Energy Generation Through Footsteps: An approach for sustainability

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Abstract

Power and energy are two very important needs of humans in day-to-day life. With the increase in population, electrical energy consumption is increasing and the resources are depleting at a much faster rate. As most of resources are conventional in nature, so now a day the idea of electricity generation from renewable resources is growing around the globe. Energy generation from renewable energy resources is very costly and huge investment and time is needed to start the plant. To overcome this problem present study proposes a new approach for electricity generation through footstep. This is based on the concept of regeneration. This, a device is made to utilize the energy, which is wasted while walking. If this is compared to conventional systems, it is very useful, easily accessible and ecofriendly.

Keywords: Energy, Footsteps, Sustainability, renewable source.

1. Introduction

With the increase in use of large non-renewable energies such as fossil fuel, the world is facing an energy crisis as these non-renewable energies will decrease and vanish as a result in a minimum of a few decades or a few centuries. To overcome the issues of increased energy prices and carbon emissions, most of the government agencies and technical companies are focusing on use of non-conventional resources for power generation [1]. For this purpose, solar panels, wind turbines and hydro power plants are used to produce electrical energy. But there is a need to come up with new ideas to harvest energy from our day-to-day activities. When a person steps on road, his body weight is transferred on the road and this cause waste of energy in the form of heat, friction and sound. In order to use and convert this energy into useful form, we have made an electricity-harvesting device. When a pedestrian has over it, the person's weight induces the top plate's downward movement. With the aid of a rack and pinion system, this linear plate movement is transformed to rotational motion and then used to rotate the dynamo shaft. The electricity generated will be stored in a battery and can be used for lighting the building [2]. When the device is overcrowded, then more electricity will be produced. So this concept can be very beneficial, if it is found in crowded places where constant movement is taking place such as train stations, town footpaths and shopping malls etc.

2. Literature Review

The use of traditional forms of power production, such as coal burning, biomass, diesel (generators) etc., is rapidly depleting our natural resources, such as fossil fuels, which is the demand for electricity that has
exceeded the supply because of the growing population. In addition to pollution caused by traditional methods, the consequences of deforestation are global warming, power shortages such as the one we face at Tamilnadu [3]. For producing electric power output, non-conventional energy using a foot step does not need any fuel input power. Because power generation using footstep gets its energy needs from the Non-renewable energy source. Energy from the mains is not required and there is less pollution in this energy source. It is beneficial in roads and all sorts of measures that are used to produce non-conventional energy such as electricity. Foot step energy generation can be used at high ways where are rushes of the vehicles too much thus increase input torque and ultimate output of generator. If we used this project at very busy stairs palace, then can produce efficient useful electrical for large purposes. This is applicable in street light for LED light for specific purposes or in air circulation system for room by the small fans. With the increase in population, electrical energy consumption is increasing and the resources from which electricity is generated are depleting at a much faster rate. So, the idea of electricity generation from renewable resources is gaining interest among peoples for this a device is made to utilize the energy, which is wasted while working. The device is made of special rack and pinion arrangement and this will generate approximately 3.127 MW annually with a displacement range of 0.75-1.5 inch [4]. Even if the planet doubled the amount of solar and wind power available tomorrow, there would still be a shortage of clean electricity. So need to grab energy from wherever we can find it, that is why piezoelectricity has recently begun to pick up the interest of entrepreneurs and scientists on solid materials such as crystal and ceramic in response to strain. One of the most popular uses for piezoelectricity in the past few years relies on road sand sidewalks. This present project deals with the generation of electricity through traffic pressure by placing piezoelectric generators on the roads the axial load of the traffic pressure deforms the generator and thus produces the electric energy as an output, which may use for the street lighting. After coming to Earth a few million years ago, man has been in constant need of and use of energy for his sustenance and wellbeing. Because of this, a great deal of energy was used up and wasted [5]. So for highly populated countries like India and China, the proposal for the use of foot power waste energy with human locomotion is very relevant and important in the future. We can attach a grid backup supply so that we can charge the battery from the gird in case of power shortage and the next choice is to combine the device with the solar system and form a hybrid system so that the cost storage equipment is reduced and pure clean energy is produced with high reliability. When people walk on the ground, generating electrical energy by unconventional means, some forces typically exert waste while walking. The concept is therefore to transform mechanical footstep energy that people practice into electrical energy using transducers known as the foot step generation system. In this power generating board, the kinetic energy is converted into electricity so that the daily demand for electrical energy rises and energy shortages become the root issue worldwide and traditional sources are not sufficient to meet the total demand for electrical energy [6]. The energy which is wasting as people climb the stairs. This human energy is being used and transformed into electric energy [7]. The power can be generated by walking on the stairs, it will store the power generated and it can be used for home use. The way energy is generated is
environmentally friendly and is not harmful to humans. The waste energy which is provided by humans is used in this device.

3. Energy

In physics, energy is the property that needs to be transferred to an object to perform work on—or heating—the object, and can be converted into shape, but not created or destroyed. The SI energy unit is the joule, the energy that the mechanical work of moving it 1 meter away from a force of 1 newton transmits to an object [8]. Popular forms of energy include the kinetic energy of a moving object, the potential energy produced by the position of an object in a force field (gravitational, electrical or magnetic), the elastic energy created by the stretching of solid objects, the chemical energy emitted when a fuel burns, the light-borne radiant energy and the object's temperature.

3.1 Energy: Sources

Source of energy has been grouped into conventional and non-conventional energy sources [9].

A. Energy Sources: Conventional

- Coal
- Petroleum and natural gases
- Nuclear Energy

B. Energy sources: Non- Conventional

- Solar
- Wind
- Tidal
- Geo Thermal

Conventional energy resources

Coal

It is one of the main source of conventional form of energy. It was created from the remains of the trees about 500 million years ago, and ferns flourished in swamps. The bacterial and chemical degradation of such plant debris (which remained buried under water or clay) produced an intermediate product called peat, mainly cellulose \((C_6H_{10}O_5)_n\), due to progressive heat and pressure decomposition, the cellulose lost moisture from H2 and O2 and was converted into coal according to the equation [10].

natural gases and petroleum

Oil is amalgamation of hydrocarbons, mainly alkanes, and cycloalkanes. This exists beneath the Earth's surface, embedded in rocky strata. The viscous black liquid in its crude form is known as petroleum, and natural gas is called petroleum-contact gas which flows naturally from oil wells. The composition of natural gas is a mixture of primarily methane (95.0 percent), small amounts of ethane, propane and butane (3.6 percent), and traces of
CO₂ (0.48 percent) and N₂ (1.92 percent) [12]. A liquid mixture of propane and butane can be obtained from natural gas or refining fuels, at room temperature at a pressure of 3-5 atmospheres. This is contained and shipped in 40-100-liter stainless steel cylinders. Of industrial and domestic use, crude petroleum is required of refining and purification as petrol, diesel, kerosene, lubricating oil, plastic etc. The oil reserves are located in Ganga-Brahmaputra Basin, Bombay High, Gujarat plains, Thar Desert of Rajasthan, and area of Andaman Nicobar Islands, India. Petroleum deposits are found in Saudi Arabia, Iraq, Iran, Kuwait, the USA, Mexico, Russia and so on all over the world. World oil deposits are decreasing at a much faster rate according to the current survey. The existing petroleum will be available up to a maximum of 40 years if preventive measures are not taken.

Fuel woods
For their daily cuisine, rural people need wood fuel or firewood from natural forests and plantations. The supply of firewood or fuel wood is getting difficult due to rapid deforestation [12]. This issue may be avoided by extensive afforestation (planting) on degraded forest land, cultivable waste land, barren pasture land, etc.

Hydropower
Hydro-power is known to be energy obtainable from the flow of water or water falling from higher potential to lower potential. It is a traditional and renewable form of energy which can be transmitted to a long distance through cables and wires. In India, hydroelectric power is generated in the river valley through a range of multipurpose projects, e.g. Hirakud hydroelectric power project, Bhakra Nangal project, Sardar Sarovar project, Nagarjun Sagar project [13].

Nuclear energy
A small quantity of radioactive substance (U²³⁵) through the nuclear fission process will produce much energy. For example, one ton of uranium will provide energy well beyond three million tons of coal or 12 million barrels of oil. Nuclear reactors are needed to produce nuclear power [14]. There are roughly 300 nuclear reactors around the world. India has just four nuclear (reactor) facilities. Nuclear energy can be used in the manufacture of electric energy as a fuel for marine vessels and space ships as well as heat generation in chemical processing plants. Uranium deposits are found in India at various parts of Rajasthan and the Singhbum of Jharkhand. Thorium is mined from monazite sand found in the state of Kerala. Such radioactive substances can be used in nuclear reactors to initiate energy crises because of the higher energy release trend [15]. But the radioactive substances are exhaustive, and they can be used to produce chemical weapons of mass destruction.

Energy Sources: Non-Conventional

Solar
Solar energy, a primary source of energy, is both non-polluting and inexhaustible.

There are three methods of harnessing solar energy

i. Using photo cells or photovoltaic cells or silicon solar cells to directly convert solar energy into electrical energy in solar power stations
ii. Use of photosynthetic and biological processes to trapped resources [16].

iii. Solar energy conversion into thermal energy through suitable devices that can be further converted into mechanical, or electrical energy. Solar energy is readily available and its conversion to other form of is also non-polluting in nature, so major focus should be on optimizing the use of this energy.

**Wind energy**

Air movement is due to the convection occurring in the atmosphere which is again due to the heating of the earth's surface due to solar radiation, earth rotation etc. Air motion occurs both vertically and horizontally. The average annual wind density is 3 kW/m²/day along Gujarat, central western ghat parts of India, which can indicate a seasonal variation (i.e. up to 10kW/m²/day in winter). Because wind has a huge power, its can be converted into mechanical or electrical form using suitable machines, converting it into electrical energy, which further can be used for pumping water, maize grinding, etc. [17].

**Tidal energy**

This form of energy is associated with conversion of the Ocean's tides into electrical energy. In 1966 France installed its first tidal power plant. India could take up the conversion of Ocean Thermal Energy (OTEC) and will be able to generate huge amount electricity to meet the power requirements of remote oceanic islands and coastal towns. The Netherlands is notorious for its windmills. In India, there are windmills at Gujarat and Tamilnadu [18].

**Geothermal energy**

This energy can be defined as the heat energy which can be obtained from the hot rocks contained in the crust of the Earth. At the deeper portion of the Earth's crust, the solid rock is melted into the magma due to very high temperatures [19]. The places where hot magma is concentrated at a relatively low depth are called hot spots.

**Bio-mass based energy**

Biomass is referred to as organic matter derived from living organisms such as wood, cattle dung, sewage, agricultural waste, etc. Such substances can be burned to generate heat energy that can be used to generate electricity [20]. Thus the energy generated by biomass is known as biomass oil.

4. **Energy Demand in India**

Indian primary energy use is the third largest after China and the USA with a 5.3 percent global share in 2015[21]. Total primary energy consumption from crude oil (27.91%), natural gas (6.50%), coal (58.13%), nuclear power (1.23%), hydroelectric power (4.01%), and renewable energy (2.21%) [22]. India's net imports were nearly in 2013: crude oil 144.3 mt, LNG 16 mt and 95 mt of coal 255.3 mt, equivalent to 42.9 percent of total energy feeding. India is increasingly dependent on fossil fuel imports to meet its energy demand by 2030, India's energy import dependence is expected to exceed 53 per cent of the country's total energy consumption [23]. By fast economic growth, India establish among world's fast developed energy market, and is anticipated
second largest contributor to world energy call by 2035. Utility power plants have an installed capacity of 314.64 GW as of 2017 [24] (refer table 1). There are sets of about 75,000 MW of combined diesel generator capacity with unit sizes ranging from 100 KVA to 1000 KVA however. Electricity consumption in India during fiscal year 2015-16 is nearly 1075 kWh per capita.

Table 1: Installed Power Capacity

<table>
<thead>
<tr>
<th>Sector</th>
<th>Power capacity (MW)</th>
<th>Share (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>State units</td>
<td>10,246.53</td>
<td>33.00</td>
</tr>
<tr>
<td>Central units</td>
<td>76,982.26</td>
<td>25.00</td>
</tr>
<tr>
<td>Private units</td>
<td>130,559.49</td>
<td>42.00</td>
</tr>
<tr>
<td>Total</td>
<td>310,005.28</td>
<td></td>
</tr>
</tbody>
</table>

5. Energy Generation from footstep

Walking is the most prevalent practice of the day. When a person walks, in the form of impact, vibration, sound, etc., during each step, he / she loses energy to the road surface due to the transfer of his / her weight to the road surface, dropping down on the ground by foot. This energy can be extracted and converted in the usable form, like electrical energy. A method for generating electricity from a pedestrian was planned to develop a technique for harnessing step energy from foot. This device, if installed in the footpath, will turn foot impact energy into electric form. The working theory is simple; if there is a pedestrian step on top of the device, the plate will slightly dip down due to the weight of the pedestrian [25]. The top plate returns to its original position thanks to the negating spring installed in the system. When the battery reaches its maximum capacity the lamp will light up automatically. The flashlight stayed lighted until the battery lapsed. Nonetheless, if there is continuous pedestrian motion over the unit, the bulb may be kept lighted continuously. The power generated by the footsteps may be stored in an energy storage system. The top plate of this system is mounted on a shaft, which welds the chain (which acts as a rack) and springs. Chain links are engaged with sprocket teeth (this mechanism acts like a rack and pinion arrangement) and sprocket shaft is connected to the dynamo shaft through a chain link mechanism. Due to its body weight, a slight downward displacement of the plate may occur when a person steps onto the top plate of the unit. The plate is pushed back to its initial position because of the force of spring when the person moves on and takes off his step. Using a special combination of rack and pinion, the linear reciprocating motion is transformed into rotational motion. The rotational motion of the sprocket shaft rotates the dynamo shaft and creates stress. The voltage is stored in condenser for further use.

Components Used

1. Frame
2. Shaft
3. Dynamo
4. Sprocket and chain
5. Spring
6. 5 watt LED

Mechanism for energy generation

Rack and pinion system is a type of linear actuator comprising a pair of gears that converts rotational movement into linear movement. The movement applied to the sprocket causes the thread, up to its travel limit, to move sideways. This system offers minimum backlash and feedback, and senses the use of a variable rack to enhance vehicle reaction and feel steering, especially at high speeds, and has been adapted to the generation system; an adapted version of net-shape hot-presses forging is utilized to produce the racks in final shape. For every pair of conjugate involute profiles there's a simple rack. Figure 1 demonstrate the outline of mechanism for energy generation through footsteps.

![Figure 1: Circuit Diagram](image)

The basic rack is the profile of the conjugate gear of the infinite pitch radius. A generating rack is a rack outline used to construct a generating system, such as a gear shaper cutter, to show the size and dimensions of the tooth. The pushing power is converted to electric power by proper driving arrangement. Chain and sprocket arrangement, spring is fixed at the inclined step. The spring is utilized by removing the load in the same position to return the inclined step. The pinion shaft is attached to the supporter via end-bearings. The larger sprocket is also combined with the pinion shaft, so the same small sprocket speed is operated to increase the number of dynamo rotations. The larger sprocket is combined with the small diameter sprocket, with chain support. The larger sprocket helps to pass the rotational energy to the smaller sprocket. This system will be very helpful to generate energy in crowded areas like shopping complex, educational universities, busy industry etc. This non-conventional way of producing power provides a path to fulfill future energy demands.

6. Conclusions

During extensive literature review it is observed that, the research carried out are all related to energy harvesting device from human footsteps and scope of improvements. Design research methods like product
study, market study, user study and ethnography helped in knowing the existing technology to harvest human footstep energy, who are the competitors. Concept was produced by addressing issues such as health, ergonomics, streamlined process, aesthetics, and cost. Mock-up model developed, to understand the features and feasibilities of the product and user’s feedback found satisfactory. Working prototype developed as a proof of concept to harvest energy from human footsteps. In future aspects, present study will be used in speed breakers at high ways where rushes of the vehicles are too much thus increasing input torque and ultimate output of generator. This process can also be applicable at very busy stairs palaces to produces huge amount electricity.

REFERENCES


