ASSESSMENT OF POTENTIAL ENVIRONMENTAL BENEFITS OF USING SOLAR POWER FOR IRRIGATION PUMP: A CASE STUDY IN BANGLADESH

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ABSTRACT

Energy crisis is one of the major problems in Bangladesh. 20.36 % of the total generated energy is utilized for peak irrigation, when the whole country faces an acute energy crisis due to load shedding of 1248 MW. Present pumps are mostly diesel engine operated where electricity from the national grid is not sufficient to maintain them properly. Due to declined fuel availability and the price volatility caused by demand-supply gap, the attention must be centered towards renewable, readily available and non-polluting source like solar energy, which is abundant in Bangladesh. The current study considers Dhaka-Keranigonj area for the solar system based irrigation system. We choose Boro rice, which is grown during mid-January to late April , and is themost practiced crop in Bangladesh. This study focuses on the availability of solar energy in different zones of Bangladesh on the basis of daily solar radiation data, comparison of the irrigational pump systems on the basis of green house gas (GHG) operational emissions for identifying most suitable energy option for irrigation. This study is an effort to provide appropriate technology to environmentalists and policy makers to formulate control strategy of using solar power for irrigation pump in Bangladesh and take appropriate measures to minimize degradation of environment caused by other methods.

Keywords: *Irrigation; renewable energy; solar system; GHG emission*

1. INTRODUCTION

In Bangladesh, adaptation of irrigation techniques is reported to play a vital role in the improvement in the field of food grain resulting in the need of a remarkable number of pumps in rural areas of the country for irrigation in upcoming days. Present pumps are mostly diesel engine operated, where electricity from the national grid is not sufficient to maintain them properly. On the other hand, there is a great problem for grid connected irrigation pumps because supply of electricity in Bangladesh is not regular due to deficiency of electrical energy and electricity has not served in every irrigational zones of Bangladesh. Shortage of energy in Bangladesh is acute (Karjokrom, 2013). 20.36 % of total energy generated is utilized for peak irrigation (Karjokrom, 2013). Total generation capacity of energy is 8275 MW, which is 86.90 % of total requirement (Bureau of Statistics, 2011). It is roughly estimated that the number of diesel engines in Bangladesh is more than 700,000, among which 200,000 are grid supplied electric pumps which consume 1685 MW electricity while on operation (Bureau of Statistics, 2011). During peak irrigation the whole country faces an acute energy crisis due to load shedding of 1248 MW (Bureau of Statistics, 2011).

There are 68,000 villages in Bangladesh, and each village has at least 10 irrigation farms. Every year we have to import 27,29,477 metric ton JP-1, kerosene, petrol, octane and diesel are 11,81,097 metric ton of crude oil, total 39,10,574 metric ton which produces 186,69,460 metric ton of CO_2 (Bureau of Statistics, 2011), impacting the economy at a great extent (Haque, 2001). CO_2 is a known GHG and general index to indicate the extent of GHG emissions. Both diesel and grid operated pumps are generating huge amount of GHG which is very detrimental for the existence of our environment. Conventional irrigation system is dependent on fossil fuel or hydro carbon which is finite in nature. Moreover, burning of fossil fuel/hydrocarbon causes GHG emission, which is mainly responsible for climate change in the earth. This is right juncture to think the alternative, renewable, green energy like solar energy which is abundant in nature. Bangladesh Energy Policy aims to achieve 5 % Renewable Energy of total energy by 2015 when total power generation will hit 13,000-14,000 MW and 10% Renewable Energy by 2020 when the total power generation will hit 22,000 MW.(Power

Division, Ministry of Power, Energy and Mineral Resource, Government of the Peoples Republic of Bangladesh, 2008)

Bangladesh is situated between 20.30 and 26.38°N latitude and 88.04 and 92.44°E longitude, which is an ideal location for solar energy utilization. Daily global solar radiation varies between 5 and 7.5 KW-hr/m^2/day. Solar PV technology is an important emerging option for electricity generation. So, densely populated tropical country like Bangladesh could be electrified by PV grid system using the inexhaustible and pollution free solar energy. Compensation of electricity shortage and reduction of CO_2 emission would be done by introducing solar energy sources for electricity generation in mass scale (International Institute for Sustainable Development, 2012).

Introduction of solar energy for irrigation is observed in various places of Bangladesh like Tangail, Chapainawabganj, and Naogaon. This study is an effort to provide appropriate technology to environmentalists and policy makers to formulate control strategy of using solar power for irrigation pump in Bangladesh and take appropriate measures to minimize degradation of environment caused by other methods.

The main objective of the study is to make a feasibility study on the potential environmental benefits of using solar power for irrigation pump in Bangladesh.

2. METHODOLOGY

The current study will consider Dhaka-Keranigong area for the solar system based irrigation system, run by BUET. The current study will consider Boro rice which is grown during mid-January to late April. Boro is selected because of its crop-water requirement is high in comparison to wheat (6:1) (Islam, Rahman & Matin, 2011). This project paper will focus on the availability of solar energy in different locations of Bangladesh on the basis of daily solar radiation data, Sunshine Hour, comparison of the irrigational pump system on the basis of GHG operational emissions for identifying most suitable energy option for irrigation.

2.1 Case Study: Keranigonj Solar Irrigation Pump

According to analysis of a solar pump design there are 3 solar units, 3 pumps and a control panel. Each unit of solar panel contains four panels (12v) and capacity of total panel array is 3 kWp. Solar panel units and motor lifting three pipes are connected to the 6" main bore well which is 120 feet deep and the static water level is 20-25 feet. The case study was carried out on Boro rice which is produced at the mid of the January to mid of the April. The Pilot project was carried out on 4 Bighas of land at keranigong, Dhaka.

This design committed to contribute to sustainable agriculture development, where the use of fossil fuels can be reduced by using solar energy systems.

2.1.1 System Elements

- Solar system: This element converts the solar energy into electrical energy
- Centrifugal pump: This element distributes the water by pumping it from one place to another, using the necessary energy or the adequate level of flow and pressure.
- Control panel: The control panel allows the users to adjust the received current from the solar panel to the rotation speed of the water pump.
- Tank: There is the option of installing water to be able to also use the irrigation system during periods when the sun radiation not received sufficiently or during hours of darkness of night.

2.1.2 Working Principal

These motors will start to work at minimum 24v. From 7am-12 pm: At the starting of the day when solar panel start to get charging at least one motor will start to run. From 12pm-3pm: At the middle of the day solar panel will be charged more than earlier and two motors can be run equally. From 3pm-6pm: Solar panel can have its peak value at this time and can run three motors easily.

When the sunshine/radiation is rising, that time production of Current is less so capable of running one motor and subsequently two and three at a time. This system has been installed with the intention to obtain optimum discharge in any time of the day.

2.1.3 Comparison of the Irrigational Pump System on the basis of GHG operational emissions.

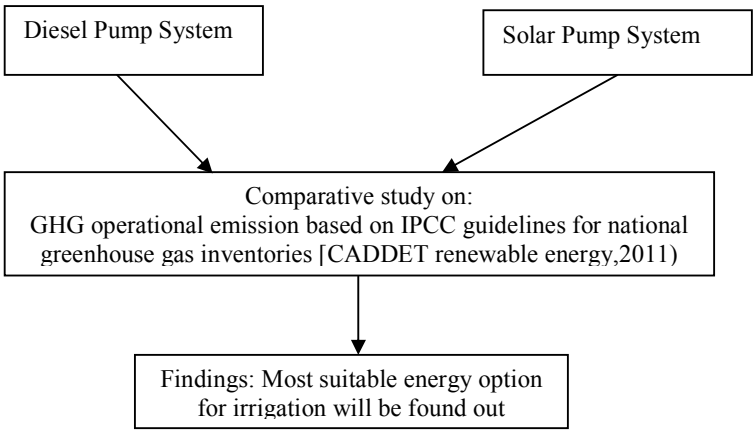

Figure 1: Comparison of the Irrigational Pump System on the basis of GHG operational emissions

2.1.4 Greenhouse Gas Emission Reduction Analysis-Photovoltaic Projects

GHG operational emissions based on IPCC guidelines for national greenhouse gas inventories are given in table 1 and 2 in below (United Nations Environment Programme & Minister Resources Canada, 2000-2005):

Table 1: Greenhouse Gas Emission Reduction Analysis-Photovoltaic Projects

Background Information	
Project Information	Global Warming Potential of GHG
Project name-PRE-RSF Pump Project	1 tonne CH_4 = 21 Tonne CO_2 (IPCC, 1996)
Project Location-Dhaka	1 tonne N_2O = 310 Tonne CO_2 (IPCC, 1996)

Base Case Electricity System(Baseline)

Fuel type	**Fuel mix (%)**	**CO_2 emission Kg/GJ**	**CH_4 emission Kg/GJ**	**N_2O emission Kg/GJ**	**Fuel conversion efficiency (%)**	**GHG Emission (tCO_2/MW-h)**
Diesel (#2 oil)	100.0%	74.1	0.0020	0.0020	12.3%	2.192

Proposed Case Electric System(Photovoltaic Project)

Fuel type	**Fuel mix (%)**	**CO_2 emission**	**CH_4 emission**	**N_2O emission**	**Fuel Conversion efficiency**	**GHG Emission**
Diesel (#2 oil)	100.0%	0	0	0	75%	0

Table 2: GHG Emission Reduction Summary

Electronic system	**Base case GHG (tCO_2/MW-h)**	**Proposed case GHG emission factor (tCO_2/MW-h)**	**End use annual energy delivered (MW-h)**	**Annual GHG emission reduction (tCO2)**
	2.192	0	7.221	15.83
				Net GHG emission reduction tCO_2/MW-h = 15.83

From the above chart it is found that using diesel as fuel causes net GHG emission of 2.19 kg/GJ. On the other hand solar pump system causes GHG emission of 0.00(Kg/GJ). It indicates that on GHG emission point of view the most suitable energy option for irrigation is PVP system.

2.1.5 Cost of PV Irrigation Pump

As solar powered pump is sponsored by IDCOL and donor agencies, so 40% of total cost is given as grant to encourage micro credit investor to collect less tool of cost of irrigation. During Tangail visit it was observed that farmers earlier used to give ¼ of crop produced but now after solar power installation introduction they give 1/5 of crop produced. So as a result of new method farmers save (1/4-1/5) =1/20 crop produced.

3. RESULT AND DISCUSSION

A thorough study was carried out to find the suitability of using solar power irrigation in Bangladesh considering its inherent benefits of no emission of GHG while generating electricity. Through data analysis deductions have been drawn about the feasibility of solar power harnessing in Bangladesh and data are produced about the environmental effects of traditional systems.

3.1 Solar Radiation and Sunshine Hour

The effectiveness of solar irrigation pump largely depends on the sunshine hour and solar radiation of a particular region. Monthly records of solar radiation (from January- December) of different districts of Bangladesh have recorded throughout the study. Basing on these records, a comparison on the quantity of solar radiation can be made and the effectiveness of the designed solar irrigation pump can be assessed.

3.1.1 Monthly and Daily Solar radiation

The average solar radiation has been recorded in April is 5.5-6 KWH/m^2/Day, in July it is 4-4.5 KWH/m2/Day and in December it is 4.5-5.0 KWH/m^2/Day which is sufficient enough to generate electricity out of solar PV panel and represent three different seasons. It has been found during the installation of the solar energy power pump in Keranigonj for the cultivation of Boro paddy crops during mid-January to late April (3.5 months). This solar pump is designed on the assumption of peak sunshine at 5.5 hrs/day and 3 times' manual tracking.

The daily radiation pattern of Dhaka city and other district are based on the annual total radiation data. For Dhaka the LCL radiation of January, 2011 has been recorded as 1.86 kW-p m^2/day and UCL has been recorded as 2.1 kW-p m^2/day. The variation in upper control limit and lower control limit has been shown in Figure 2

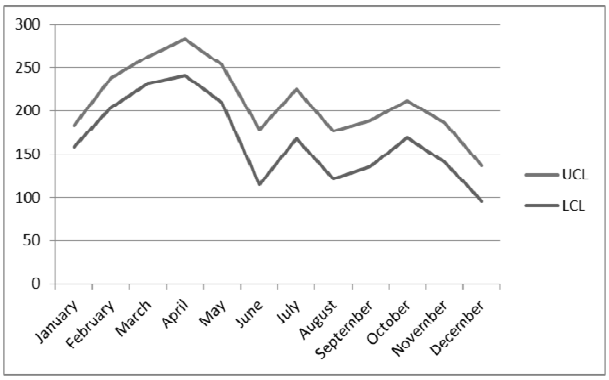

Figure 2: Monthly Solar Radiation of 2011 of Dhaka city (unit-cal/sq-cm/day)

3.1.2 Daily sunshine hour pattern in Dhaka city:

The 10 year's daily sunshine hour pattern of Dhaka city is based on the annual total sunshine hour data. The minimum sunshine hour has been recorded as 5.21935484 in the year of 2003 and maximum was 7.93870968in the year 2001.

Basing on the average monthly sunshine hour of 10 years, a general trend can be developed. Figure 3 shows about the daily sunshine hours in January (10 years data considering in Dhaka City). Figure 4 shows the variation of average sunshine hour per month. Here UCL and LCL represent the upper control limit and lower control limit of daily sunshine hour which accuracy is 95%.

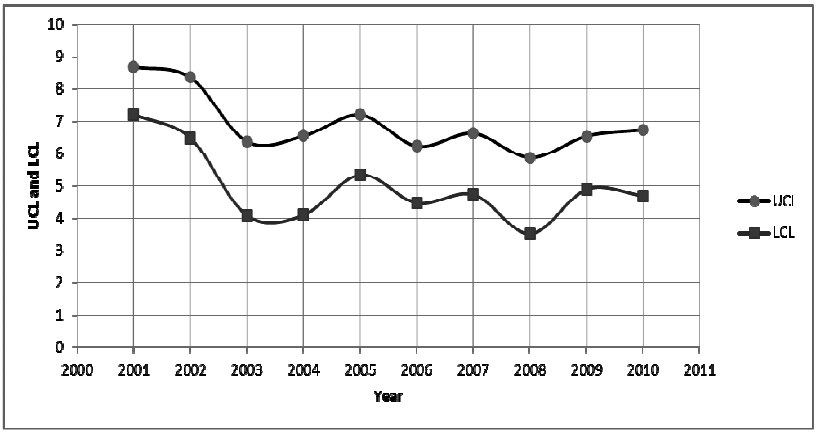

Figure 3: Daily Sunshine Hour in January

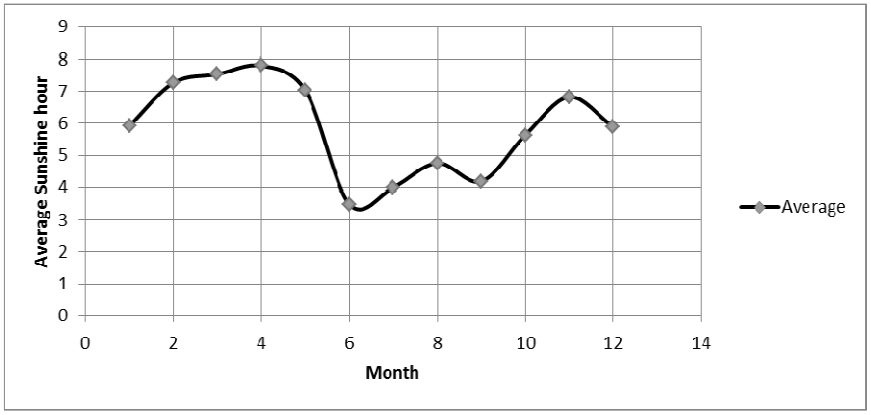

Figure 4: Average Sunshine Hour Variation per Month of Dhaka City.

Figure 4 shows that average sunshine hours of January are 5.9. Solar pump works fully during 12pm -3pm (3 hours) which indicates that proper sunshine hour is available for the optimum utilization of the solar pump.

3.2 CO_2 Emission

Table 1 and 2 shows that Greenhouse Gas (GHG) Emission Reduction Analysis in Photovoltaic Project. It is observed that when Diesel (#2 oil) is used as fuel CO_2 emission is 74.1 kg/ GJ, CH_4 emission is 0.0020 Kg/ GJ, N_2O emission is 0.0020 Kg/ GJ and total GHG emission is 2.19 tCO_2/MW-h. On the other hand, when solar pump is used CO_2, CH_4 and N_2O emission is reduced to 0.00 Kg/GJ and total GHG emission is 0.00 Kg/GJ. Finally it shows that solar pump can reduce annual GHG emission by 15.83 (tCO2).

3.3 Environmental Comparison

The environmental impacts of photovoltaic power generation are analyzed in this section. The energy used in manufacturing the PV modules and the other components of the PV system is derived from various components which has somehow effects either directly or indirectly and is therefore associated with emissions of greenhouse gases and acidic gases. The materials for construction of the complete PV system other than the PV modules are steel, aluminium, copper, concrete, and electronic equipment, with which are associated the standard industrial hazards. Though disposal materials are heavy materials but as these are recycled, so no chances of polluting the environment

4. CONCLUSIONS

Water pumping is an energy intensive activity and consumes a large amount of diesel and electricity. Solar pumping systems are inherently more reliable than diesel powered systems. Based on our findings through the case studies, the learning outcomes can be summarized as follows:

- Solar power irrigation in though is in initial stage level but due to the gradual depletion of non-renewable energy in far future. Its uses will be increasing with courses of time. Solar power irrigation pump while in operation do not emit any GHG (while manufacturing produce some GHG which is very negligible and most of the parts are recyclable) which is most remarkable positive attributes to this system.

- The advantage of the solar power is non-polluting. The GHG emission of diesel is very high. The emission can be reduced by implementing solar powered pump as it emits no GHG.A small amount of hazardous materials emits from PV modules but the effect of hazardous materials are reduced substantially by recycling process

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