire can power only 1km fence length for 4 strains of fence wire.

### 3.2 Insulators:

Insulators are a fundamental component of electric fence. They are made from a non conductive material, either porcelain or thermoplastic, and form a barrier between the electrified wire and its wooden post to prevent current leakage to the ground. Those insulators are not readily available in our market and are not cost effective if imported. Using 32 or 25 mm HDPE pipe cut into 10-11 cm length as an alternative insulators was found to be equally effective, readily available in the local market and costs less compared to the imported ones.



HDPE Pipe pieces used as Insulators

### 3.3 Earth return (Electric fence earthing and household earthing are not similar):

The electric fence earth return is sometimes referred as earth rod, spike, or simply earthing. It is one of the important electric circuit's paths in electric fence system. It collects the high voltage and current from the ground/earth and returns it to the energizer. Without proper earth, the electric fencing system will not work or be effective.

However, the electric fence earthing is quite different from household electric earthing in its purposes. The main purpose of household electric earthing (ground) is to dump the electric energy safely in the earth when there is faulty electric circuit i.e., short circuits, lightning strike in the electric appliances or in the household electric circuits. (safety aspect i.e., not to get fatal electric shock) where as in electric fence, the earth is used as returning path for electrons to complete its circuit. So, an animal touching the fence wire gets an effective electric shock. Therefore, **house electrical earth cannot be used for electric fence earth or vice versa.**

## 4. Safety precautions

The electric fences should be installed and operated in a way that ensures there is no electrical hazard to people, animals or their surroundings. The following safety precautions should be strictly followed when installing electric fence in the field:

- Always seek approval from Bhutan power cooperation (BPC) especially when using line (AC) powered energizers. The procedure on how to apply for approval is presented in Annexure 1.
- For the safety purposes, use only IEC certified energizers and also never use energizer whose output energy is more than 5 joules
- Clear warning or precaution sign boards should be put up mandatorily



Figure 2. Warning signs

wherever electric fences are installed. This will help to reduce possibility of unaware people from having secondary accidents like jerking back and hitting on rocks, trees, walls etc., when they receive unexpected electric shock from the fence. The warning/precaution sign board should be at least 100mm x 200mm in size and clearly visible from 10 m distance. The Inscription should be written in both Dzongkha and English and also with cartoon expression of electric shock (Shown in Figure 2) on a yellow background.

- To be extra careful for the implementers to monitors the risk of an animal or person becoming entangled in electric fence wires. Receiving few electric shocks for short duration from the electric fence is harmless. However, if animal or person got entangled with fence wire, they will receive prolonged period of repeated electric shock which might cause involuntary muscular contractions, physical exhaustion and might die as a result. Normally animals with horns are vulnerable to be entangled in electric fence.
- Never use barbed wire for electric fence or never electrify existing barbed wire fences. This is because when human or animal gets electric shock from barbed wire fences they might get serious physical injuries from barbed hooks.
- Do not allow children to pee on the electric fence. The shock sensation will be very painful and may harm children
- A faulty electric fence can produce a spark, so do not place combustible materials (gasoline, kerosene, cooking gas etc.) near the fence or energizer
- An electric fence should not be powered from two separate energizers
- Since the purposes of electric earthing and electric fence earth are different, do not use household electric earthing for electric fence or vice-versa. Also the when constructing electric fence earth it should be separated at least 8-10 m distance from household electrical earth.
- Energizers if possible, should be installed inside the house on the roof attic unreachable by children. If mounted outdoors, they should be mounted on a substantial structure to protect from rain and theft.
- Avoid as much as possible to build electric fence line in parallel to power and communication lines (as shown in Figure 3A).



**Figure 3A. Electric fence in parallel with power line**



**Figure 3B. Electric fence line in perpendicular to power line**



- *Electric fence wire crossing over with overhead power lines should be avoided wherever possible. If such a crossing cannot be avoided, and the following clearance should be maintained and it should be made underneath the power line at right angles to it.*

Line Voltage (KV)	Vertical Clearance (m)
< 1 KV	3
1 - 33 KV	4
> 33 KV	8

- *Put another sign board (Figure 4) near the house where energizer is installed to remind the users and other farmers to be aware and avoid using direct current for electric fencing.*

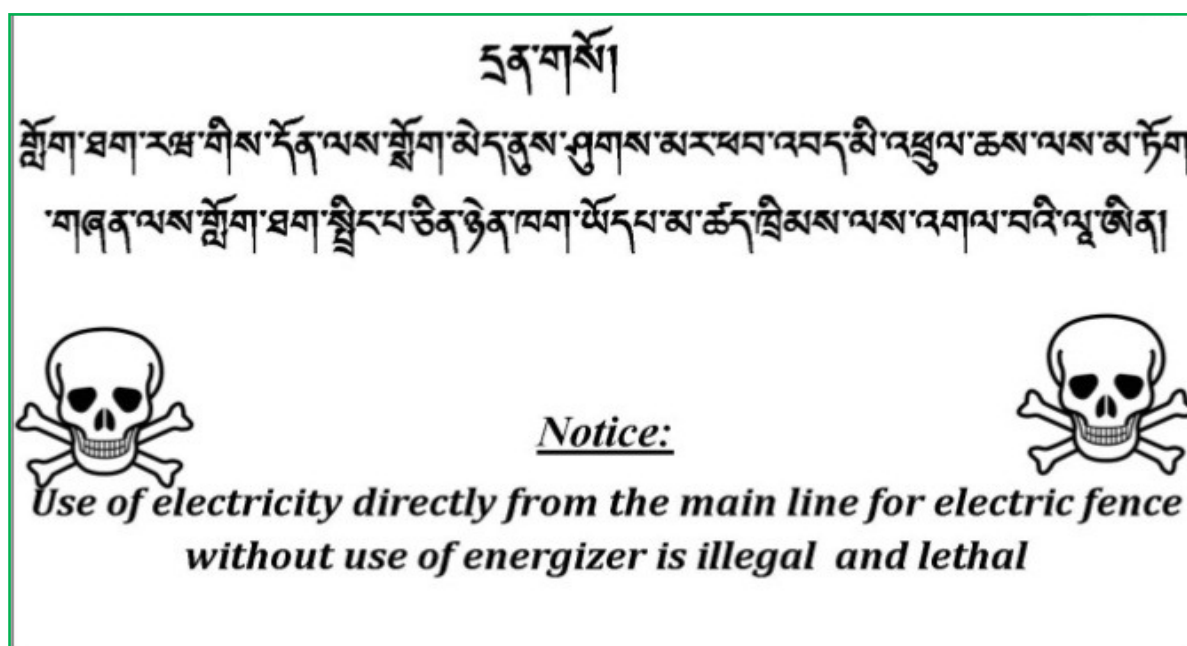


Figure 4. Warning signboard

## 5. Construction of Electric Fence

There are many activities that have to be carried out before the actual construction of the electric fence especially when carrying out at community or village level.

### 5.1 Need assessment of electric fence:

Before carrying out any physical activity, it is vital to first evaluate whether the community investment (both monetary and labor contributions) required for installing and maintaining electric fence system justify the level of crop damage by wild animals in the village. Depending upon the length of the village boundary, it would take weeks or sometimes months to install the fence around the village. If level of crop damages is not worth these investments, the

installation of electric fence in the village may face difficulty during implementation and also become unsustainable after installation. Therefore, the electric fence advocates or implementers should facilitate the community to make clear need assessment before establishing electric fencing in the village.

### ***5.2 Electing group leader and making Bylaws for the community:***

After the need assessment exercise, advocator should facilitate the community to elect group leader and make workable bylaws for electric fence group. It is essential because many issues and disputes will rise during installation and maintenance of electric fence. However, the kind of issues and disputes would vary from community to community but some of the common points that should be reflected in the by-laws are as follows:

- *Name of the group (example: Nalung electric fence Group)*
- *Roles and responsibility of the group leader*
- *Major issues and disputes in the group during the installation and solutions*
- *Major issues and disputes during maintenance and solutions*
- *Do and Don'ts of the group*
- *The bylaws should be agreed and signed by the all beneficiaries and get endorsed by Geog Administration*

### ***5.3 Determining the location, length of electric fence and material requirement:***

It is necessary to find out the exact location of the place and the approximate length of the electric fence that is going to be installed. If the area is small, it can be easily done by measuring manually. However, if the area is big (at village/community level), manual measurement is not feasible and is going to take lots of time. If you have laptop installed with Google Earth (free version. For e.g. see Figure 5) and connected with internet, this can be done easily and more precisely without having to walk physically around the village boundary. You can do planning as well as discussion with the farmers using this map before the actual implementation of the work. For example we can:

- *Find out the boundary where the fence needs to be installed in the village*
- *Get approximate length of the fence so that quantity of material (insulators, wooden poles, GI wire etc.,) requirement can be estimated beforehand.*
- *Get approximate area enclosed by the fence boundary*
- *Find out approximate numbers of gates, crossover and corner poles that needs to be installed*

- And also get other important information on village's geographical features like the locations of rock cliff, landslides areas, rivers, streams, forest etc., to get the proper alignment of electric fence.

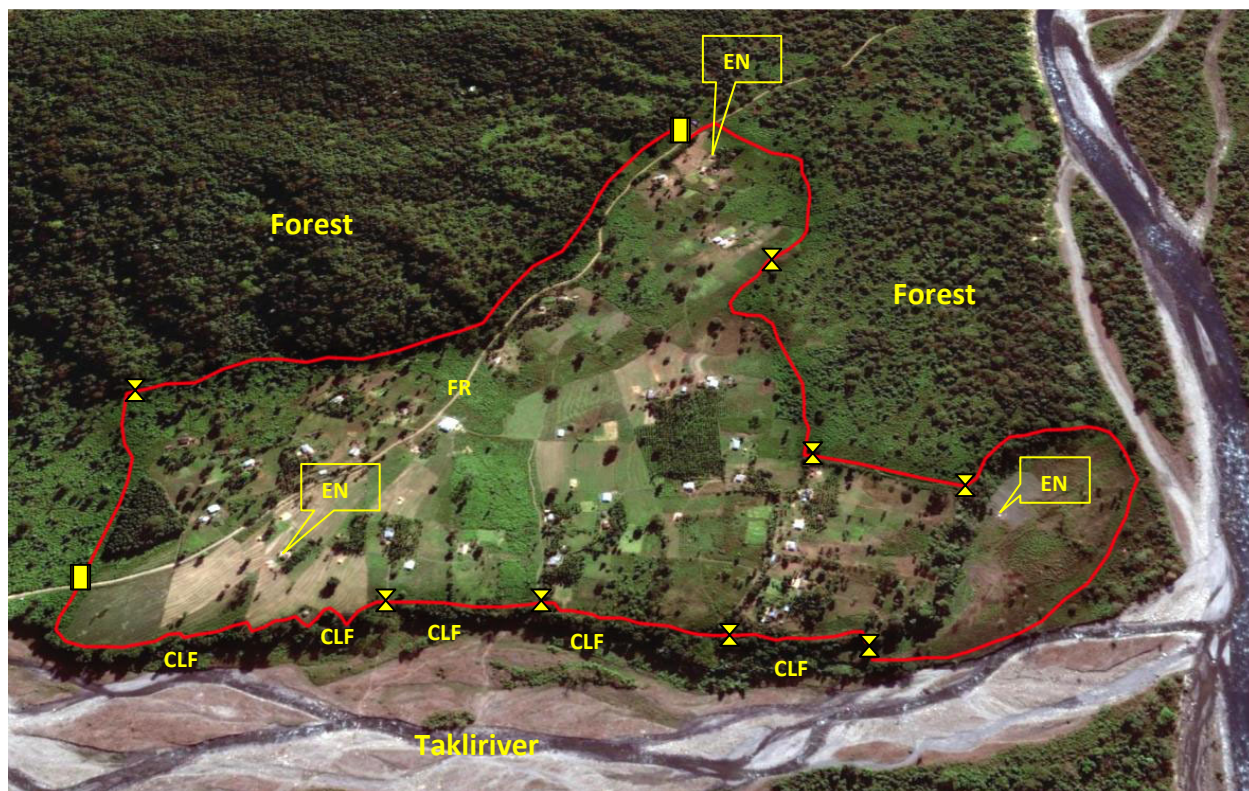





Figure 5.Using Google Earth to develop initial electric fencing plan in the village.

### Example

Village information	Village name: Mindrupling, Bangtaar Dungkhag Beneficiary households: 48 ; Approximate fence perimeter= 4 KM No of gates needs to be installed=10 nos. Approximate area enclosed by the electric fence=200 acres
	Electric fence boundary
	Overhead gate for vehicle
	Overhead gate for people and livestock
CLF	Steep cliff
EN	House where energizer will be installed
FR	Farm road

### 5.4 Estimating material requirement and costing:

The amount of material required can be estimated based on the information gathered from the above exercise and baseline data for 1 km fencing estimate is shown in Table 2:

**Table 2. Fencing material estimate for 1 strain fence wire per km**

<b>Materials</b>	<b>Quantity Per KM (Estimate)</b>
<i>Wooden poles</i>	
1. Plain area	330 nos
2. Sloppy areas	450 nos
<i>32mm HDPE Pipe</i>	
1. Plain areas	34.65 m
2. Sloppy areas	47.25 m
<i>3 inch nails</i>	
1. Plain areas	4.8 Kg
2. Sloppy areas	6 Kg
<i>GI wire (SWG 16)</i>	17 Kg
<i>GI wire (SWG 18)</i>	10 Kg

**Example:**

Let's take the Mindrupling village as an example for estimating the material requirements and cost estimate.

- The electric fence perimeter around the village= 4 KM
- Land terrain type: 80% plain and 20% sloppy
- Number of strain of wire in the fence= 3 strains, Size 16 SWG
- Solar powered energizer

Therefore, length of fence in plain area(80%) = 4 km X 0.8= **3.2 KM**

Length of fence in slope area (20%) = 4 km X 0.2= **0.8 Km**

**Material requirement:**

- **Wooden post**= In plain area (3.2 km X 330/km)= **1056**  
In the slope area(0.8 km X 450/km) = **360**  
**Total= 2301 posts**
- **HDPE pipe**= In plain area(3.2 km X 34.65m/km X 3 strains) = **332.64m**  
=In slope area(0.8 km X 47.25m/km X 3 strains) = **113.40 m**  
**Total= 446m**
- **3 inch nails**= In plain area (3.2km X 4.8/km X 3 strains) = **46.08kg**  
Slope 0.8 km X 6kg/km X 3 strains = **14.4 kg**  
**Total=60.48 kg**
- **GI wire (SWG 16)**=(4 km X 17kg/km X 3 strains) = **204 kg**
- **Gear oil**= 4 km X 0.3L/km X 3 strains= **3.6L**

**Cost estimate:**

The cost of the materials such as HDPE pipe, GI wire, nails may vary from Dzongkhag to Dzongkhag due to the transportation cost. The item rate in the Table 3 is as of Mongar in 2012.

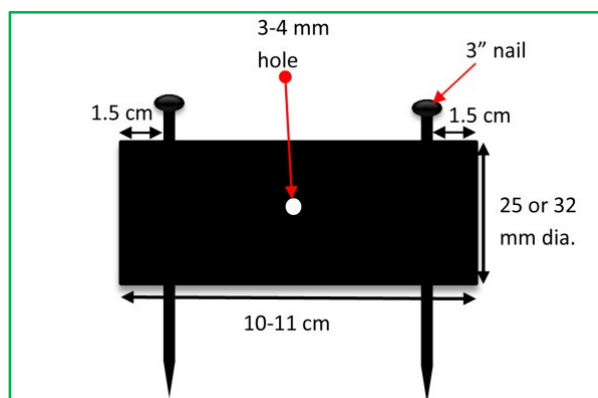
**Table 3. Cost estimate for 4 km, 3 strains wire electric fence (CIF Mongar 2012)**

Item	Quantity	Rate (Nu)	Total (Nu)
• HDPE pipe (32mm)	446m	48/m	21408.00
• GI wire (SWG 16)	204kg	95/kg	19380.00
• Gear-oil	3.6 L	254/L	914.40
• 3 inch nails	60.48 KG	80/kg	4838.40
• Earthing plates	6pcs	600/pcs	3600.00
• Energizer	3 set	9500/set	28500.00
• Acidic battery	3 nos	2800/pcs	8400.00
• Solar Panel (20 watts)	3 nos	7000/pcs	21000.00
• Charge controller	3nos	1800/pcs	5400.00
• 7/22 copper wire	1 rolls	4500/roll	4500.00
• Other accessories			1000.00
		<b>Total cost</b>	<b>1,18,940.80</b>
		<b>Cost/KM</b>	<b>29,735.20</b>

*Note: Poles and labour cost not accounted as these can be contributed by the beneficiary (individual or community)*

### 5.5 Preparation of HDPE pipe insulators:

Insulator forms a barrier between the electrified wire and its support material to prevent current leakage to the ground. The manufactured insulators are not easily available in our market and are not cost effective if we import. Therefore, using HDPE pipe as an alternative insulator was found to be equally effective, readily available and cost almost 4-5 times less compared to the imported ones. A HDPE pipe (32mm or 25 mm diameter, 10 kg/cm<sup>2</sup> pressure capacity type) can be cut into 10-11cm length, drilled hole at the center and fixed with two 3 inch nails at the both ends of the pipe (Figure 6A & B). The nails should be soaked in the gear oil to prevent rusting before fixing to the HDPE pipes.



**Figure 6A. Dimension of HDPE pipe insulator**



**Figure 6B. Preparing HDPE pipe insulators**

### 5.6 Clearing and surfacing fence line:

Without adequate clearing and leveling, the electric fence system become ineffective very easily due to leakage of electric current to ground through either by touching the fence wire directly to the ground or to the vegetation. Therefore, at least about 1.5m width of bush clearing and surfacing works are required along the boundary (Figure 7) for successful establishment of electric fence.



**Figure 7. Clearing and surfacing fence line**

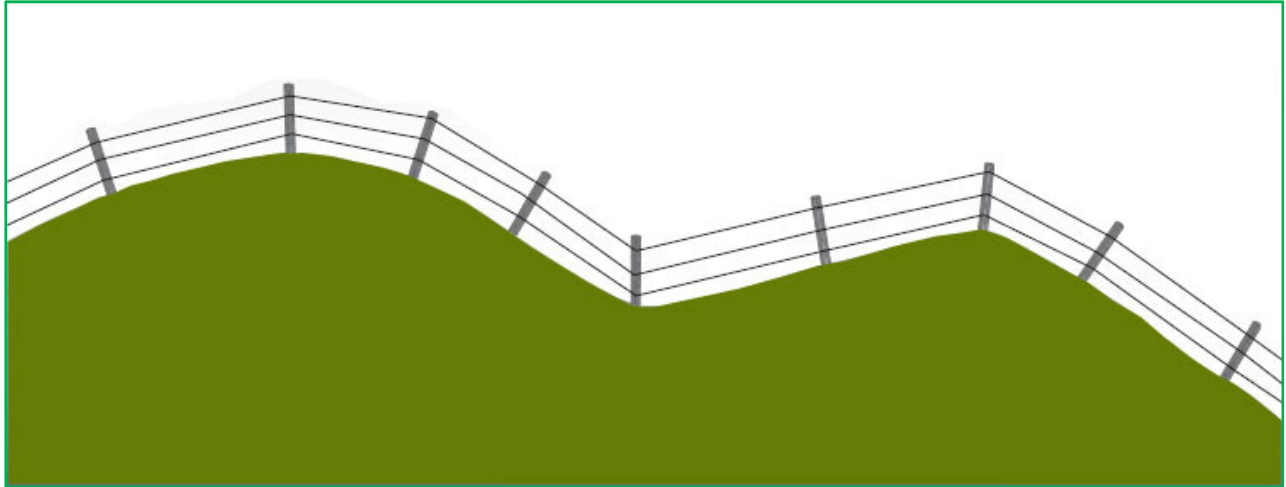
### 5.7 Preparation of wooden post:

In general the supporting wooden pole should be 10-18 cm in diameter but length depends upon the species of animals to be controlled. Removing the bark, sharpening the top end and painting the bottom end with used engine oil will help the poles to last longer (Figure 8 A). The poles should be fixed firmly in the soil following the outline of cleared surface (Figure 8B). The distances between poles should be maintained based on the terrain type.



**Figure 8: Bark removing and painting of wooden poles (A); Wooden poles fixed in the soil (B).**

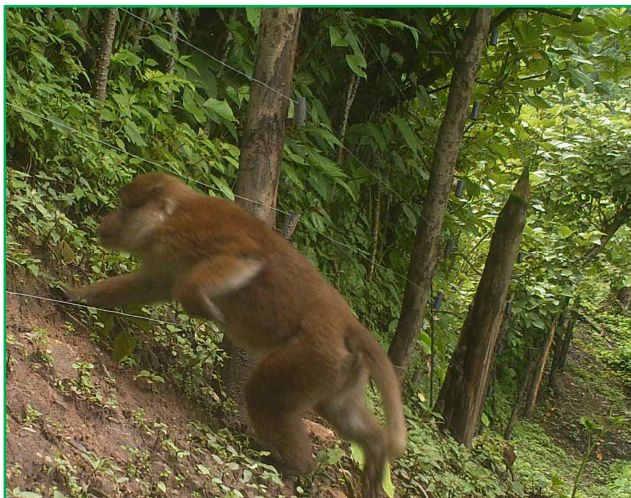
In the flat terrain the posts should be spaced 2.5-3 m apart while for uneven/sloppy terrain it should be spaced about 2m or less. On hillsides, pole should be installed perpendicular to the slope to keep the wire at the proper height and prevent from touching the ground or the insulators (Figure 9).



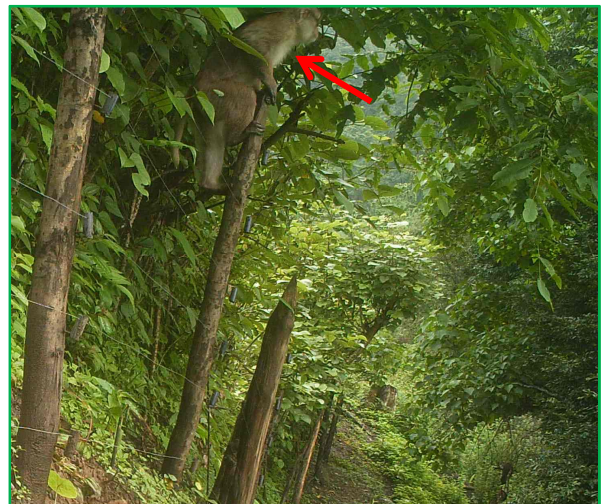
**Figure 9. Posts installed perpendicular to the slope**

### **5.8 Fence design:**

The number of wires in the fence and their position depends on the size and agility of the target species to be controlled. The number and position of wires should be designed to stop animals being easily escape without touching the wire or jump over them (Figure 10 A & B).



**Figure 10 A. Monkey carefully crossing electric fence without touching the wire**



**Figure 10 B. Monkey using electric fence pole itself to jump across the fence**

The fence designed to control smaller, agile species such as wild rabbits and porcupines requires the first wire positioned about 0.14-0.16 m from the ground whereas bigger animals like wild boar, deer, bear etc., requires 3-4 strains of wires positioned at 0.25, 0.4-0.5, 0.7-0.8 and 1-1.2 meter from the ground(Figure 11).

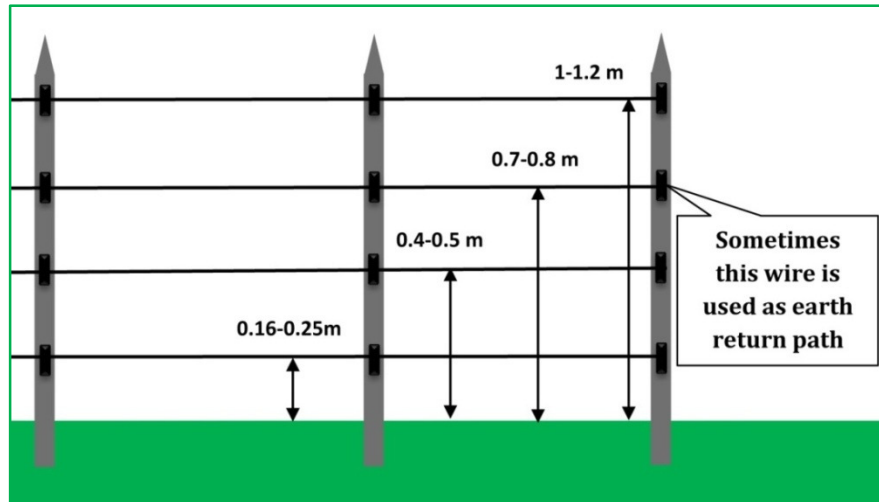


Figure 11. Fence design for porcupines, wild pig, deer, bear and stray cattle

For elephant, one or two strains of wire should be positioned at 1.5-1.8 m from the ground and the supporting the poles should be erected at 45° angles from the entrance side of the field. The post should be protected by providing a few loops of electrified wire around the post (Figure 12).

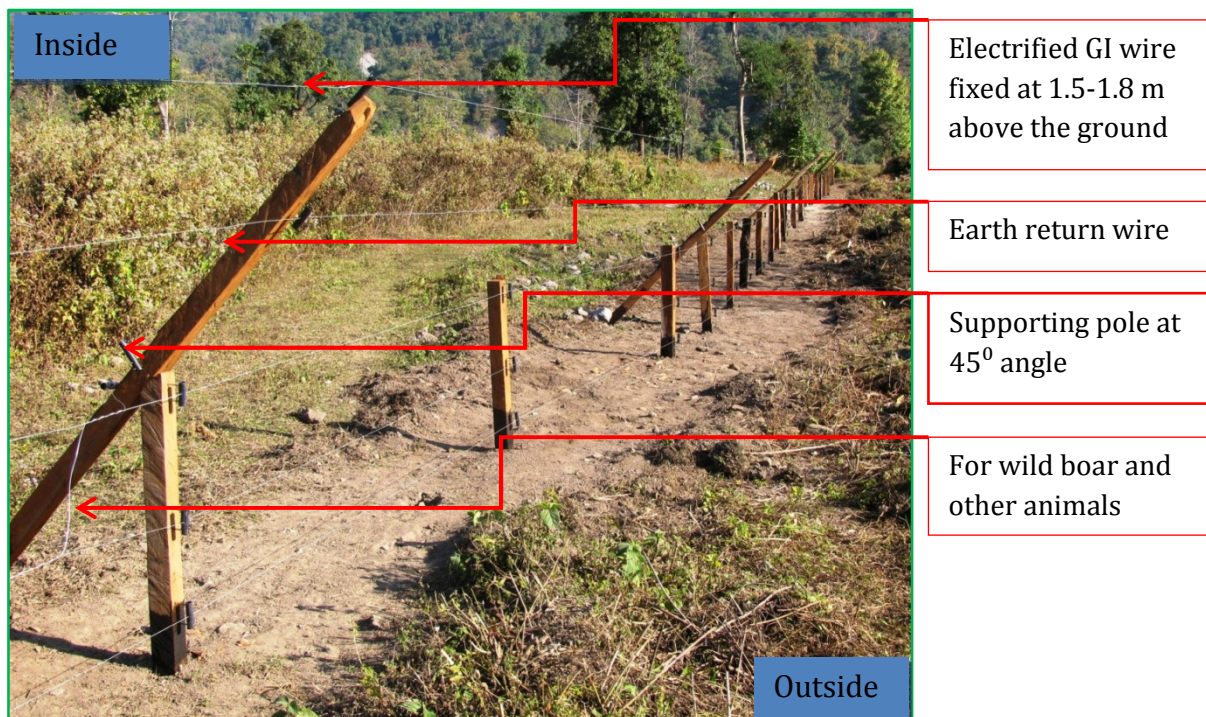


Figure 12. Fence design for wild elephant



For primates (monkeys) the overall height of the fence will depend on the height that a monkey can jump from a free standing position. The primates can jump very high when they have a platform like trees, rocks etc., to propel themselves from. Therefore, trees and rocks situated near to the fence must be removed and a large enough space must be cleared. The actual fence design is given in Figure 13 with seven strains of wires. The 7<sup>th</sup> strain should be supported on the 25cm HDPE pipe which is fixed on the top of the wooden pole at 90° angles to the entrance side of the field. This design will prevent monkey climbing on the wooden post and jump into the field.

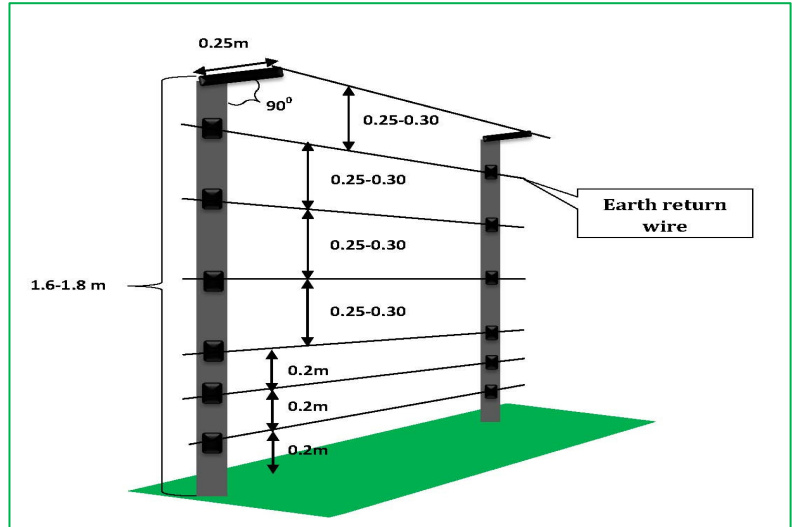


Figure 13. Fence design for primates

### 5.9 Fixing HDPE pipe insulator:

After determining the number and the position of each wire, the HDPE pipe insulator has to be fixed firmly on each wooden pole. When fixing at least 3-4 cm gap should be kept between each HDPE insulator and the wooden post.



Figure 14A. HDPE insulator fixed in opposite direction of the wire tension

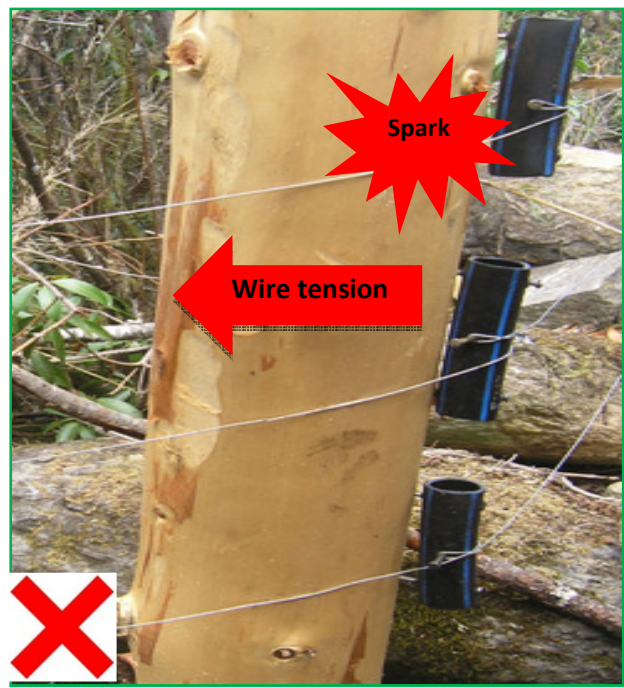


Figure 14B. HDPE insulator fixed in same direction of the wire tension

Always fix the HDPE insulator in opposite direction of the wire tension (Figure 14A) especially when fixing in the curves and turning posts. If it is fixed in the same direction of the wire tension the wire will touch the wooden pole and create short circuit which may cause electrical spark (Figure 14B)

### 5.9 a Fixing GI wire:

After fixing HDPE pipe to wooden posts, first the GI wire should be soaked with gear oil and then pulled through each HDPE insulator. It needs helping hands and coordination of many people as each strain of wire has to be pulled through several numbers of HDPE pipe insulators for several meters of fence length (Figure 15).



Figure 15: Fixing GI wire

### 5.9 b Gate construction:

Proper gates are required in an electric fence for people, cattle even machineries like tractors, trucks etc., to access the farm. There are two methods to construct electric fence gates:

- i. **Underground gate:** Taking the electric circuit underground with use of heavy insulation materials (able to insulate >20,000 V). This method is simple but heavy insulation materials are hard to find and expensive (See Figure 16 A).
- ii. **Overhead gate:** Using long wooden poles to take the electric circuit beyond the reach of passing object. This method is cheap as normal HDPE pipe insulators and GI wire can be used to support the high voltage electric circuit overhead effectively. Any size of the gate can be designed by this method (See Figure 16B)

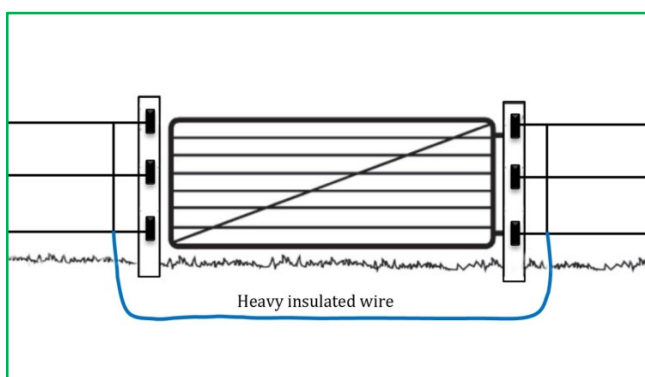


Figure 16A. Underground gate

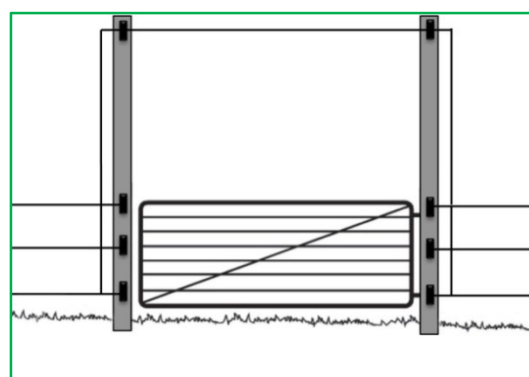


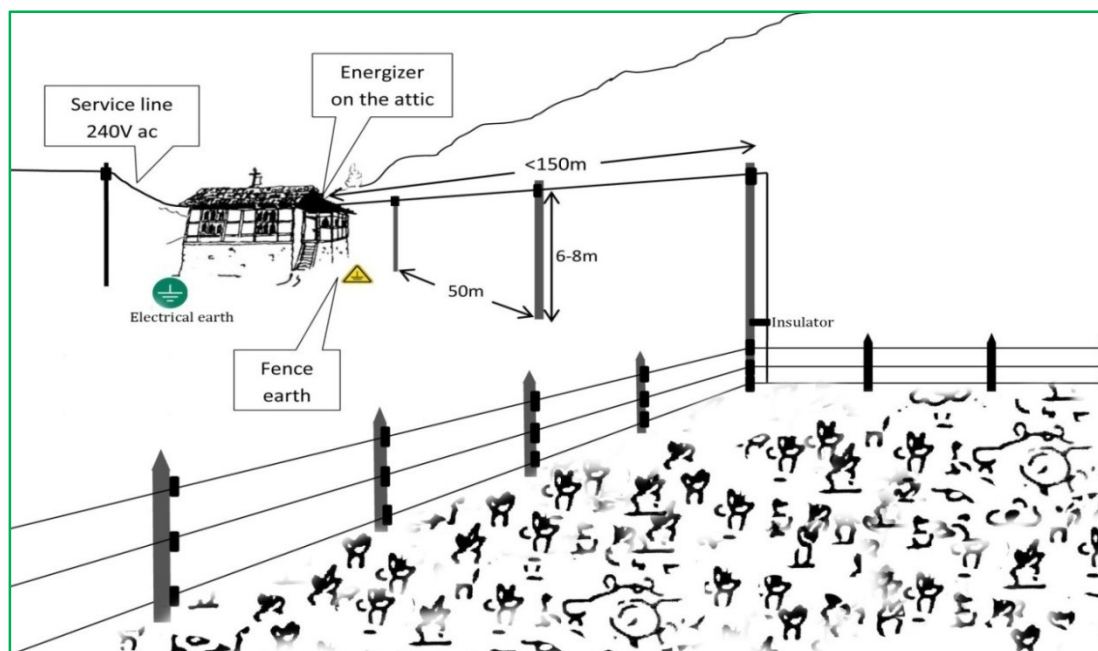
Figure 16B. Overhead gate

## 6. Installation of energizer

In general the energizer should be installed in secure place where there is no risk incurring from fire or mechanical damages, reach of children and animals. In our rural context, the safe place to keep the energizer (both mains and solar powered) indoor is on the roof attic. However, the fencing area should be near by the house and should not be more than 150 m from the house. If the distance between house and fencing area is more than 150 m, it is better to build proper shed near the fence area and power the system by solar or request Bhutan Power Cooperation (BPC) to extend separate power connection to the field.

**6.1 Setting up of energizer on thereof attic:** When installing energizer on the roof attic the following points should be considered.

- *The distance between energizer and the fencing area should not be more than 150 m.*
- *Avoid the having the household power supply cable and the energizer's output cable in the same side of the house. If possible install the energizer on the opposite side of the power supply cable (Figure 17). If at all not possible, separate the energizer's output cable from the household power supply cable at least by 3m distance.*



**Figure 17. Installing energizer on the roof attic**

- *The output from the energizer should be taken to the fencing area by overhead connection supported on 6-8m high wooden poles. The supporting wooden poles should be erected every 40-50m intervals. Avoid GI wire touching to any standing structures.*

- Also avoid the overhead wire running parallel to power line and other communication lines.
- If there is no power plug points installed on the roof attic, ask BPC personnel or authorized electrician to extend supply from the household MCB switch box to the roof attic. The general connection plan for supplying power for energizer from household power supply is given in Figure 18. Before mounting the energizer on the roof attic, make sure to read and follow all the company provided instructions for installation of the energizer.

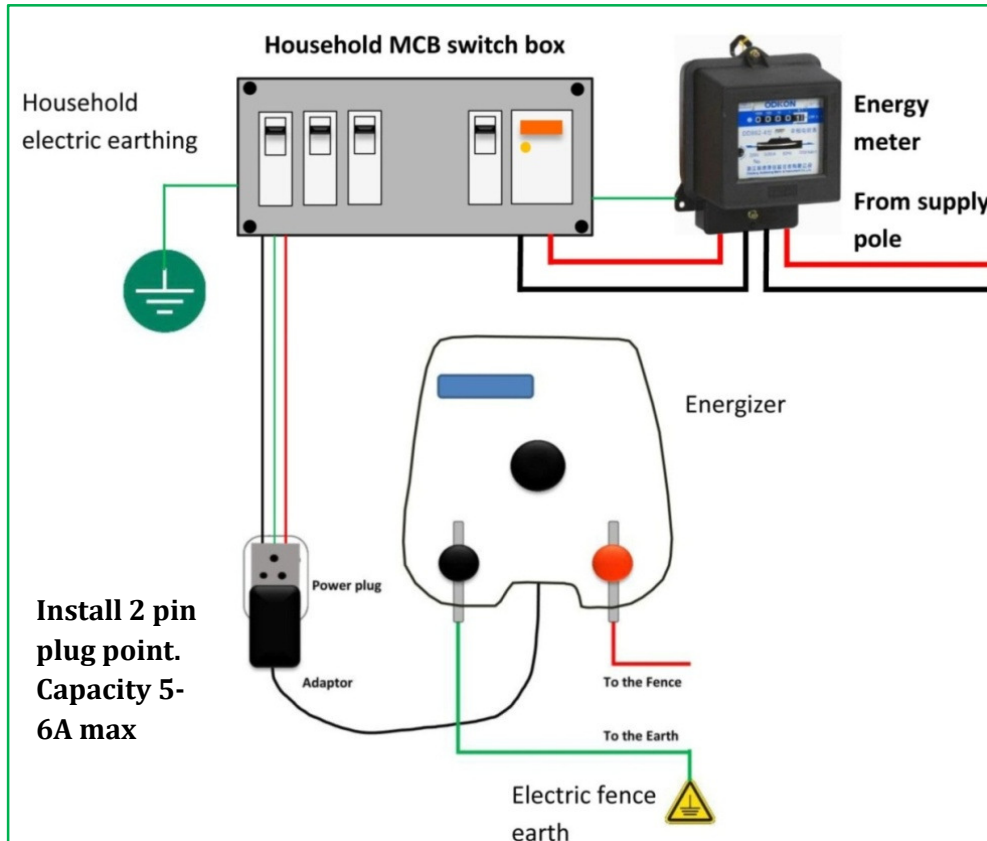


Figure18. General wiring plan for electric powered energizer

### 6.2 Setting up of energizer in a shed (outdoor):

The sheds are commonly built in a location where the fencing area is very far from house and mostly powered by solar and battery. However, sometime shed needs to be built near the house if there is no proper place in the house to keep the energizer and accessories safely.

- Shed should be constructed in an appropriate safe location outreach of children and animals (at least 2-3m high) (see Figure 19 and 20)
- It should have enough space to keep energizer and other accessories freely. It should be rain proof.

- The insect like ants, wasp and bees love to build nest in the shed. Frequent monitoring is required
- If powered by solar, the solar panel should be positioned and fixed properly to get the maximum sunlight

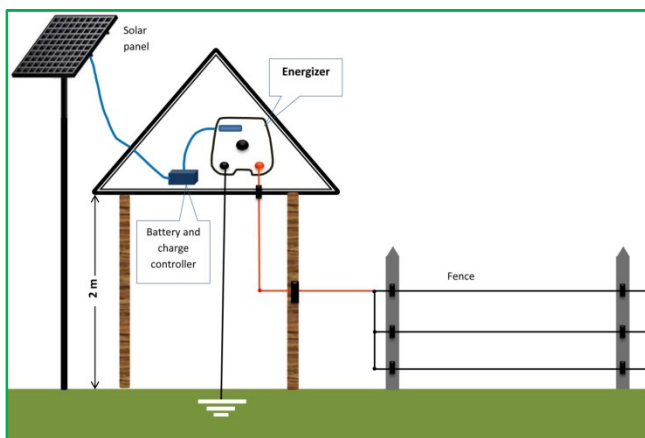


Figure 19. Installing energizer outdoor

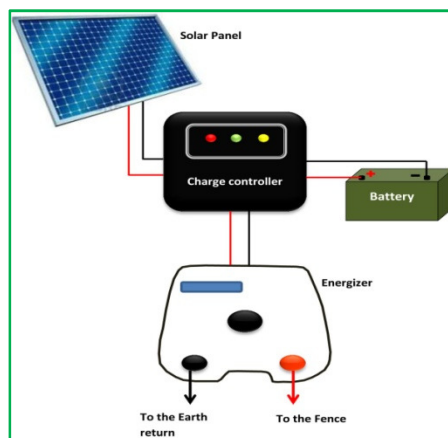


Figure 20. Wiring plan for solar powered energizer

### 6.3 Lightning Protection:

Electric fence energizers are sensitive and easily damaged by lightning surges. Under Bhutan conditions, the lightning surges coming from power supply side is more common than coming from fence side. This is because there are many structures which are much taller than electric fence poles. Therefore, use of a power surge protector is recommended for electric powered energizer.

## 7. Installation of earthing

The quality of the earthing (earth return) is vital to maximizing the performance of fence fencing system. Without proper earth system, electric fence system become incomplete circuit and has no effects on animals when touching the fence wire. There are two types of electric fence earthing system:

- **Earth electrode only system:** This system consists of one more earth electrodes driven into the ground alongside the fence and connected to the energizer's negative terminal. It is used in the situation where soils are consistently wet and have low resistance to the flow of electricity (Figure 21).
- **Earth electrode plus earth return system:** In this system one stain of the fence wire is connected to energizer's negative terminal and run along the entire length of the fence. At regular intervals (about 50m) series of earth electrodes are driven into the ground

and connected to earth return wire. This type of system provides a more effective and reliable earth system in a place where soil has low moisture and poor conduction of electricity (Figure 22). The main drawback of this system is that it increases the likelihood of a dead short if live and earthed wires were to come into contact.

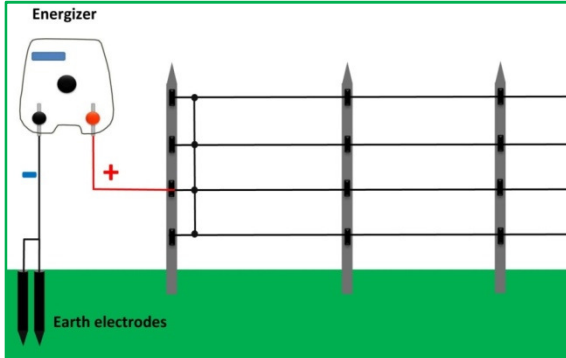


Figure 21: Earth electrode system

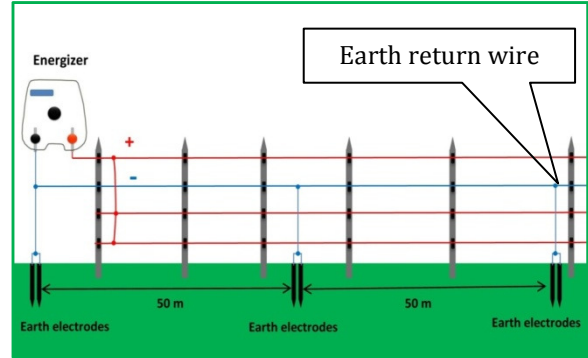


Figure 22: Earth electrode plus earth return system

### 7.1 How to build effective earth electrode using locally available materials?

An effective earth electrode can be made using locally available materials as shown below:

- Dig a pit measuring about 1 x 1 m width and 1.5-2 m depth where the soil remains moist most of the time. In the village the most suitable place is just below the tap water drainage. But before digging the pit, make sure the household electrical earth is not close by. The household electrical earth should be separated at least by 5-10 m from fence earth.



Figure 23A. GI earth plate



Figure 23B. GI earth plate placed vertically in the pit

- Normal GI electrical earth plates of different sizes are available in local hardware shops. Choose medium size plate although the bigger size is better. The plate should be connected with GI or aluminum wire with supplied nut bolt and bury in the pit vertically (Figure 23 A and B). Then should

fill pit with a mixture of wood char-coal powder, table salt and sand all in equal part and add water on the top. The pit should be watered daily during the dry season.

## 8. Equipment testing, fault identification and rectification

After the completion of all the installation works, proper testing, fault identification and rectification are necessary before actual commissioning the electric fence.

### 8.1 How to test the energizer's power supply system:

Test the energizers power supply system as shown below:

- Read the energizer's instruction manual carefully before connecting to the power supply.
- Plug the energizer into a power outlet (mains or battery) and switch ON.
- If the Power on LED on the front of the energizer is green the power supply is OK.
- If no LED is on, check the power supply connections

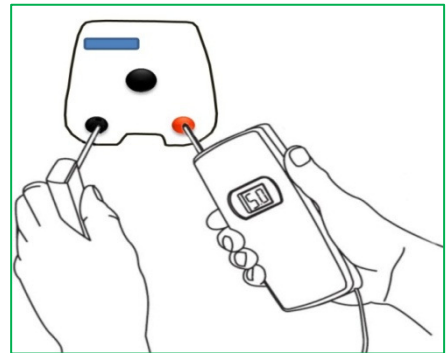


Figure 24. Testing with digital fence voltmeter

### 8.2 How to test the energizer's output:

Test energizers output as shown below:

- Switch the energizer and check the output LED flash periodically. If yes, then there is output from the energizer
- Without connecting the energizer to the fence and earth, test the output voltage with the electric fence voltmeter (Figure 24). If there is no output voltage or less than 5KV, then there is fault with the energizer. Should immediately contact the manufacturer.

### 8.3 How to test the ground system and rectify the fault

You can test the ground system and rectify as shown below:

- Turn off the energizer.
- About 100 m away from the energizer, short-circuit the fence by laying 2-3 metal pegs against the fence. The metal peg should drive into the ground at least 20-30 cm.
- Turn the energizer on.

- Using digital voltmeter check the ground voltage as shown in the Figure 25.
- The reading on the voltmeter shouldn't be more than 300V. If anything higher than this value indicates rectification of earth return is required.
- Rectification: Either improved the existing earth by adding more earth plates or build additional earth and connect together.

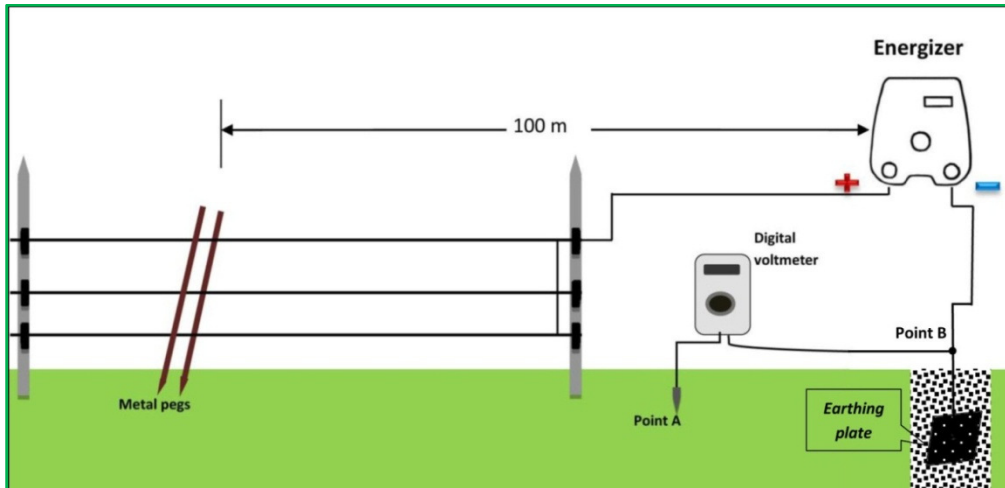


Figure 25. Testing ground with voltmeter

#### 8.4 How to test fence voltage and rectify the fault

Test the fence voltage and rectify as shown below:

- Connect both fence and earth lines to the energizer and power on the energizer
- Drive the negative pin of the fence voltmeter into the soil about 20-30 cm depth. Now read the voltage on each strand of fence. The voltage should at least above 3 KV on each fence wire to be effective.
- If it is less than 3 KV but greater than 1KV, there is either current leak with fence wire or the total length fence is above energizers capacity to run or sign of poor earth system.
- If the reading is zero volts, it is either there is dead short circuit in the fence or not connected to the energizer at all. (see Figure 26)



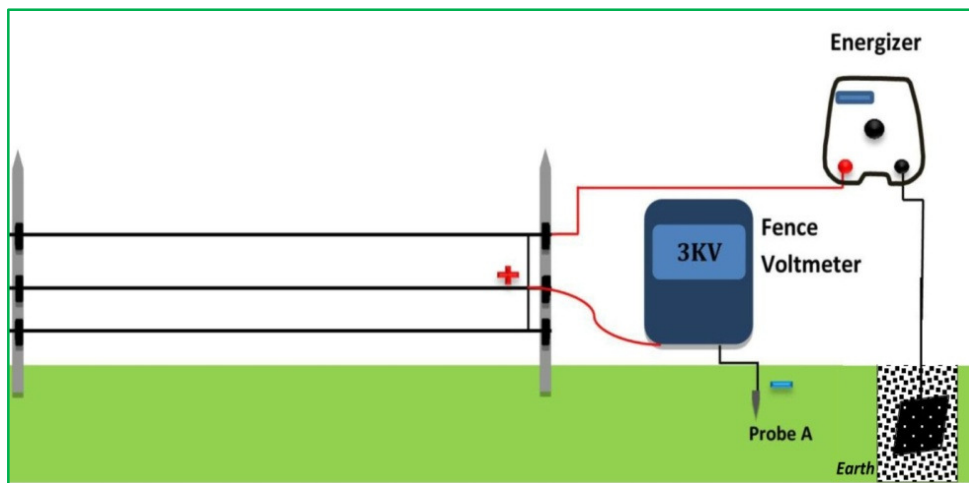


Figure 26. Testing the fence voltage

- The most common cause of low voltage in the fence line is due to the current leak on the fence line. This leaking of electrical discharge will form of an 'arc', which can be heard as clicking sound that is heard when walking along the fence line. It is cause by faulty insulators either improper installation or physical damage of the HDPE insulators. The fault can be rectified easily by replacing the faulty insulators.
- The dead short circuit fault occurs when a live fence wire become totally connected to the earth by breaking the fence line and touching the ground completely or the green vegetation totally touching the fence wire. This can be rectify by repairing the fence wire or removing the vegetation

### 8.5 Alternative way to check the fence line voltage

If digital fence voltmeter is not available there is alternative way to check the fence line voltage. This is done by using small piece of insulated wire joining one end to the fence and bringing other end nearer to the ground. If the fence voltage is above 3KV, electric spark will jump 2-3cm gap distance with a strong click when the other end of wire is brought near to the ground (Figure 27).

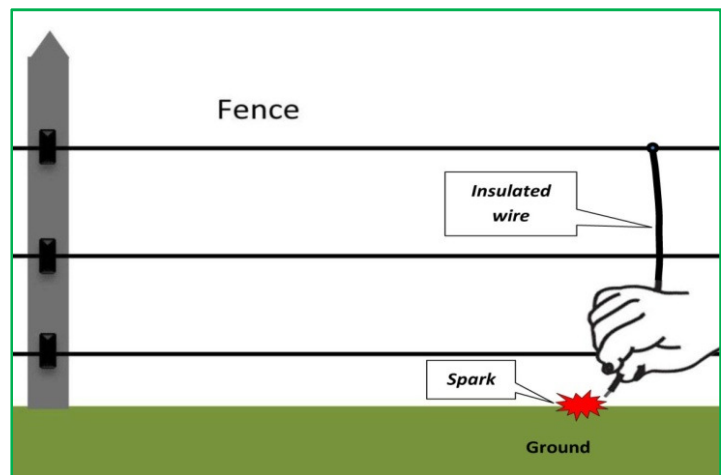


Figure 27. Testing fence voltage without digital voltmeter

## 9. Fence maintenance

Once established, electric fences should be monitored frequently. Daily inspections are required during 1<sup>st</sup>-2<sup>nd</sup> week after fence establishment for the following reasons:

- *The intensity of the initial electric shock felt by an animal determines its subsequent reaction to the fence. Therefore, daily inspections are required to ensure that fence lines are working perfectly so that animals have the maximum opportunity to receive the initial effective shock*
- *When animals encountering the electric shock for the first time may react differently. Some may step back and deter it from crossing the fence while some would cross the fence very forcefully and thereby damaging the fence i.e., breaking of fence wire, insulator or pulling down the wooden poles etc. Therefore, daily inspections are required to repair such damage*

After 2<sup>nd</sup>-3<sup>rd</sup> weeks after installation, most animals would have encountered the electric shock and will tend to avoid the fence. Therefore, the daily inspection is not necessary. Weekly inspection is enough. At each inspection the following activity should be performed:

- *Walk the perimeter of the fence regularly to ensure that the fence remains operational. Clear vegetation and other objects that may short-out the fence.*
- *Check the voltage output of the fence regularly to ensure it is functioning properly.*
- *The fence wire and the nails should be soaked with engine or gear oil at least twice a year to keep them free from rust.*
- *The electrical pulse should be checked at each end of the fence and on each conductor wire on multi-wire fences*
- *The connections between the power and energizer, the energizer and earth rod and the energizer and fence should be checked*

## 10. References

- *British Columbia, Ministry of Agriculture, Food and Fisheries (1996)*. Introduction to electric fencing.
- *T.Penjor and ChokiNima (2011)*: Progress report on locally fabricated solar electric fence in Mindrupling village under Bangtaar Dungkhag.
- *T.Penjor (2010)*: The technical details of fabricated electric fencing system, Report submitted to Bhutan Electricity Authority (BEA) and Bhutan Power Cooperation (BPC)
- *RNR-RDC Wengkhaz, MoAF (2011)*. Poster on basic working principle of electric fencing system
- *I G McKillop, H W Pepper, R Butt and D W Poole*: Electric Fence Reference Manual
- *Midwest Rural Energy Council*: Installation and Operation of Electric Fences, Cow Trainers and Crowd Gates.

**Annexure 1.**

Bhutan Power Corporation Limited  
Distribution and Customer Services Department

**APPLICATION / AGREEMENT FOR ELECTRIC FENCING**

Date:.....

The Manager  
Electric Services Division,  
Distribution & Customer Services Department

Sir/Madam,

We would like to request for the electric fencing connection at the location described below:

- (a) District:\_\_\_\_\_ (b) Geog:\_\_\_\_\_
- (c) Village:\_\_\_\_\_ (d) Name of area:\_\_\_\_\_
- (e) Approximate length of fencing in meter:\_\_\_\_\_

We hereby declare that the Company’s Terms and Conditions of Supply of Electricity including the Schedule of Tariffs and Miscellaneous Charges have been read by me/us and I/We agree to be bound by all the terms and conditions laid in here.

I/We assure that all the information filled in above by me/us are true and that we are liable for any action by the Company as per sub-clause 4.2 and 25.2 of Low Voltage Terms & Condition, if any of the information filled in are incorrect.

I/We hereby declare that through this Agreement, Bhutan Power Corporation Limited (BPC) shall be indemnified, and hold harmless from any and all actual or alleged claims, demands, causes of action, liabilities, loss, damage and or injury (to the property or to person including without limitation to death) resulting from electric fencing and its accessories.

Name:\_\_\_\_\_ ID Card Number:\_\_\_\_\_

Mobile No:\_\_\_\_\_



Signature of the Customer

*(For the group fencing, name and signature on the legal stamp by all the group members must be attached separately)*

**I. TO BE COMPLETED BY THE CONCERNED GUP**

The area identified by the above applicant/applicants for electric fencing is registered under Tharm number: \_\_\_\_\_, Village: \_\_\_\_\_, Geog: \_\_\_\_\_

Dzongkhag: \_\_\_\_\_

The Geog office declare that BPC shall be indemnified, and hold harmless from any and all actual or alleged claims, demands, causes of action, liabilities, loss, damage and or injury (to the property or to person including without limitation to death) resulting from electric fencing and its accessories.

Signature and seal of Gup

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**II. RECOMMENDATION BY THE CONCERNED RNR EXTENSION OFFICER**

(Tick appropriately)

ELECTRIC FENCING IS: REQUIRED  NOT REQUIRED  FOR THE ABOVE INDIVIDUAL/GROUP

If electric fencing is installed for the above Individual/Group, BPC shall be indemnified, and hold harmless from any and all actual or alleged claims, demands, causes of action, liabilities, loss, damage and or injury (to the property or to person including without limitation to death) resulting from electric fencing and its accessories.

The electric fence energizer conforms to the approved specification as per Bhutan Electricity Authority (BEA) approval no. BEA/CEO/COM/2011-12/3097 dated June 28, 2012

The applicant/applicants electric fencing systems was inspected and found to be (tick appropriately)

Satisfactory  Unsatisfactory for release of electric supply

Signature and seal

Of Agriculture/Forest/Livestock Officers

**III. TO BE FILLED BY THE BHUTAN POWER CORPORATION LIMITED**

The electric fencing shall be connected from:

Meter Number:

Consumer Number:

Meter type and capacity:

Meter multiplication factor:

CT ratio of meter (If CT Operated)

The electric wire connection to the electric fencing energizer and earthing system was checked and found to be (tick appropriately)

Satisfactory     Unsatisfactory for release of electricity supply

Verified by:

(Name and Signature of Supervisor/Engineer)

(Name and Signature of Manager/In-charge with official seal)

## Annexure 2. Energizers and accessories

### Energizer, Earthing materials and other accessories

- **Line powered energizer**



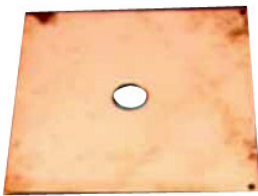
Energizer (2 Joules output)=1nos



7/22 copper wire (red=20m, Blue=20m)



Finger switch=1



Earthing plate (2-6nos depends upon soil types)



Aluminium sheet to make shed = 1 m X 1.8 m

- **Solar powered energizer: additional items**



Solar panel (20-40 Watts)= 1nos



Lead acid battery ( 14-20Amp/Hr)=1nos



Battery charge controller (6-10 Amp)=1 nos

### Annexure 3. Hand tools and accessories

Hand tools and accessories required for electric fence installation and maintenance:



Electric fence volt meter= 1 nos



Digital voltmeter=1nos



Battery operated hand drill= 1 nos



Drill bits for metal(1.5-10mm size)= 1 set



Pliers= 2-3 nos



Claw-hammer=2-3 nos



Screw driver= 1 set



Pruning saw=1-2nos



Electric insulation tape=2-3 nos