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Generation of Electricity through Bicycle and Solar Energy

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Abstract

Bicycle is the main mode of transportation for many Indian villagers. Most of these villages are un-electrified. Power generated by pedaling can be converted from mechanical to electrical energy by using either dynamo or alternator. Small powered lighting devices can be charged using dynamo and can be used in the night by students for study purposes. This principle can be extended to power mobiles, iPods, laptops etc. Power can be also generated from the rotation of the wheels of alternator vehicles like bikes and cars, where there is a possibility of generating more power. The generated power can be either used in the same vehicle or can be stored in a battery for powering some other devices. Riding bicycle helps in maintaining a good physic and along with-it power can be also generated. This paper presents methods in generating electricity by pedaling a bicycle**.**

As the number of people longing for a cleaner environment grows, so does the solar industry. Solar cells are becoming increasingly cost-effective as more distributors enter the market and new technologies continue to offer more choice and new products. We might even see the end of the combustion age in our lifetime. Cars might soon be powered by new fuel cells that create electricity through chemical reaction. Solar panels are being mounted to the sides of houses when roof space is not an option.

Keywords: PMDC motor; Bicycle; Battery; Inverter circuit; Solar Panel

I. INTRODUCTION

World is a storehouse of energy. We all know that energy can neither be created nor destroyed but can be transformed from one form to another. But we are wasting resources that can produce energy as if they are limitless. If we can renew and reuse the energy we waste, it would help in some way to the problem of scarcity of energy, which is the major threat of present world. Humans can generate approximately 150W of power while riding bicycle. However, this power goes waste without any use. If we can make use of this energy, we would be able to power many electronic devices. A dynamo or an alternator can be used for harvesting the energy generated by a cycle rider while riding. We can charge mobile phones or a small lighting device with this power. People use bicycles as the main medium of transportation in villages. In addition, in cities, where most people use exercise bikes, the energy can be productively used to power electronic gadgets, which require less power. In India, many of the villages are still without electricity and most of them use bicycle as their medium of transportation. In such places, our system will be of great help.

Renewable energy is rapidly gaining importance as an energy resource as fossil fuel prices fluctuate. One of the most popular renewable energy sources is solar energy. Installing residential solar panels for our home can bring big financial benefits, especially in the form of permanently reduced energy bills. It is probably the most reliable form of energy available everywhere and to everyone, unlike other sources. With dwindling supplies of petroleum, gas and coal, tapping solar energy is a logical and necessary course of action.

II. ELECTRIFIED INDIA

In reference to the report [1], number of Towns and Villages Electrified in India by IIFL, even after 65 years of independence 17.7 percent of India is still in dark during nights. All the 5161 towns in India are electrified, i.e. cent percent in the case of towns. However, in India villages are more than towns and development of India is only possible by the development of those villages. Out of 593732 villages in India only 488439 villages are electrified, i.e. 105293 villages are un-electrified. Andhra Pradesh, Goa, Kerala, Punjab, Tamil Nadu, Haryana, and Delhi are the few of the states that are 100% electrified. Arunachal Pradesh, Bihar, Jharkhand, Orissa, Meghalaya and Tripura are the states where less than 60% of the villages are electrified. The worst situation is in Jharkhand where only 31.1 %villages are electrified. The consumption of electricity in the country is increasing at the rate of 10% per year. The energy usage has been increasing through years, but there has been not enough increase in the production. In the case of electricity, this leads to load shedding and increase in prices.

III. TURNING SWEAT INTO WATTS

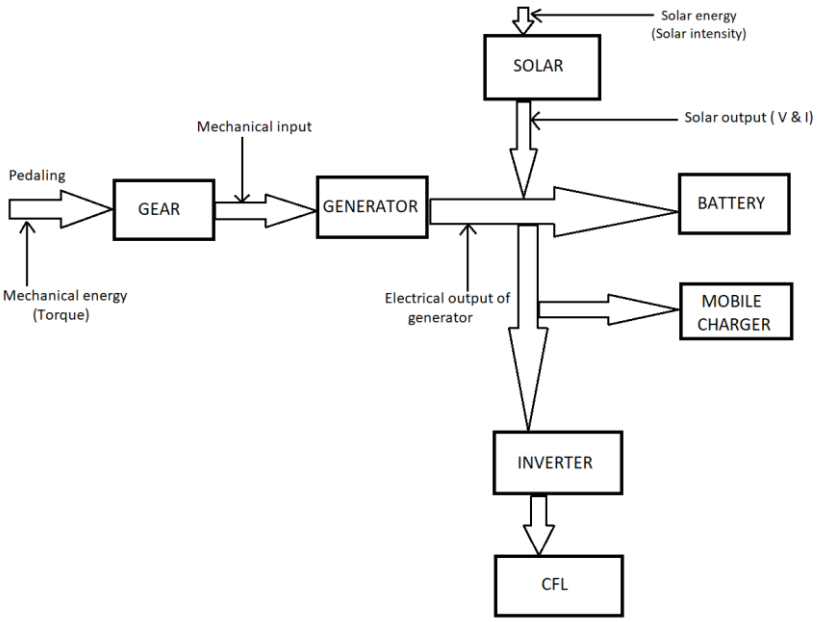
In the July-2011 [2] issue of IEEE Spectrum, a detailed study and analysis of pedal power energy generation, its usage, feasibility, and economics is presented. The power is produced from the exercise bikes used in gyms by means of a small generator. This

article presents a case where in it looks at the overall feasibility of including the pedal power technology in the mainstream. To be in the mainstream means, this technology must produce lot of power. In addition, it lists many household devices and the pedaling time required to operate each of the devices for an hour. For CFL it takes 18 minutes of pedaling. For laptops, it takes 30 minutes. For fan, it takes 1 hour. However, for cloth dryer it takes 40 hours. From this, we can conclude that power produced from such machines will not be enough for powering high-powered devices. But in our case where we want to make use of the pedal power in un-electrified villages, the scenario is entirely different.

IV. PEDAL POWER GENERATION USING BICYCLE

There are various renewable energy sources such solar, wind, hydropower etc. In addition, people use fossil fuels, which are non-renewable. These resources are very expensive. Therefore, there is a need for cheap, renewable energy source. Power generation using bicycle is very cheap and eco-friendly. The rotational energy that is generated when the tire rotates because of the application of force on the pedals can be used in two ways. This energy can also be used in dynamo/alternator, which is then converted to electrical energy. Rotational energy of the tire can be used to pump water out from the well, to drive a washing machine, to operate blender/grinder etc. These applications can be of very great use in un-electrified places. Using exercise bikes also power can be generated. Particularly for people living in cities, it is an added advantage that no separate time is needed and along with exercise, our effort will not go waste.

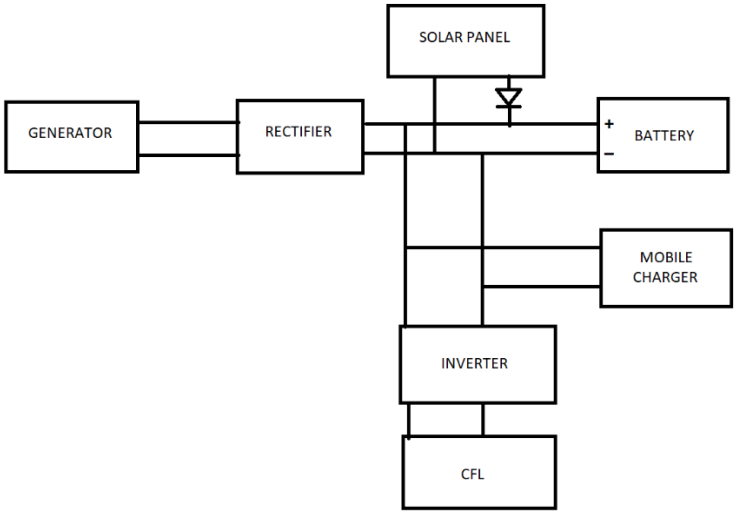
V. ENERGY FLOW DIAGRAM



VI. SYSTEM DEVELOPMENT

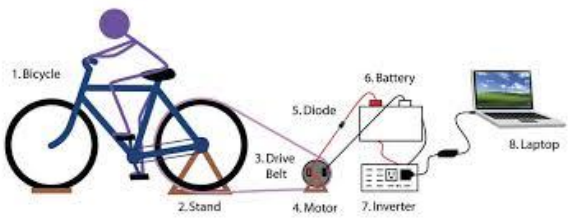
We can use the muscular or physical energy of human being which is available at any time at any place by converting it into electrical energy. The pedaling electricity Generator is primarily designed to charge a 12V battery and to supply electricity CFL via inverter (AC appliances can be used with the Human Power Generator by using a DC-AC inverter) as well as to contribute to a 12V mobile charging system. There are three system of operation in the project including 12V power generation to the battery and tapping the supply from battery to the mobile charging system, to the CFL via inverter circuit. Moreover, the renewable source of energy has also been utilized. Renewable energy is rapidly gaining importance as an energy resource as fossil fuel prices fluctuate. Solar energy can be used to generate electricity with the help of solar generation system. Installing residential solar panels for our home can bring big financial benefits, especially in the form of permanently reduced energy bills. Solar energy is virtually inexhaustible.

A. BLOCK DIAGRAM



B. DESIGN OF BIKE-POWERED ELECTRICITY GENERATOR

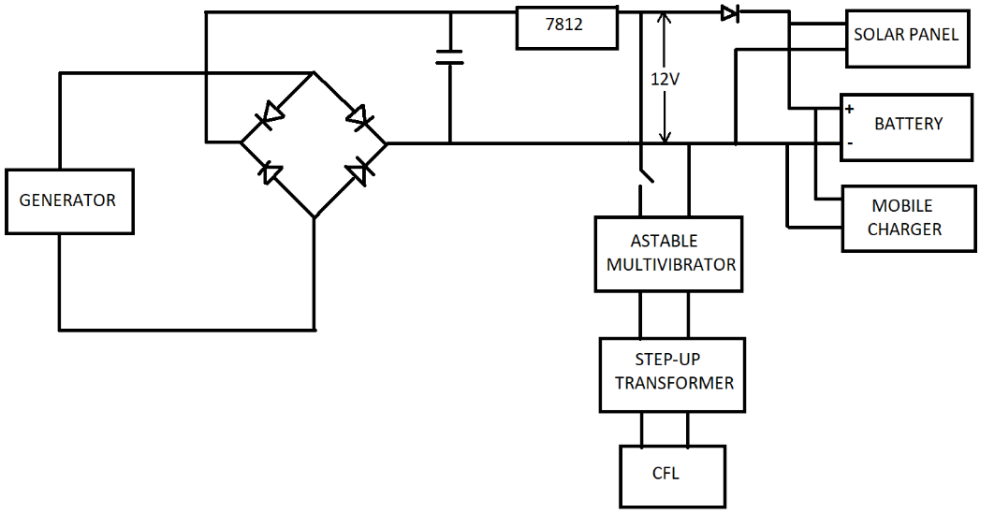
The intention of this paper is to build a straightforward human powered generator from a used bicycle and to use it to power light bulbs, blenders, cell phones, laptops, and other small appliances. Following is the general design procedure of the single bike electricity generator.



In our design:

a. Use of PMDC motor on just moving the shaft by pedaling produces electricity.
b. Use of inverter so that both AC and DC equipment's can be used.
c. Use of solar panel so that bicycle can be used in stationary condition.
d. Use of dry cell battery for storing energy and weight consideration of bicycle.
e. Voltage controller circuit for limiting fluctuating current of motor.

C. CIRCUIT DIAGRAM OF BICYCLE GENERATOR

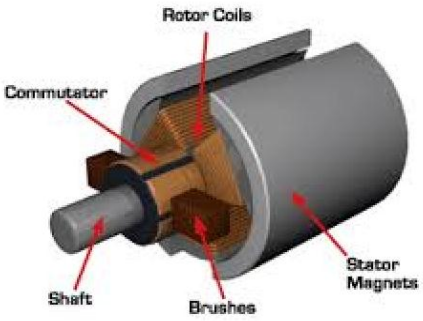


D. EQUIPMENTS USED IN THE BICYCLE GENERATOR

Sr. No	Equipment's	Specification	Quantity
1	PMDC motor	12V, 200 rpm	4 no.
2	Battery	12V, 2.5 amps	1 no.
3	Solar Panel	5W	1 no.
4	CFL	3W	1 no.
5	Inverter Circuit	12V	1 no.
6	Voltage Controller Circuit	IC7885, 5V	1 no.
7	Bicycle		1 no.

1. PMDC MOTOR

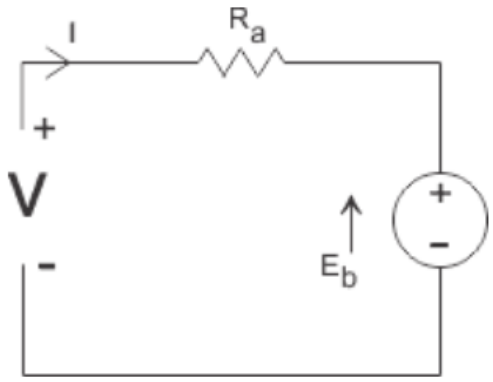
In a DC motor, an armature rotates inside a magnetic field. The basic working principle of DC motor is based on the fact that whenever a current carrying conductor is placed inside a magnetic field, there will be mechanical force experienced by that conductor. A PMDC motor is a type of DC motor that uses a permanent magnet to create the magnetic field required for the operation of a DC motor.



1.1 Working Principle of Permanent Magnet DC Motor or PMDC Motor

The working principle of PMDC motor is just similar to the general working principle of DC motor. That is when a carrying conductor comes inside a magnetic field, a mechanical force will be experienced by the conductor and the direction of this force is governed by Fleming's left hand rule.

1.2 Equivalent Circuit of Permanent Magnet DC Motor or PMDC Motor

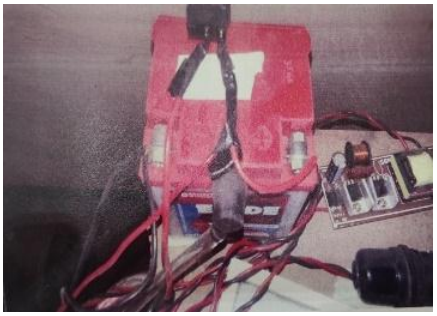


The voltage equation of the motor is given by,

$$V=IR+Eb$$

Where, I is armature current and R is armature resistance of the motor, Eb is the back emf and V is the supply voltage.

2. LEAD ACID BATTERY

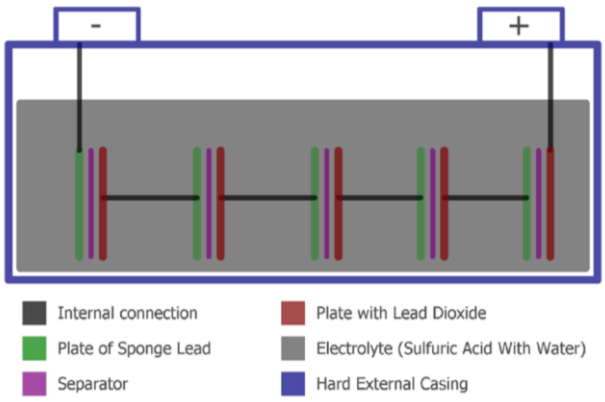


2.1 Specifications

Specific energy	35-40 Wh/kg [3]
Energy density	80-90 Wh/L [3]
Specific power	180 W/kg [4]
Charge/discharge efficiency	50-95% [5]
Energy/consumer-price	7(sld) to 18(fld) Wh/US$[6]
Self-discharge rate	3-20%/month [7]
Cycle durability	<350 cycles [8]
Nominal cell voltage	2.1 V [9]
Charge temperature interval	Min. -35 °C, max. 45 °C

2.2 Construction of Lead Acid Battery

Lead is a chemical element (symbol is Pb and the atomic number is 82). It is a soft and malleable element. So, a battery, which consists of Lead and anhydrous plumbic acid, is called as Lead Acid Battery. A Lead Acid Battery consists of the following things, we can see it in the below image:



A Lead Acid Battery consists of Plates, Separator, Electrolyte and Hard Plastic with a hard rubber case. In the batteries, the plates are of two types, positive and negative. The positive one consists of Lead dioxide and negative one consists of Sponge Lead. These two plates are separated using a separator which is an insulating material. This total construction is kept in a hard-plastic case with an electrolyte. The electrolyte is water and sulfuric acid.

3. SOLAR PANEL

Photovoltaic solar panels absorb sunlight as a source of energy to generate direct current electricity. A photovoltaic(PV) module is a packaged, connected assembly of photovoltaic solar cells available in different voltages and wattages.

The most common application of solar energy collection outside agriculture is solar water heating systems.[10]

3.1 Specifications

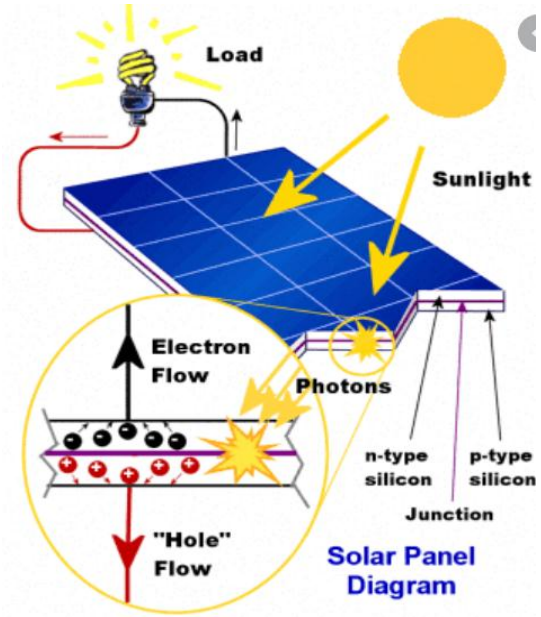
Dimension- 205mm x 195mm

Weight- 2.5 kg

Output- 5W

3.2 Working Principle

Solar panels work by absorbing sunlight with photovoltaic cells, generating direct current (DC) energy and then converting it to usable alternating current (AC) energy with the help of inverter technology. AC energy then flows through the home's electrical panel and is distributed accordingly.



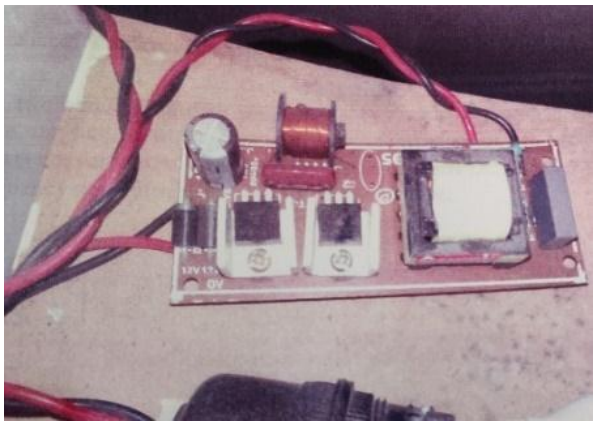
4. CFL (compact fluorescent lamp)

A compact fluorescent lamp (CFL), also called compact fluorescent light, energy-saving light, is a fluorescent lamp designed to replace an incandescent light bulb. A CFL has a higher purchase price than an incandescent lamp, but can save over five times its purchase price in electricity costs over the lamp's lifetime.[11] Like all fluorescent lamps, CFLs contain toxic mercury[12] which complicates their disposal. In many countries, governments have banned the disposal of CFLs together with regular garbage.

4.1 Principle of operation

The principle of operation remains the same as in other fluorescent lighting: electrons that are bound to mercury atoms are excited to states where they will radiate ultraviolet light as they return to a lower energy level; this emitted ultraviolet light is converted into visible light as it strikes the fluorescent coating. White LED lamps now compete with CFLs for high-efficiency lighting,[13] and General Electric is stopping production of domestic CFL lamps in favor of LEDs.[14]

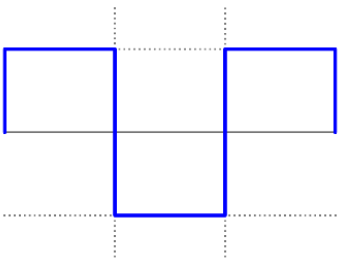
5. Inverter Circuit



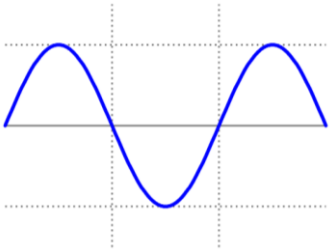
A power inverter, or inverter, is a power electronic device or circuitry that changes direct current (DC) to alternating current(AC).[15] The applications of DC involves several small types of equipment like solar power systems. Direct current is used in many of the small electrical equipment such as solar power systems, power batteries, power-sources, fuel cells because these are simply produced direct current.

5.1 Output waveform

An inverter can produce a square wave, modified sine wave, pulsed sine wave, pulse width modulated wave (PWM) or sine wave depending on circuit design.



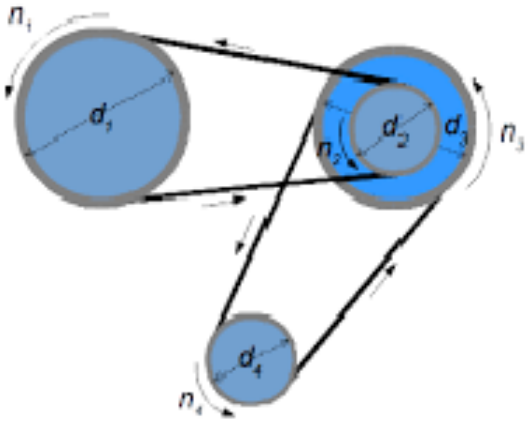
Square wave



Sine wave

VII. PERFORMANCE ANALYSIS

1. Mechanical Input Power



Single Belt Transmission- one driving and one driven pulley

For a system with two shafts and two pulleys- as indicated with pulley 1 and 2 in the figure above:

d1n1=d2n2 (1)

where

d1= driving pulley diameter (inch, mm)

n1= revolutions of driving pulley (rpm-rounds per minute)

d2= driven pulley diameter (inch, mm)

n2= revolutions of driven pulley (rpm- rounds per minute)

Equation (1) can be transformed to express the

Revolution of Driven Pulley

n2 = d1 n1 / d2 *(2)*

Revolution of Driver Pulley

n1 = d2 n2 / d1 *(3)*

Diameter of Driven Pulley

d2 = d1 n1 / n2 *(4)*

Diameter of Driver Pulley

d1 = d2 n2 / n1 *(5)*

Multiple Belt Transmission Systems

For a system a with three shafts and four pulleys - as indicated in the figure above:

$n2 = n3$ *(6)*

$n4 = n1 (d1*d3) / (d2*d4)$ *(7)*

Here,

d1= 18cm

d2= 9.5 cm

d3= 60 cm

d4= 6.5 cm

n4= n1(18*60) / (9.5*6.5)

200= n1(18*60) / (9.5*6.5)

As n2 = n3

n1= (200*9.5*6.5) / (18*60)

n1=11.44 rpm

Speed required to the driver pulley is

n1=11.44 rpm

Force input = mass*9.8

= 50*9.8

= 490 N

Torque on pedal = f *d

= (mg)*0.17 m

= (50*9.8) * 0.17 m

= 83 Nm

Power = $T*\omega_m$

= 83* (11.44* 2π/60)

= 83* (1.18 rad/ sec)

= 97.29 joule/s

2. Charging Time of Battery

Charging current capacity is purely dependent on the battery capacity.

Charging time of battery = battery Ah/Charging current

T=AH / A

Where,

T= charging time

Ah= battery rating

A= charging amperage

As for the battery we are using 2.5 Ah batteries

First, we will calculate charging current for 2.5 Ah battery

As we know that charging current should be 10% of the Ah rating of battery

So, charging current for 2.5Ah battery = 2.5*(10/100)

= 0.25 Amps

But due to losses, we can take 0.25 to 0.34 Amps for charging purpose

Suppose we took 0.3 Amp for charging purpose,

Then charging time for 2.5 Ah battery = 2.5/0.3

= 8.33 hrs.

But this was an ideal case

Practically this is noted that 40% of losses (in case of battery charging)

Then 2.5*(40/100) = 1 (2.5 Ah * 40% of losses)

Therefore, 2.5+1= 3.5 Ah (2.5 Ah + losses)

Now charging time of battery = Ah/charging current

= 3.5/0.3

= 11.66 or 12 hrs. (in real case)

Therefore, a **2.5Ah** battery would take **12Hrs** for completely charging (with 0.3A charging current)

3. Discharging time of battery under load

Discharging time of the battery is given by the following expression

Td= Battery rating * Battery Volt / Applied load

As for our battery rating is given as 2.5 Ah and the working voltage is 12 V and the applied load which is a CFL bulb of rating 3 Watt

We have the following solution

Td= (Battery Ah * 12 V) / 3 Watt

= 10hrs

(with 40% loss at maximum = 10*(40/100)

= 4 hrs.

For sure, the backup will last up to 4 hrs.

Load= 3W, Battery rating = 12V, 2.5 Ah

VIII. CONCLUSION

At a time when there is energy crisis casting its shadow all over the world, one must investigate alternate renewable energy resources. One such alternate way to generate power is presented in this paper. The rotational energy of the tires in the bicycle, generated by pedaling can be used to operate small powered devices. We can use the muscular or physical energy of human being which is available at any time at any place by converting it into electrical energy by means of pulley arrangement to fulfill our preliminary requirement of electricity.

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