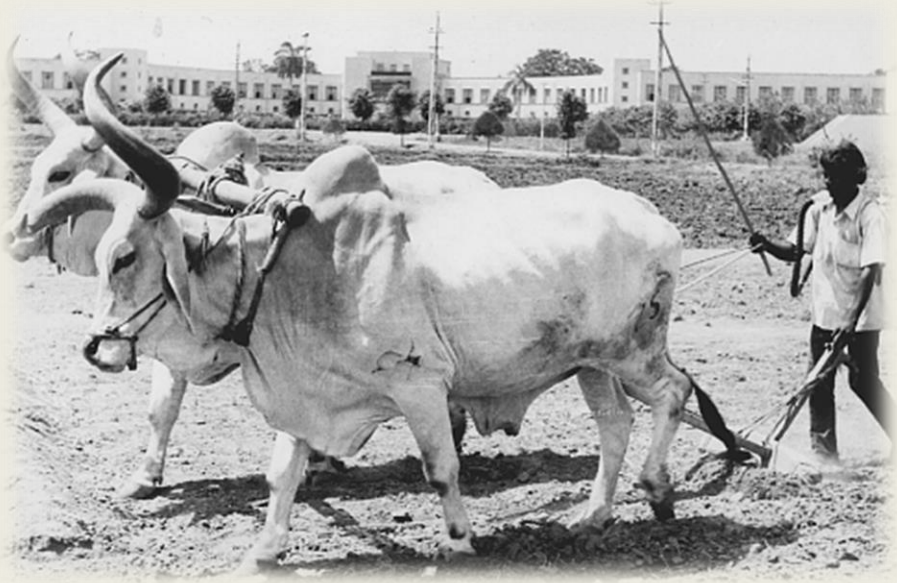
Lect.-1
Sources of farm power and its status in India and Rajasthan.



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Power

Power is defined as the amount of energy transferred or converted per unit time.

The SI (Standard International) unit of power is the watt, equal to one joule per second.

1 joule is equal to 1 Newton- metre. (N·m)

One Newton is the force needed to accelerate one kilogram of mass at the rate of one metre per second squared in the direction of the applied force.

$F=m\cdot a$ *or* $N=1\ kg\cdot 1\ m/s^2$

1 calorie = 4.184 J (Energy unit)

Horse power

- If the rate of doing work is equivalent to 75 kg m/sec, it is said to be one horse power.
- The electrical equivalent of one horsepower is 746 watts.
- One unit of electricity = 1000 Watt.hr = 1 KWh

Example: If an electric motor of 3 hp is operated for 6 hours per day, then monthly electricity consumption will be:

$$\frac{3 \times 746 \times 6 \times 30}{1000} \text{ units} = 402.84$$

Farm Power

- Farm power is an essential input in agriculture for timely field operations for operating different types of farm equipment and for stationary jobs like operating irrigation equipment, threshers/shellers/cleaners/ graders and other post harvest equipments.
- With the increase in intensity of cropping the turn round time is drastically reduced and it is not possible to harvest and thresh the standing crop, on one hand, and prepare seed bed and do timely sowing operations of subsequent crop, on the other hand, in the limited time available, unless adequate farm power is available.

- Availability of adequate farm power is very crucial for increasing production and productivity and handling the crop produce to reduce losses.
- The power productivity relationship shows that those states having higher farm power availability per hectare have higher productivity.
- Type of power sources available on Indian farms are:

  Human Power, Animal power, mechanical power, electrical power and power from renewable energy sources like solar, wind, biomass etc.

Various types of agricultural operations performed on a farm can be broadly classified as

(1)**Tractive work** such as seed bed preparation, cultivation, harvesting and transportation and

(2)**Stationary work** like silage cutting, feed grinding, threshing, winnowing and lifting of irrigation water, operating threshers,shellers/decorticators,cleaners, graders and other post harvest operations.

The **mobile farm power** (for tractive work) comes from human, draught animals, power tillers, tractors and self propelled machines; whereas the **stationary power** is obtained from oil engines (diesel, petrol and kerosene), electric motors and renewable energy sources (solar energy, biogas, biomass and wind energy).

Sources of Farm Power

The different sources of power available on the farm for doing various mobile and stationary operations are as under:

Mobile Power

1. Human (men, women, children)
2. Draught animals (bullocks, buffaloes, camels, horses and ponies, mules and donkeys)
3. Tractors
4. Power tillers
5. Self propelled machines (combines, dozers, reapers, sprayers etc.)

Stationary Power

1. Diesel/oil engines (for pump sets, threshers, sprayers and other stationary operations)
2. Electric motors (for pump sets, threshers, sprayers and other stationary operations)

Human Power

- The availability of labour to work in agriculture is crucial in sustaining agricultural production. The population dynamics of Indian agricultural workers shows that by 2020, the population of agricultural workers in the country will be about 230 million of which 45 % will be the female workers.
- It is predicted that the population in rural areas will decrease to 62.83 % in 2025 and to 44.83 % in 2050. Thus, there is going to be a significant role of farm workers in country's agricultural production.
- Agricultural wages have traditionally been low, due to low productivity.

Human Power

- Main source of power for operating small tools and implements.
- They are also employed for doing stationary work like threshing, winnowing, chaff cutting etc.
- On an average a man develops nearly 0.1 hp. Or 0.075kW (female worker 80% of man worker)
- Availability of human power in agriculture sector is decreasing day by day due to better payment in industrial sector MNAREGA.
- Labour use efficiency can be improved by engaging labour in gang where sequence of operation demands a team work for effective output.

Human power

- ✓Costliest power compared to all other forms of power.
- ✓ Very low efficiency.
- ✓ Requires full maintenance even when not in use.
- ✓ Affected by weather condition and seasons.

Animal Power

- Mainly, bullocks and buffaloes happen to be the principle sources of animal power on Indian farms. However, camels, horses, donkeys and elephants are also used for the farm work.
- India is having the highest cattle population in the World.
- The utilization of animals for draft purposes as well as the power developed by them depends mainly as how they are tamed, trained and harnessed.
- The traditional double neck yoke mostly employed by Indian farmers is an inefficient device as comparison to light weight collar type padded harness. The use of improved harness can give 20% additional power by reducing the strain on animals.

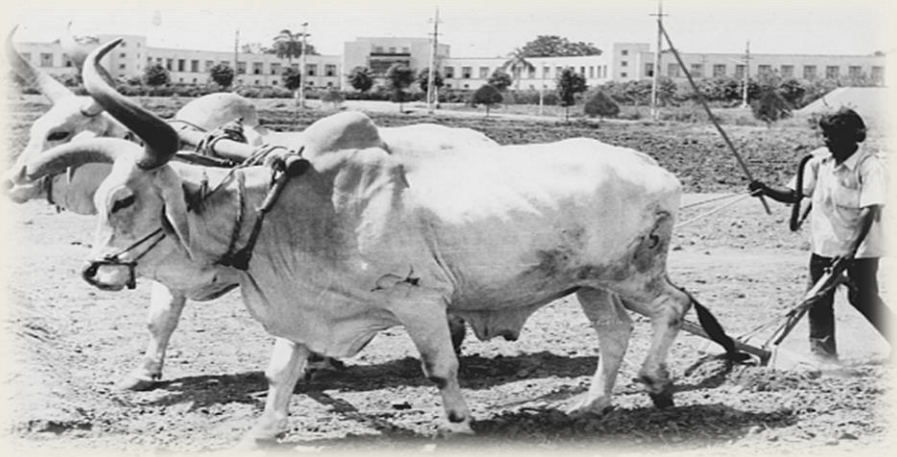
- Utilization of draft animals on Indian farm is affected by type of animals, climatic conditions and supplementary power source available on the farms.
- The power available from draught animals is related to its body weight.

Bullocks: 10-12% of body weight in summer and 12-14% in winter (about one tenth of its body weight)

Buffaloes: 12% of body weight in all seasons.

On the basis of the body weight draught animals are categorized as

- Small (200-300 kg)
- Medium (300-400 kg)
- Large (400-500 kg) and
- Heavy (above 500 kg) animal.



ANIMAL POWER

1. Easily available in villages.
2. Used for all types of work.
3. Low initial investment.
4. Supplies manure to the field and fuels to farmers.
5. Live on farm produce.

But

1. Not very efficient.
2. Seasons and weather affect the efficiency.
3. Cannot work at a stretch.
4. Require full maintenance when there is no farm work.
5. Creates unhealthy and dirty atmosphere near the residence.

- From a good pair of animals weighing between 900-1000 kg we can get about 0.75-0.78 KW power.
- But in most of the States the pair weight of draught animals ranges between 600-800 kg/pair and power availability from them is only about 0.50-0.55 KW/pair.
- OR **Power developed by an average pair of bullocks is about 1 hp for usual farm work.**
- **The average command area of a pair of draught animals is considered to be 2 ha.**

Mechanical Power

- Mechanical power is available through tractors, power tillers and oil engines.
- In oil engines the fuel is converted into useful work. The thermal efficiency of diesel engine varies between 32 to 38 per cent whereas that of petrol engine (carburettor engine) the efficiency is 25 to 32%.
- Generally, stationary diesel engines are in demand for pumping irrigation water (3-10 hp), flour mills, oil ghanis, cotton gins (14-20 hp), chaff cutter, sugarcane crusher, threshers and winnowers etc.

Advantages: Efficiency is high; not affected by weather; can run at a stretch; requires less space and cheaper form of power.

Disadvantages: Initial capital investment is high; fuel is costly and repairs and maintenance needs technical knowledge.

MECHANICAL POWER

Advantages:

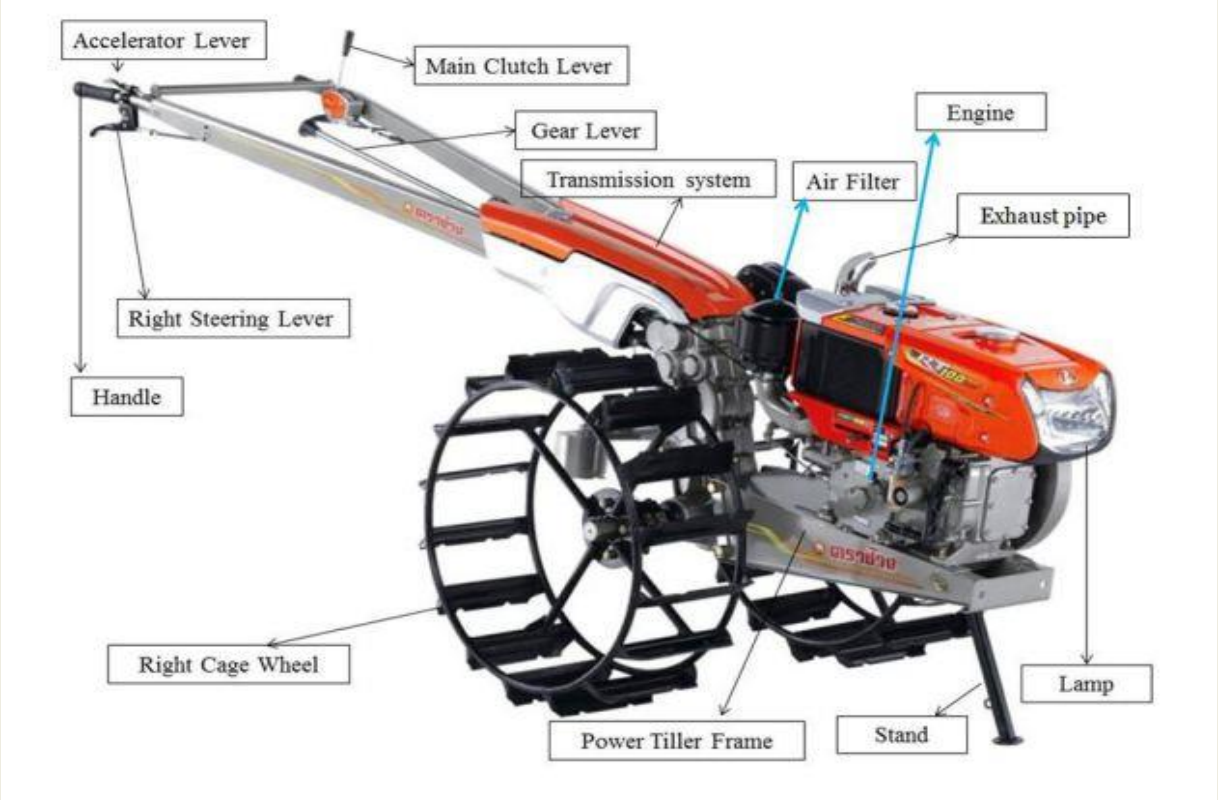
- Efficiency is high;
- Not affected by weather;
- Can run at a stretch;
- Requires less space.

Disadvantages:

- Initial capital investment is high;
- Fuel is costly and
- Repairs and maintenance needs technical knowledge.

- **In India tractor and power tiller production started in 1961** with the establishment of **first plant by Massey Fergusson and subsequently known as Tractor And Farm Equipment (TAFE), Limited by Madras (Chennai)**
- India has emerged as number one producer of small tractors in the world.
- For calculating power availability from tractors on the farm, a weighted average of 26.1 kW per tractor can be taken.
- The replacement rate is 10 bullocks /tractor of about 20 kW power output.

Power tiller



Power tiller is a prime mover in which the direction of travel and its control for field operation is performed by the operator walking behind it. It is also known as *hand tractor or walking type tractor.*

- Average size of holding in India is about 2.5hectares. 89% of total land holdings are of less than six hectares. Under such conditions, power tiller may be useful as a power unit.
- **The average command area of a power tiller of 7.46 kW is considered to be 6 ha and that of a tractor of about 26.1 kW it is 15 ha.**
- For calculating power availability from power tillers on the farm, a weighted average of 7.0 kW per unit can be taken.

Diesel engines

- For calculation purposes the average weighted power of diesel engines can be taken as 5.6 kW and for electric motors as 3.7 kW and 7.46 kW for small pump sets and submersible pumps respectively.
- **The low, medium and high power range machines can be categorized to represent 3 kW, 10 kW and 28 kW machines serving the needs of Indian agriculture**.

Electrical power

- Electricity is the most efficient and clean source of power used on agricultural farms.
- In India, availability of electricity per capita is extremely low as compared to the developed nations.
- The major sources of generated power in the country are from Thermal, Hydro, Nuclear and wind sources. Efforts are being made to generate electricity from solar, ocean, geo-thermal biomass and biogas.
- **On an average 1/10th of the total electrical power generated in India is used for farm work**.
- The use of electrical power in agriculture is mainly for pumping of irrigation water, threshing, dairy industry, agro processing units, rice mills, cold storage, cattle feed grinding etc.

Renewable sources of energy

- Energy sources which are continuously and freely produced in the nature and are not exhaustible are known as the renewable sources of energy.
- In farming system the main renewable sources are (a) solar (b) wind (c) biomass, and (d) biogas.
- Renewable energy can be used for lighting, power generation, water heating, drying, greenhouse heating, water distillation, refrigeration and diesel engine operation.

Advantages of renewable energy

a) These sources of energy are renewable and there is no danger of depletion. These reoccur in nature and are in-exhaustible.

b) Renewable energy sources are more site specific and are used for local processing and application. There is no need for transmission and distribution of power.

c) Most of the devices and plants used with the renewables are simple in design and construction which are made from local materials, local skills and by local people. The use of renewable energy can help to save foreign exchange and generate local employment.

d) The rural areas and remote villages can better use the locally available renewable sources of energy. There will be huge savings from transporting fuels or transmitting electricity from long distances

Wind power

- The development of wind power in India began in the 1990s.
- Air in motion is called wind. i.e. A moving mass of air.

➢ The winds on earth surface are caused primarily by the unequal heating of the land and water by the sun.

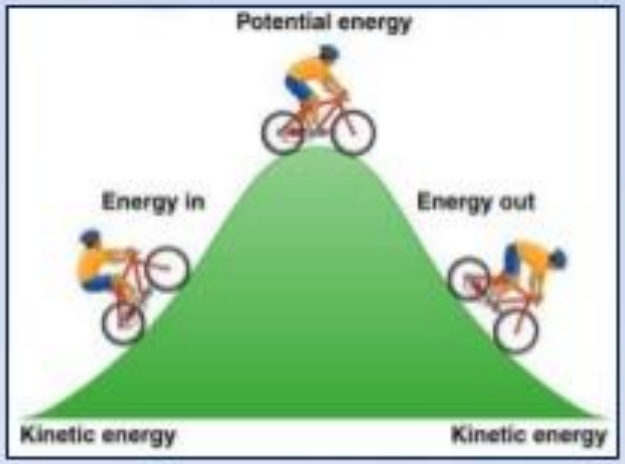
➢ The differences in temperature gradients induce the circulation of air from one place to another place. The hot air being lighter, rises upwards. The cooler air starts flowing towards the space vacated by the rising air.

➢ Experimental results show that a wind mill having 3.6 m dia wheel, mounted on 12.0 m tower is able to produce from 0.1 hp to 0.9 hp with the wind velocity varying from 6.4 to 37 km/hr. Thus **the average capacity of a wind mill would be about 0.50 hp**.

- As on 31 March 2019 the total installed wind power capacity was 36.625 GW, the fourth largest installed wind power capacity in the world.
- Wind power capacity is mainly spread across the South, West, North and East regions.
- Wind power accounts for nearly 10% of India's total installed power generation capacity and is nearly 4% of total electricity generation.

Wind energy

- Wind Energy is kinetic energy from the wind that can be directly converted to electrical or mechanical energy by reacting to the atmospheres pressure slope.
- The windmill was invented in 200 BC in China and was used to pump water and grind grain
- In modern days, wind energy has doubled through the years



$$E_k = \frac{1}{2}mv^2$$

Power in the Wind

- The power in the wind is:

$$\text{Power} = \tfrac{1}{2}\,\rho\,A\,V^3$$

= 1/2 x air density x swept rotor area x (wind speed)^3

ρ

Density = P/(RxT)

P – pressure (Pa)
R – specific gas constant (287 J/kgK)
T – air temperature (K)

kg/m^3

A

Area = $\pi\ r^2$

m^2

V^3

Instantaneous Speed
(not mean speed)

m/s

- Using the density of air at sea level:

Power = 0.6125 AV^3 (metric)

Power in Wind

$P = ½.\rho.A.V^3$

where, P is power in watts (W)

ρ is the air density in kilograms per cubic metre (kg/m^3)

A is the swept rotor area in square metres (m^2)

V is the wind speed in metres per second (m/s)

The power in the wind is proportional to:

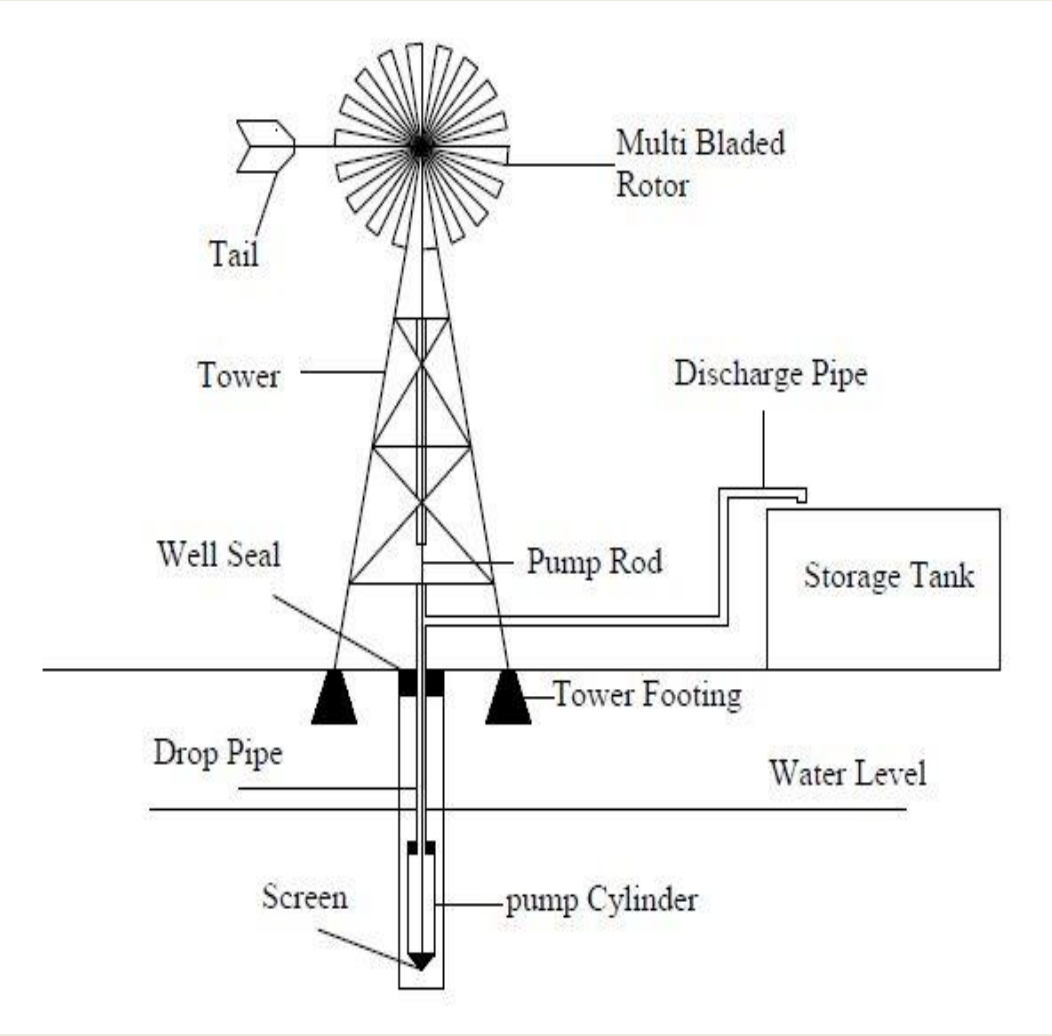
- Area of windmill being swept by the wind.
- Cube of the wind speed.
- Air density - which varies with altitude.

P (Rho) is a symbol for density

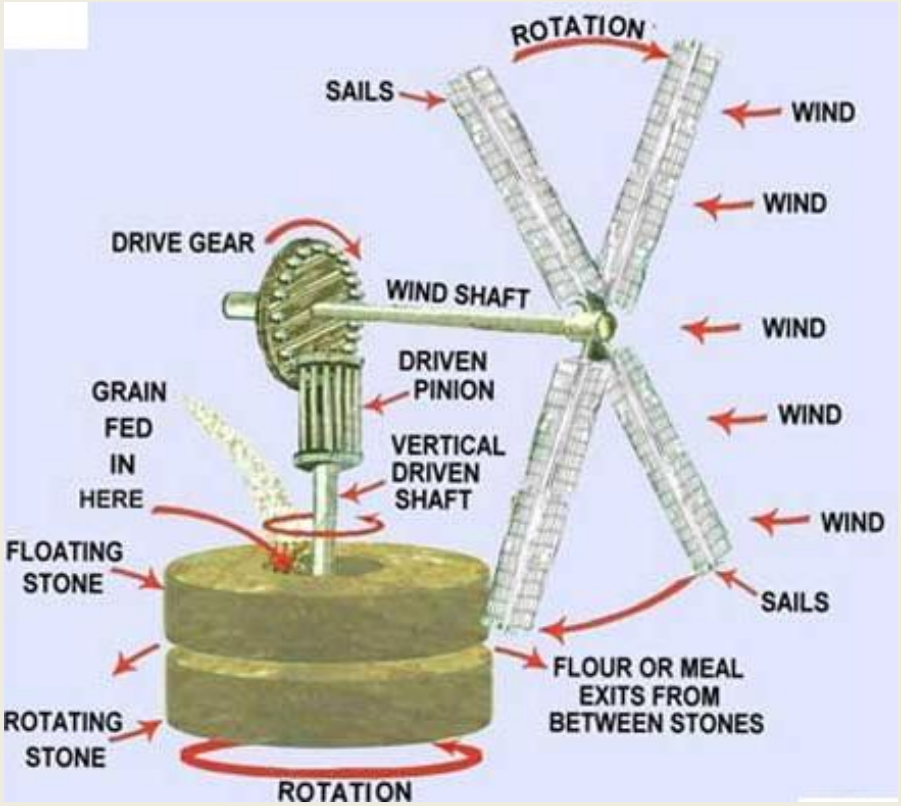
Wind mill

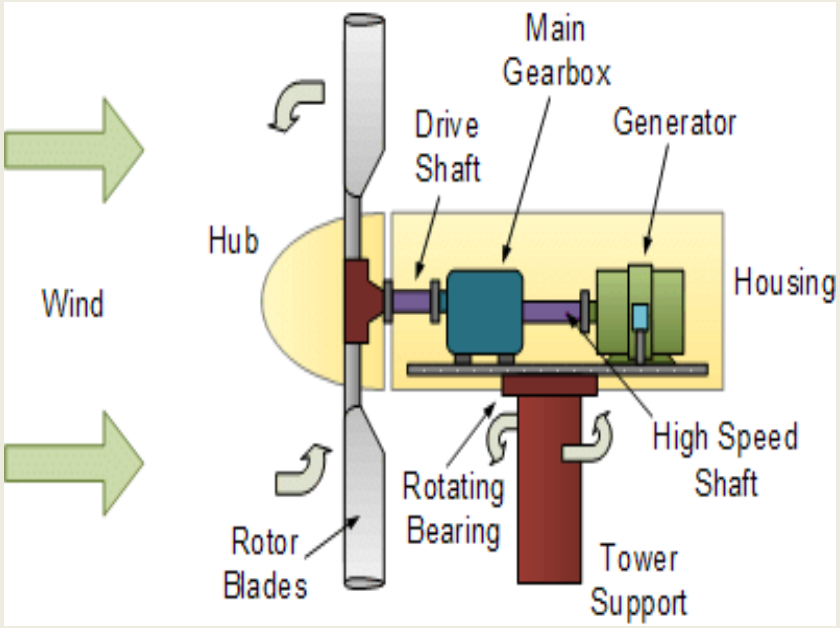
A wind mill is a machine which works with the energy of blowing wind.

It can be used for water lifting, grain grinding and electricity generation.



Gristmills





The other use of wind mills is for grinding grains into flour. These are called gristmills, corn mills or flour mills.

Biomass

- Plant matter created by the process of photosynthesis is called biomass (or) all organic materials such as plants, trees and crops are potential sources of energy and are collectively called biomass.
- Biomass also includes forest crops and residues after processing. The residues include crop residues (such as straw, stalks, leaves, roots etc.) and agro-processing residues (such as oilseed shells, groundnut shells, husk, molasses, coconut shells, saw dust, wood chips etc.,).
- The term biomass is also generally understood to include human waste, and organic fractions of sewage sludge, industrial effluents and household wastes.

Biomass as farm power

- The biomass can be used **by thermo-chemical conversion**. Thermo-chemical conversion includes processes like combustion, gasification and pyrolysis.
- **Combustion** refers to the conversion of biomass to heat and power by directly burning it, as occurs in boilers.
- **Gasification** is the process of converting solid biomass with a limited quantity of air into producer gas.
- **Pyrolysis** is the thermal decomposition of biomass in the absence of oxygen. The products of pyrolysis are charcoal, condensable liquid and gaseous products.

- The second approach is **Biochemical conversion** includes anaerobic digestion to produce biogas and fermentation to obtain alcohol fuels.
- The third approach is **oil extraction**.

Edible and non-edible oils can be extracted from a variety of grains and seeds. They can be directly used as **bio-diesel**, which is **a good substitute for conventional diesel oil.**

Biogas

- Biogas is a by-product of the decomposition of organic matter by anaerobic bacteria.
- The biogas is a mixture of methane (CH_4): 55-65% and Carbon dioxide (CO_2) : 30-40%. It also contains traces of H_2, H_2S and N_2. It is a clean and renewable energy that may be substituted to natural gas to cook, to produce vapour, hot water or to generate electricity.
- The methane gas produced by the bacteria inside biogas system may be used for cooking, lighting, and other energy needs. Waste that has been fully digested exits the biogas system in the form of organic fertiliser.

FAMILY SIZE BIOGAS PLANT

Deenbandhu biogas plant

- The calorific value of biogas ranges from 4700 kcal/cum.
- The biogas can be upgraded to synthetic natural gas (SNG) by removing CO_2 and H_2S.
- The production of biogas is of particular significance in India because of its large scale cattle production.
- The biogas is used for cooking, domestic lighting and heating, run I.C. engines and generation of electricity for use in agriculture and rural industry.
- Family biogas plants usually of 2-3 m^3 capacity.
- The by-products – biogas plant spent slurry is rich in nitrogen, phosphorus and potash compared to FYM.

Biogas - Uses

- For cooking: Gas requirement is 0.24 cum per person per day

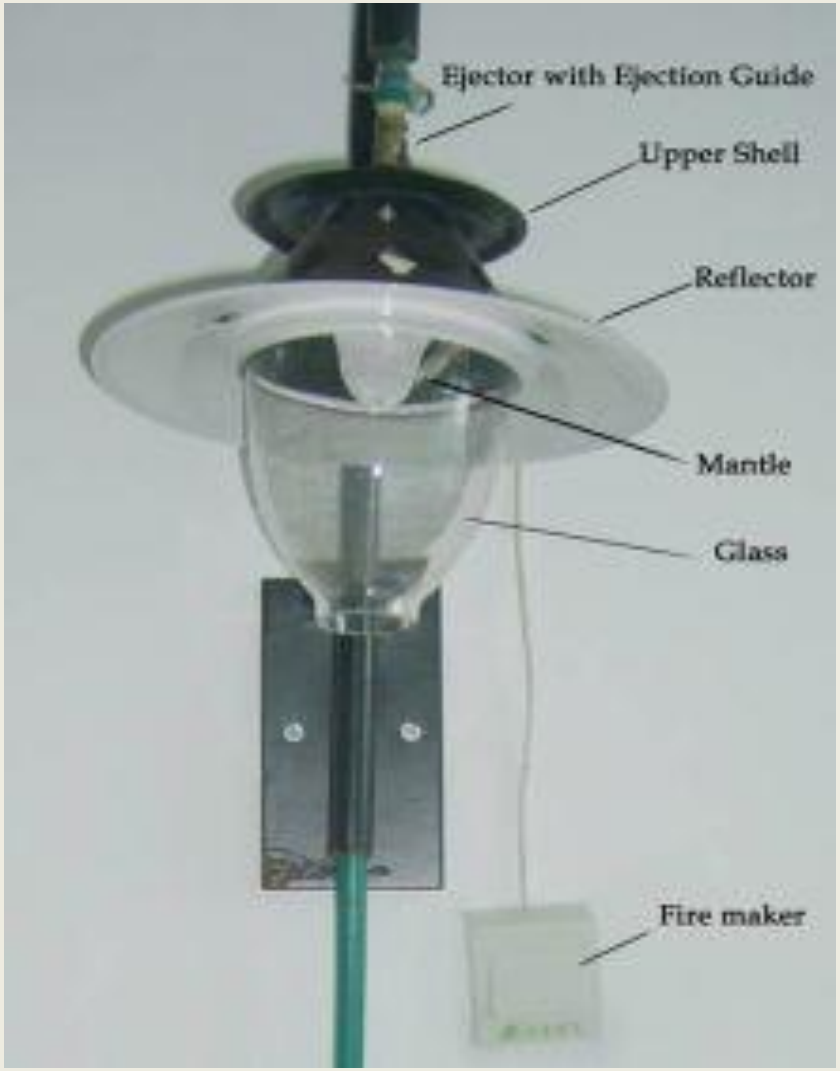
  (efficiency of cook stove is 60%)
- For lighting: Gas requirement is 0.15 cum per 100 candle power mantle lamp (= 40 w bulb) per hour.
- For motive power: Gas requirement is 0.5 cum per hp per hour. (80% gas and 20 % diesel)
- For electricity generation: 1.25 KW /cum of biogas

Biogas burner

Lighting

Lighting can be provided by means of a gas mantle, or by generating electricity.

Biogas mantle lamps consume 0.13 cum gas per hour having illumination capacity equivalent to 40 W electric bulbs at 220 volts. This application is predominant in rural and un-electrified areas.



Biogas lamps

Biogas as an Engine Fuel

Biogas can be used as a fuel in stationary and mobile engines.

It can be used to operate four stroke diesel and spark ignition engines.

Electricity generation using biogas is a commercially available and proven technology.

When biogas is used to fuel such engines, it may be necessary to reduce the hydrogen sulphide content if it is more than 2 percent otherwise the presence will lead to corrosion of engine parts.

For electricity production, small internal combustion engines with generator can be used to produce electricity.

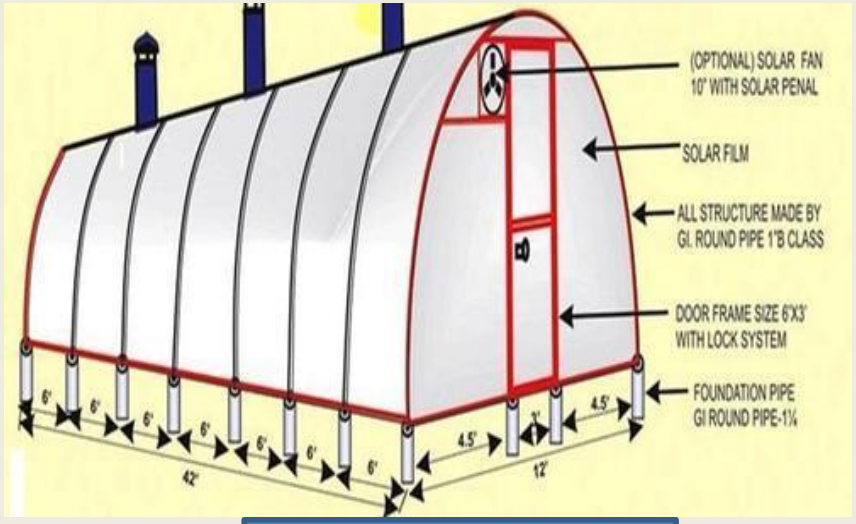
Biogas Generator

Solar Energy

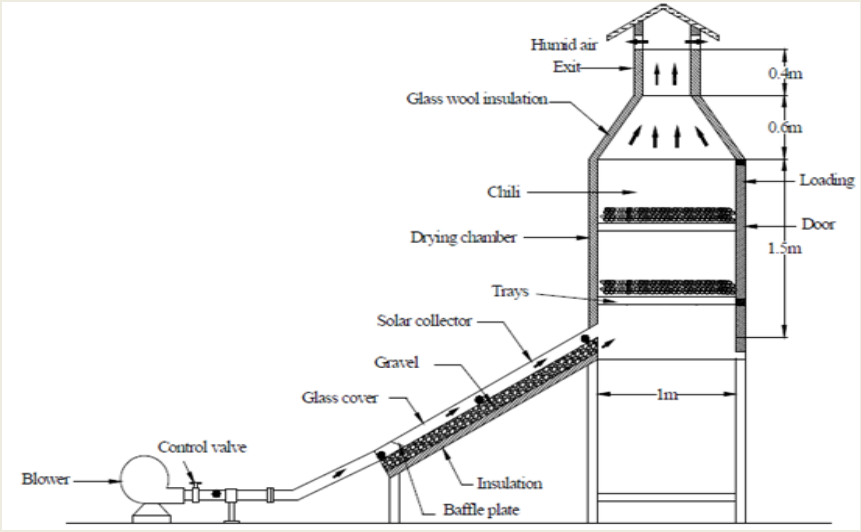
- All kinds of energy on earth originate in solar energy.
- it is non-polluting.
- Solar energy has an intensity of about 1353 W/m^2 at the outer surface of the atmosphere i.e. the rate at which energy flows through every sq.m.of area directly facing the sun.
- The solar radiant energy has been utilized in a number of ways for various purposes through solar thermal and photovoltaic routes.

- In thermal mode, heat is used for cooking, heating, drying, distillation, or generating electricity.
- A traditional and wide spread use of solar energy is **for drying** particularly of agricultural products. The solar photovoltaic route is being used for electricity generation, telecommunication, street lightning, domestic lightning, and water pumping.
- On an average 5 kW/m^2 per day solar energy is falling on the land for nearly 300 days in a year.

Drying



Solar tunnel dryer



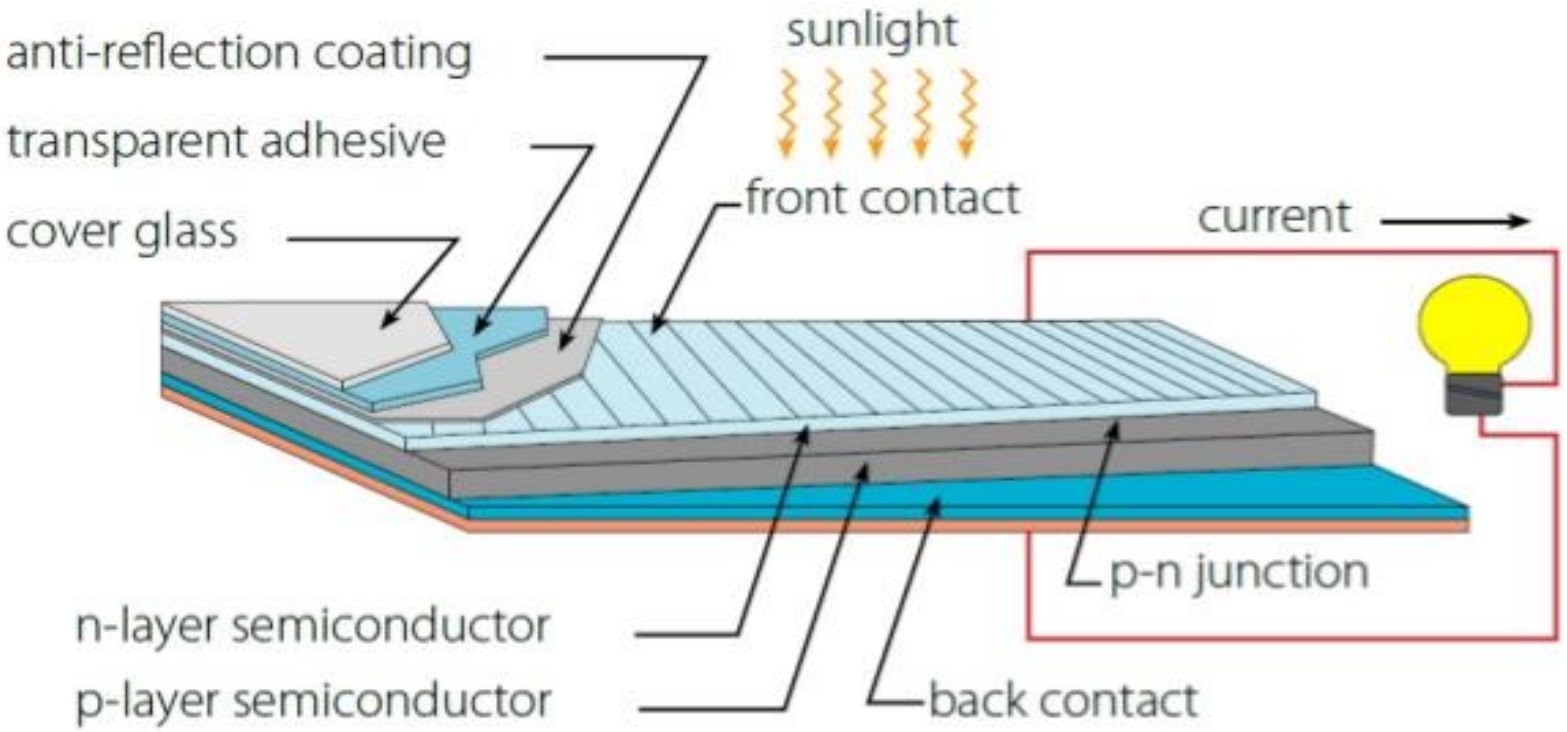
Forced convection solar dryer

Solar Animal Feed Cooker

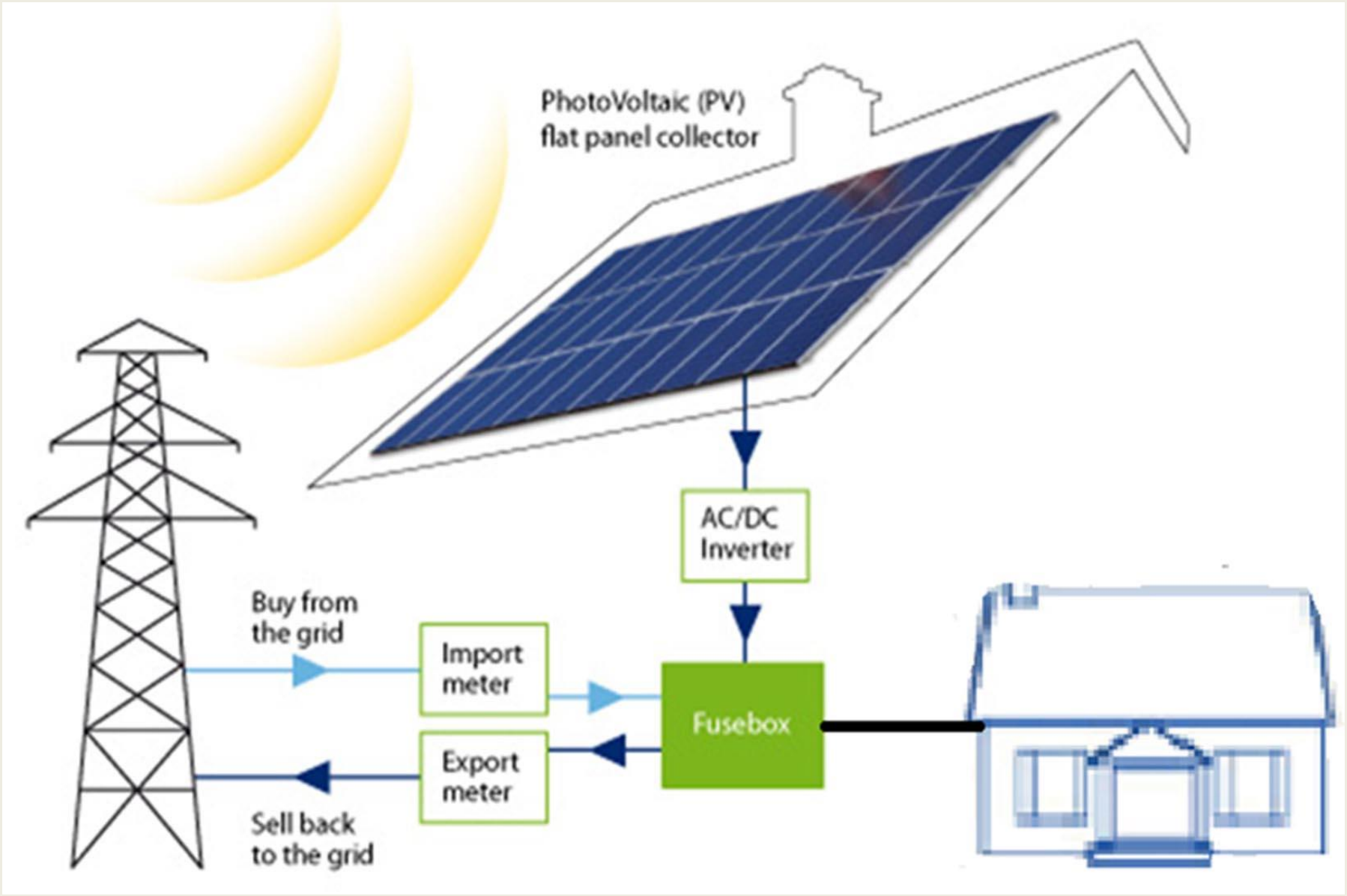

Solar Energy
Utilisation
Photovoltaic mode

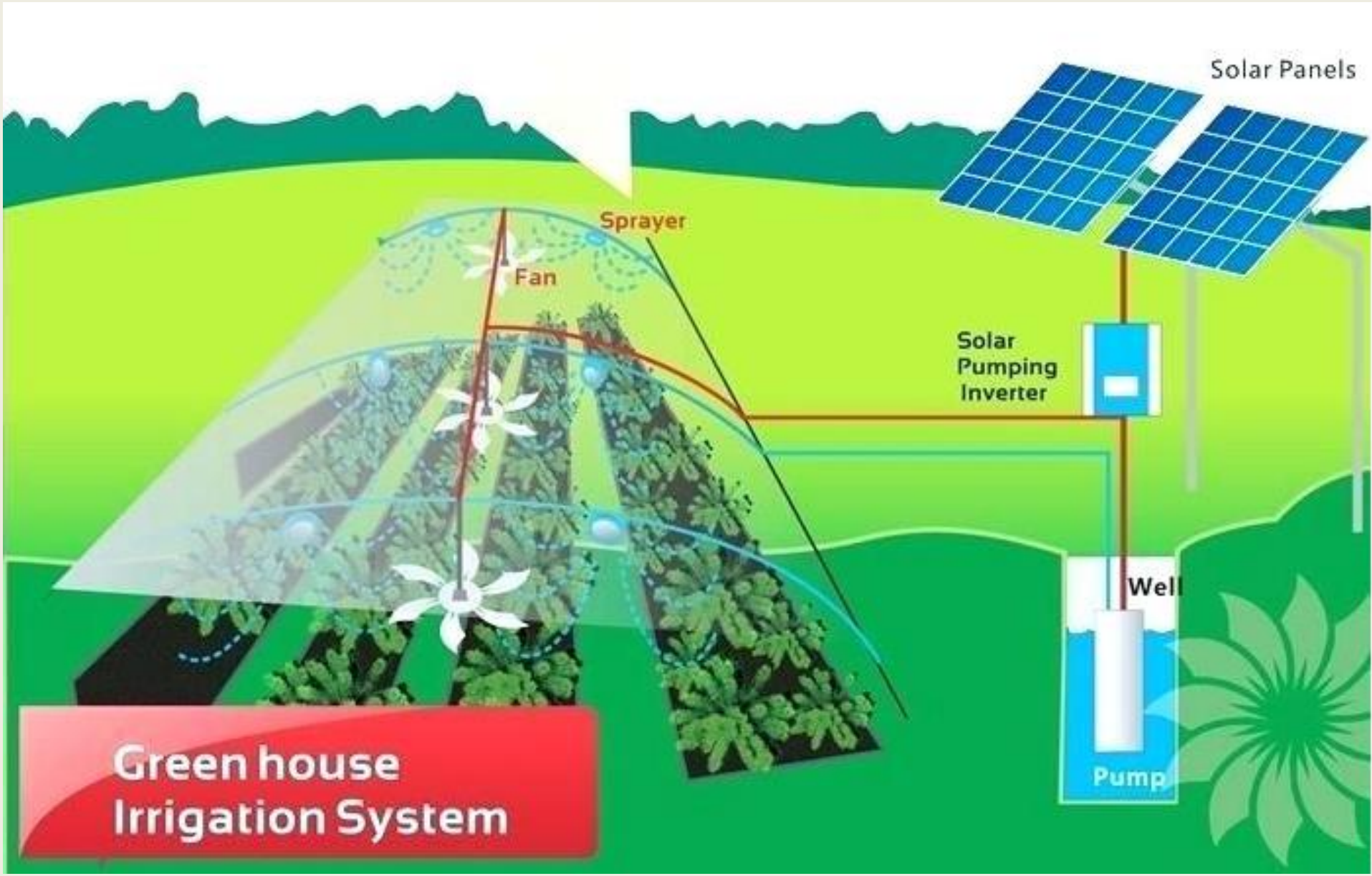
- Solar photovoltaic field is getting priority in India due to heavy pressure on conventional fuels and electricity.
- Solar cells directly convert the solar radiation into electricity using photovoltaic effect. SPV cell is a semi-conductor system made of silicon or similar materials.
- The system generates electricity when it is exposed to sunlight. Power is generated by connecting thousands of tiny solar cells which forms modules. Solar cells are quite compatible with almost all environments, respond instantaneously with solar radiation and have an expected lifetime of 25 years. These cells can be located at place of use and hence no distribution network is required.

Structure of a Solar Cell

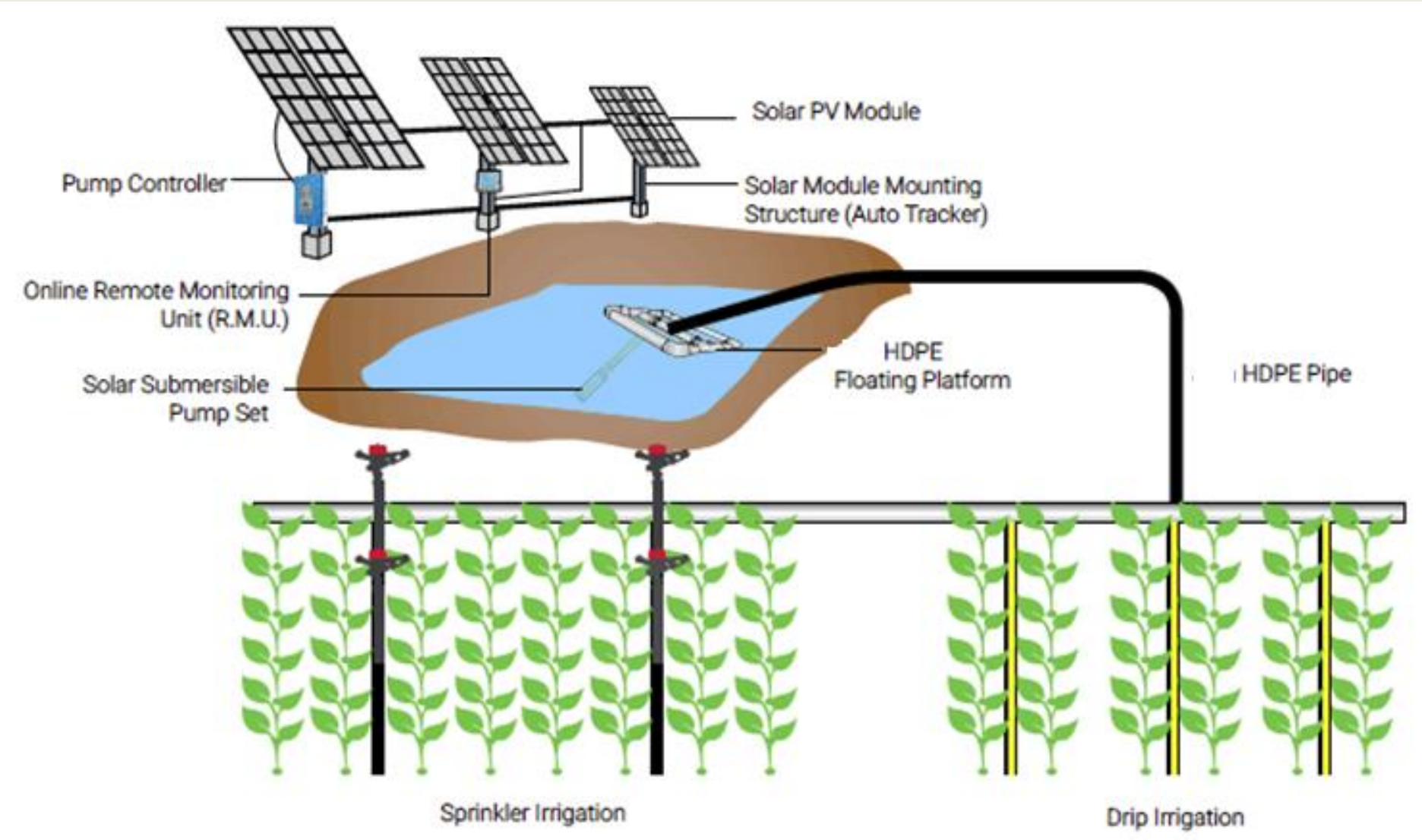


Solar Photovoltaic on Grid System




Solar Panels
Sprayer
Fan
Solar
Pumping
Inverter
Well
Pump
Green house
Irrigation System

Solar PV pump for irrigation



Solar PV water pump

- Solar photovoltaic system operates on the basis of the photovoltaic effect on a silicon junction diode designed to facilitate the collection of usable magnitudes of electricity. Usually of the order of 1.5A at 0.5V.
- Such a junction diode is called a solar cell. Number of cells are string up in series to generate power at usable voltages.
- The system has to be optimized according to the load profile and the geographic location in which it is used.

Components of Solar PV pump

- A solar photovoltaic water pumping system, essentially consists of a SPV panel / array directly powering a water pump.
- The water pumped during the day can be stored in storage tanks for use during night.
- The generated electricity from the panel is fed to the pump through a switch and a 3 phase inverter, in case of AC submersible pumpset.
- Normally, no storage batteries are provided as the water can be stored in storage tanks, if required.

Solar water pumping system

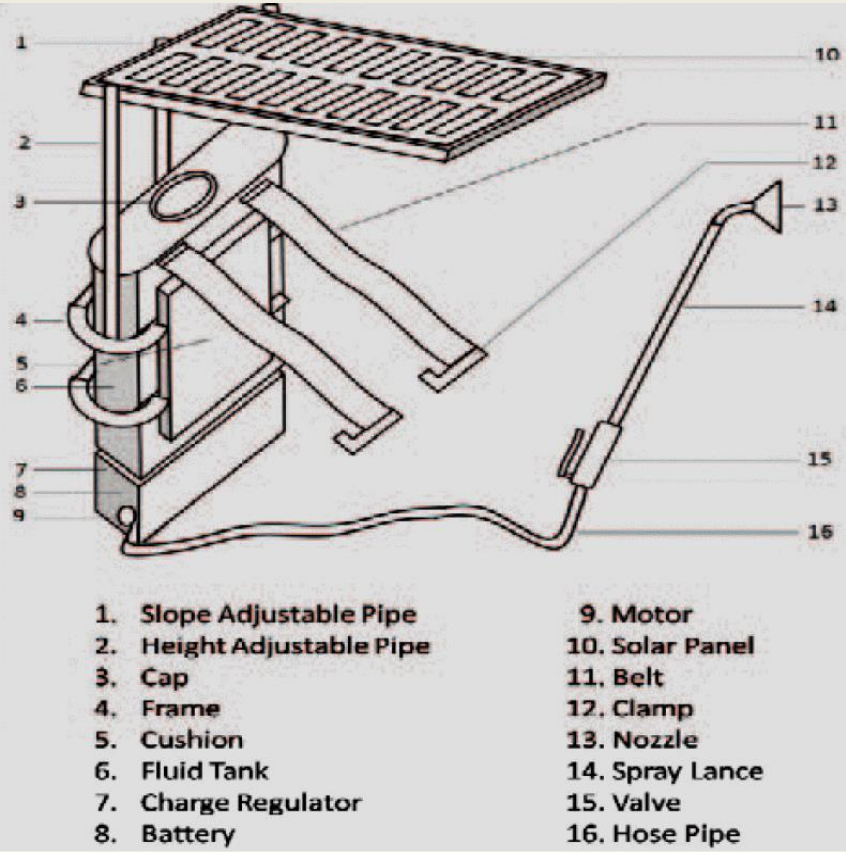
Features :

1. Noise and pollution free operation.
2. Does not require any fuel
3. Simple to install, operate and maintain.
4. Designed to give optimum output even during low sunshine period.

Photovoltaic pumping system specifications

Motor pump/ Configuration	**Output (m^3.day)**	**Head (m)**	**Solar Array (Wp)**
Submerged borehole motor pump	40 25	20 20	1200 800
Surface motor/ submerged pump	60	7	840
Reciprocating positive displacement pump	6	100	1200
Floating motor/pumpset	100 10	3 3	530 85
Surface suction pump	40	4	350

Solar Photovoltaic Sprayer



Solar panel of 20 W capacity, a 12V DC battery, a DC motor, a pump, to spray the pesticide and a tank to hold the pesticide.

Solar Photovoltaic Duster

Solar PV duster is a novel device suitable for aerial application of pesticides and insecticides in the powder form.

Duster is an impeller type centrifugal blower, gear reduction mechanism, dispensers with D.C motor.

Solar Power Electric Fence

- One of the risks in Indian farming is damage to crops by stray/ wild animals and also theft of the produce especially in orchards.
- Proper fencing is one of the solutions to overcome such type of risks.
- The fencing of barbed wire with multiple strands of plain wires or woven wire and metal/cement/ wooden posts is common. A channel linked fencing costs about Rs 950 per running meter for a height of 1.5 m using angle posts of 50 x50 x 6 mm at 3 m spacing and plain wire channel of 75 x 75 x3.15 mm.

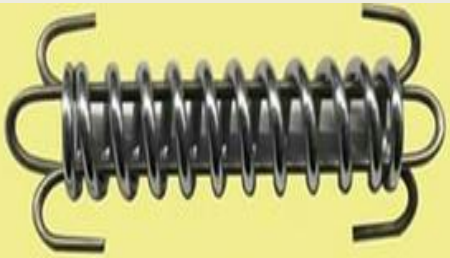
Solar powered electric fence

- It gives a sharp shock to create psychological fear, against any tampering. Electricity is generated by 75 watts solar panel which charges a 12 volt, 40 AH battery and ensures that the battery remains charged at all times.

Various Components of Solar Power Fencing

Solar Panel and control Unit

Digital Volt Meter



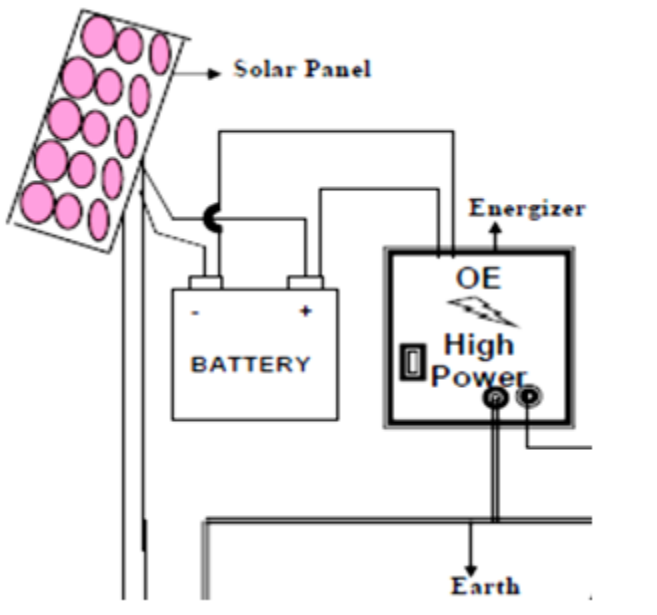
TENSION SPRING

WIRE TIGHTENER

CORNER

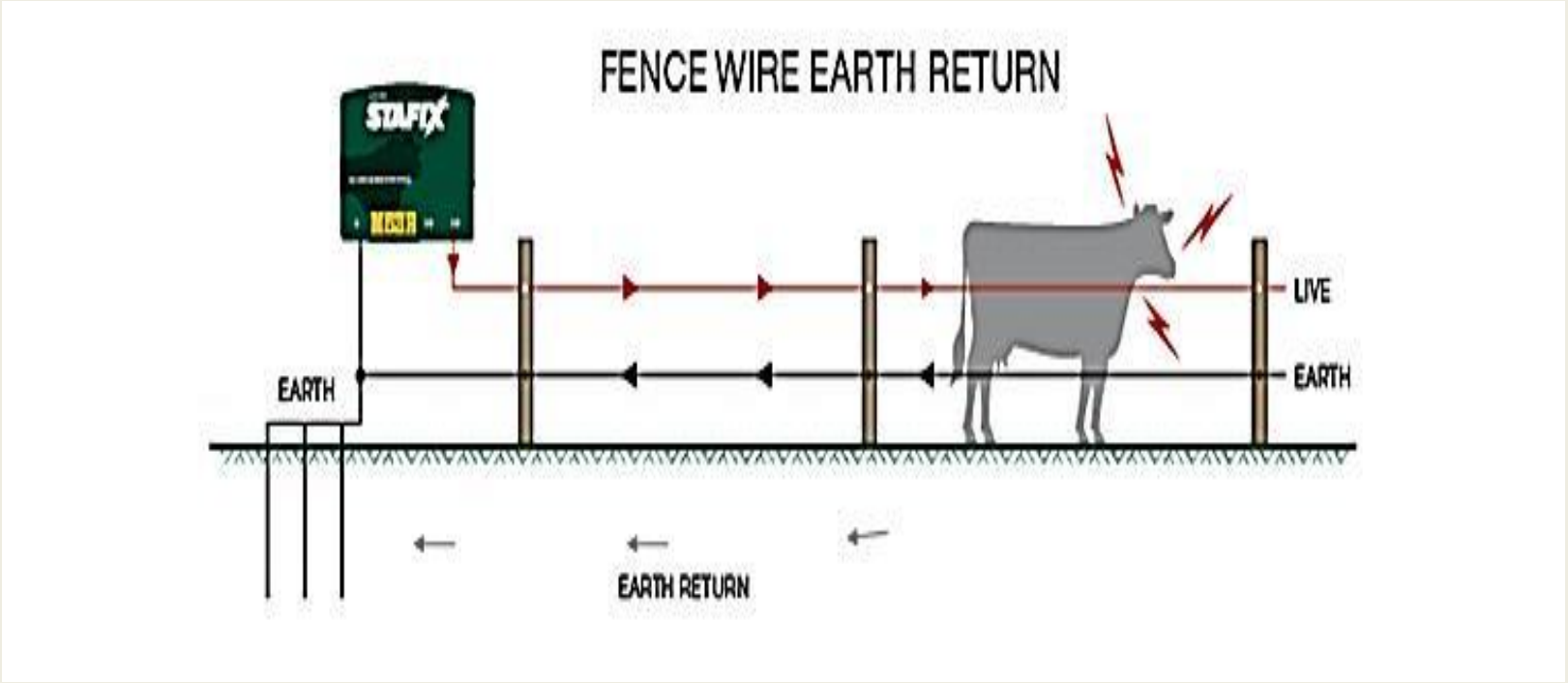
IRON REEL INSULATOR

The alarm incorporated in the system gets activated and alert the inmates of the protected area.



An energizer is used which transforms the low voltage current from battery to high voltage (up to 10,000 volts) current and sends it to the electric fence. This way the fence is electrified and animals touching the fence receive the high voltage shock and run away from the fence. The electric shock is completely safe and non-lethal for human and animals.

- As current is pulsating (not live) and passing at every 1 to 1.2 second and only for a milli-second of time, the animal gets enough time to get away from the fence. The pulsating current does not grab the animal which generally happens in continuous current which causes contraction of muscles/cramps.



In solar fencing, even if an animal is trapped in the fence, after 10 consecutive shocks the system will trip and hooter will sound so that farmer can intervene and no death causes.

Farm power - Present Scenario

- Average farm power availability for the cultivated areas of the country has been increased from 0.295 kW/ha in 1971-72 to 2.02 kW/ha in 2016-17.
- In India, medium and large scale industries manufacture tractors, power tillers, diesel engines, electric motors, land development machinery, field preparation equipment, weeders, sprayers and dusters, irrigation pumps, post-harvest and processing machinery and dairy equipment.
- The overall level of farm mechanization in India is 40-45 per cent (i.e. tillage about 40 per cent, seeding and planting about 30 per cent, plant protection 35-45 per cent and harvesting and threshing about 60-70 per cent for rice and wheat and less than 15 per cent for other crops).

- The level of farm mechanization varies greatly region to region. Northern states such as Punjab, Haryana and western Uttar Pradesh have high level of mechanization (70-80 per cent overall; 80-90 per cent for rice and wheat) due to high productive land as well as declining number of agriculture workers and also full support by state government.

- The eastern and southern states have lower level of mechanization (35-45 per cent) due to smaller and scattered land holdings.

- In the north-eastern states, the level of farm mechanization is extremely low mainly due to hilly topography, high transportation cost, and socio-economic conditions of the farmers.

Farm Power - Rajasthan Scenario

- Rajasthan contributes about 10% of India's geographical area and about 14% of the total India's Agriculture land.
- Rajasthan Agriculture is witnessing a significant movement from manual to mechanical power; the shift is mainly because of unavailability and high cost of labor at farms. Further, use of mechanical power has a direct influence on quality of farm operation which in turn increases the productivity of crops, apart from reducing the drudgery and facilitating timeliness of agricultural operations.
- Mechanical power is largely consumed in big land holdings and is still beyond the reach of small/marginal farm holders, which constitute around 75 to 80% of total land holdings.
- In order to make farm machinery with modern technologies available to small and marginal farm holders, collective ownership or Custom Hiring Centers is being promoted.

Farm Power - Rajasthan Scenario

- In the year 2001, the power availability on the farms of Rajasthan state was 0.65 KW/ha, very less as compared to 2.96 KW of Punjab state and 1.61 KW of Haryana state at that time.
- In Rajasthan, the equipment and machinery for planting some of the coarse cereals like pearl millet, their harvesting and threshing need to be introduced.
- Deep placement of seeds to make use of the receding soil moisture for proper germination is necessary. Therefore, equipment for deep tillage to increase moisture intake needs introduction.