Paper ID: ET-13

Feasibility Analysis of Electricity Generation by Combining Solar and Piezoelectric Technology in Jashore, Bangladesh

Md. Fahim Shahriar[1'a)], Md. Nayeem Hasan Khan[1, b)],Khodadad Mostakim[1, c)], Swapnil Das[1, d)], Md. Hasan Ibna Islam[1, e)] , Safwan Bin Jahangir Chowdhury[1,f)]
[1]*Rajshahi University of Engineering & Technology, Kazla, Rajshahi-6204, Bangladesh*
Email: [a]*fahimshahriar9873@gmail.com,* [b]*nayeem.utsho@gmail.com,* [c]*khodadadmostakim@gmail.com,*
[d]*swapnil1502025@gmail.com,* [e]*safwanchy01@gmail.com,* [f]*tanvir6510@gmail.com*

Abstract

Due to the advancement of science and technology in the last few decades, electricity is highly integrated in our everyday lives. But many of the regions in Bangladesh haven't received electricity supply as they are located in the remote parts of the country. Thus, it is incumbent upon us to adopt renewable and clean energy technology to provide electricity in the rural parts where there is no electricity supply yet. This paper presents a feasibility study of using solar energy combined with harvesting walking energy by piezoelectric technology in Abdulpur, Jashore. As solar energy can only be utilized during daytime, introducing piezoelectricity will be a complete power generation solution. Feasibility analysis shows, about 28 Bangladesh Taka (BDT) can be saved per day and the cost of setting up this system would be pay backed within 13 years. This system will prove to be economically feasible with environmental benefits as well.

Keywords: solar energy, piezoelectric technology, rural area.

1. Introduction

Since the dawn of time we have been mostly dependent on the nonrenewable energy resources for generating electricity. But with the rapid development of society, the energy consumption is growing exponentially which consequently leads to the continuous depletion of fossil energy. The world electricity demand will increase by almost 80% during the period of 2012-2040 in the (IEA) International Energy Agency's New Policies Scenario [1]. This electricity demand serves as an incontrovertible proof of our dependence on electricity. But unfortunately, there are still various regions in Bangladesh where there is no electricity supply.

Thus, harvesting clean and renewable energy for continuous electricity supply in rural areas has been the focus of energy research in the last few decades. Solar energy is the most prevalent energy source in Bangladesh. But the problem associated with solar energy is that it can only be utilized during day time. Thus, there exists a need for another way of generating electricity. In this context, utilization of piezoelectric materials can prove to be a felicitous choice due to their inherent ability to produce electricity when placed under mechanical stress. The main factors that effect on piezoelectric technology usage are output power per step, battery storage, cost, consumption facility, number of users, distribution of high frequency walking areas and the method of utilizing this technology to get the optimal saving energy results [2]. The prospect of kinetic energy harvesting, is concerned with converting walking, mainly in form of vibrations, into electrical energy. Walking is the main motion in normal human lives, hence, can be considered as an economical energy harvesting approach [3,4]. For feasibility study Waynergy floor technology will be considered which can generate up to 10W on each footstep. A 300-Watt solar panel build with polycrystalline silicone material is considered for utilizing solar energy.

This paper aims to facilitate using of renewable energy technology (combining solar energy with piezoelectric technology) by conducting a feasibility study where the considered area is Abdulpur, Jashore. This study shows that utilizing piezoelectric energy harvesting floor is feasible and can serve as a great source of electricity generation when there isn't any solar energy available during night time. Proper research and development on our proposed system will have a profound impact on the future of providing electricity at remote locations.

2. Insight into our proposed system

Before providing a brief insight into our proposed system it is imperative to mention the area to be considered for our proposed system. Even though piezoelectric system isn't dependent on the considered area, solar energy is highly dependent on it due to irradiation and other factors.

Choosing the area

Abdulpur, Jashore is considered for the implementation of our proposed system. The location is shown below on Fig. 1.

Fig. 1. Location of Abdulpur, Jashore

Abdulpur is a rural part of Bangladesh where the technology is still lagging far behind than rest of the country. There is no electricity supply to a huge portion of the residents in Abdulpur. This brings out the need for adopting renewable energy to supply the electricity demand in Abdulpur. A brief insight into Abdulpur was collected from Global Solar Atlas and shown below on Table 1.

Table 1. Information about Abdulpur

Site Name	Abdulpur, Jashore, Khulna, Bangladesh
Latitude	23.083300°
Longitude	89.166700°
Altitude	9 meters above sea level
Air temperature [°C]	Around 26 – 30 °C
Global horizontal irradiation [kWh/m^2]	1709 per year (4.682 per day)
Direct normal irradiation [kWh/m^2]	1060 per year (2.904 per day)
Diffuse horizontal irradiation [kWh/m^2]	958 per year (2.625 per day)
Global tilted irradiation [kWh/m^2]	1817 per year (4.978 per day), for surface tilted at 23° facing 180°

It can be seen from Table 1 that Abdulpur has solar irradiation necessary for solar energy generation. Thus, utilizing solar energy can prove to be a felicitous choice. However high installation cost needed for setting up multiple solar panels is a problem encountered in Abdulpur. This problem can be mitigated by using low cost piezoelectric technology along with solar energy.

Selection of piezoelectric technology and solar panel

For the calculation of energy harvesting by piezoelectric technology the chosen energy harvesting floor was of Waynergy technology. Information of piezoelectric energy harvesting floor by Waynergy technology is shown in Table 2 [5].

Table 2. Information about Waynergy energy harvesting floor

Product dimension	0.4 meter × 0.4 meter
Generated energy	10W per step
Price in Bangladeshi Taka (BDT)	Around 20500 BDT
Estimated Lifespan by years	20 years

Energy can be directly consumed or stored by using this type of energy harvesting floor. The current generated can thus be used for light, fans or other household devices. Energy storage is also possible for later use.

The solar panel used for calculation was a 300-Watt solar panel build with polycrystalline silicone material.

Methodology

The proposed system combines piezoelectric technology along with solar energy for optimum power generation at minimum cost. The schematic diagram of our proposed system is shown on Fig. 2.

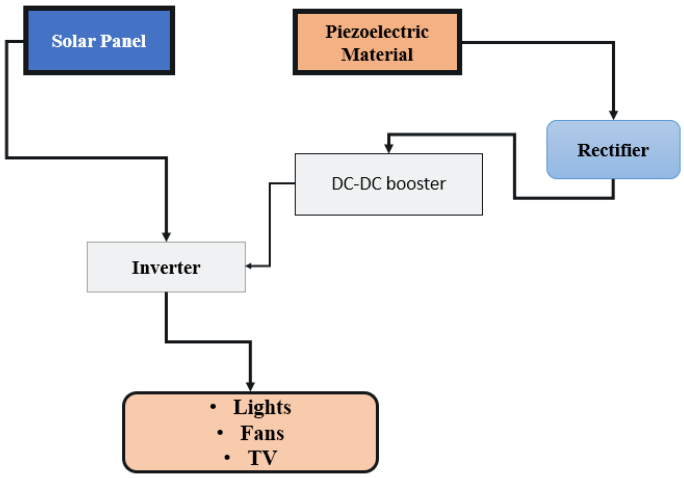

Fig. 2. Proposed Methodology

The generated current from solar panel will be in the form of direct current (DC) which is passed through an inverter to generate alternating current (AC). The current generated from piezoelectric materials will be in AC form. However, the generated current is highly unstable and must be converted into a much more stable condition. Thus, a rectifier can be used to generate DC current which can be boosted by using a DC-DC booster. The generated current will then be flown through an inverter to obtain AC current. The combined current obtained from piezoelectric tiles and solar panel will then be used to power household appliances like fan, light etc. It can be noted that energy can be directly consumed or stored (by using a battery) in the proposed system. The current generated can thus be used for light, fans or other household devices. Energy storage is also possible for later use.

3. Feasibility analysis

For calculating the feasibility analysis, a house with 4 lights, 2 ceiling fans and an 18-inch black and white TV is considered only. The total energy needed in a day is shown in Table 3.

Table 3. Total energy needed for a typical house in Abdulpur, Jashore

Equipment	Quantity	Used time per day in hours	Power for 1 equipment (in Watt)	Total energy needed (Watt-hour)
Lights	4	10	20	800
Ceiling Fans	2	18	55	1980
18 inch black and white TV	1	4	80	320
Total				**3100**

It can be noted that the average equipment may vary based on the occupants of the house. However, it will be around 3100 Watt-hour or 3.1 kWh on a typical house of four occupants. The total energy will be supplied by using a solar panel and piezoelectric tiles.

Energy generated in a Solar panel per day

The formula for energy generation by a solar panel per day is,

Energy(kWh) = Area (m^2) × Solar panel efficiency × Solar radiation on tilted panels (kWh/m^2) × Performance coefficient (1)

= 1.957 × 0.992 × 4.682 × 0.18 × 0.75 = 1.23 kWh

The remaining energy needed is (3.1 – 1.23) kWh = 1.87 kWh. The remaining energy should be supplied by piezoelectric tiles (using Waynergy technology).

Energy generated in piezoelectric panel per day

The piezoelectric tiles were installed on the main corridors and in front of doors, then sub corridors as they are the area with most footfall. The total footfall per day was considered to be 70.
Now, total energy generated by 1 piezoelectric tile per day = 10 watt × 70 = 700 watt-hour or 0.7 kWh/day
So, to generate 1.87 kWh per day required number of tiles will be = (1.87 ÷ 0.7) = 2.67 or 3 tiles.

Savings per day

Total energy generated by our proposed system per day is = Energy generated by solar panel + energy generated by piezoelectric tile = (1.23 + 3 × 0.7) = 3.33 kWh/day or 3.33 Unit.
According to Dhaka Electric Supply Company limited (DESCO) the industrial electric line cost 8.50 BDT/unit. So total savings per day is 28.305 BDT per day.

4. Payback Period

The total cost is shown in Table 4.

Table 4. Total cost

Material	Quantity	Price (BDT)
Piezoelectric tiles	3	61,500
Solar PV Panel	1	20,895
Inverter	1	30,785
DC-DC booster	1	320
Rectifier	1	220
Battery	1	20,000
Total		**1,33,720**

So, the total payback period = (133720 ÷ 28.305) = 4724.25 days or around 13 years.

5. Conclusion

This paper provided an insight into generation of electricity by combining piezoelectric system with solar energy system to provide electricity at rural places like Abdulpur, Jashore, Bangladesh. The feasibility analysis of the system can serve as an incontrovertible evidence of the proposed system energy saving (3.33 kWh per day) for one house. The concept of combining clean energy harvesting technologies to generate is not so familiar from the perspective of Bangladesh. So, this system would take the utilization of energy to the next step and help researchers for further development of the system.

6. References

[1] Scenario, N. P., M. East, and P. Cedex. "World energy outlook 2014 factsheet." Paris: International Energy Agency (2015).
[2] Elhalwagy, Adnan & Ghoneem, Mahmoud & Elhadidi, Mohamed. (2017). Feasibility Study for Using Piezoelectric Energy Harvesting Floor in Buildings' Interior Spaces. Energy Procedia. 115. 10.1016/j.egypro.2017.05.012.
[3] Gorlatova, M., et al. Movers and shakers: Kinetic energy harvesting for the internet of things. The 2014 ACM international conference on Measurement and modeling of computer systems. 2014. ACM.
[4] Donelan, J.M., V. Naing, and Q. Li. Biomechanical energy harvesting. in Radio and Wireless Symposium, 2009. RWS'09. IEEE. 2009. IEEE.
[5] Rodrigues, João André da Costa Coimbra. Waynergy: The way for energy harvesting: Business model design. Diss. NSBE-UNL, 2011. http://utenportugal.org/wp-content/uploads/Waynergy-The-way-for-energy-harvesting.pdf