Off Grid Solar Water Pump: An initiative for the students of Ramamganj High School

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1 Background :

MOTIVATION, INTRODUCTION AND PROJECT LOCATION

One of the major opportunities lies in providing energy access for off grid people, people who don't have electricity and still won't have it in the far future. This creates an opportunity for which the economics are compelling, the moral urgency profound and the development benefits enormous and so the potential leverage.

This document upholds setup of an **Off Grid Solar Water Pump System** at North Ramganj High School situated far away from grid areas in an Upazilla called Lalmohan in District Bhola in Bangladesh. This Solar Water pump setup was a pilot attempt to ensure safe water supply for 600 students of the school under School Cum Cyclone Shelter Project by Islamic Development Bank, Bangladesh. The Global Position of the school is 22°15'28.1"N 90°44'40.1"E.

(a) (b)

Figure 1: (a) District Bhola in Bangladesh (b) North Ramganj School in Lalmohan thana, in Bhola

In response to the assistance to the victims of cyclone SIDR, the Islamic Development Bank (IDB) has been entrusted with a generous donation of US$ 130 million by a benevolent philanthropist (Fael Khair in Arabic) for relief of cyclone victims in Bangladesh. The bulk of the grant (US$ 110 million) is to be utilised for the construction of School- com- Cyclone Shelters and the balance (US$ 20 million) is earmarked for the restoration of livelihoods of the victims in the coastal belt of Bangladesh. The Government of Bangladesh (GOB) and IDB have signed a Memorandum of Understanding whereby the IDB will implement the

program with assistance from the GoB. The IDB has engaged IMC Worldwide (International Management Consultants) to manage construction of the Shelters component.

Students of the school have been facing a water crisis for drinking and other purposes like for bathrooms, toilets, sinks and for other uses. Initially, the off grid Solar water pumps were supposed to be operated by Diesel Generator, but the high operating cost of the diesel generator was beyond the annual budget of the school. The alternative solar water pump was another solution to the water crisis. As the school already had an AC water pump, it was necessary to drive the pump by any solar pump driver.

The technology of the solar water pump was comprised of mainly Solar Panels, Pump Driver, AC Pump. Nearly eleven thousand students shall be benefitted from the project.

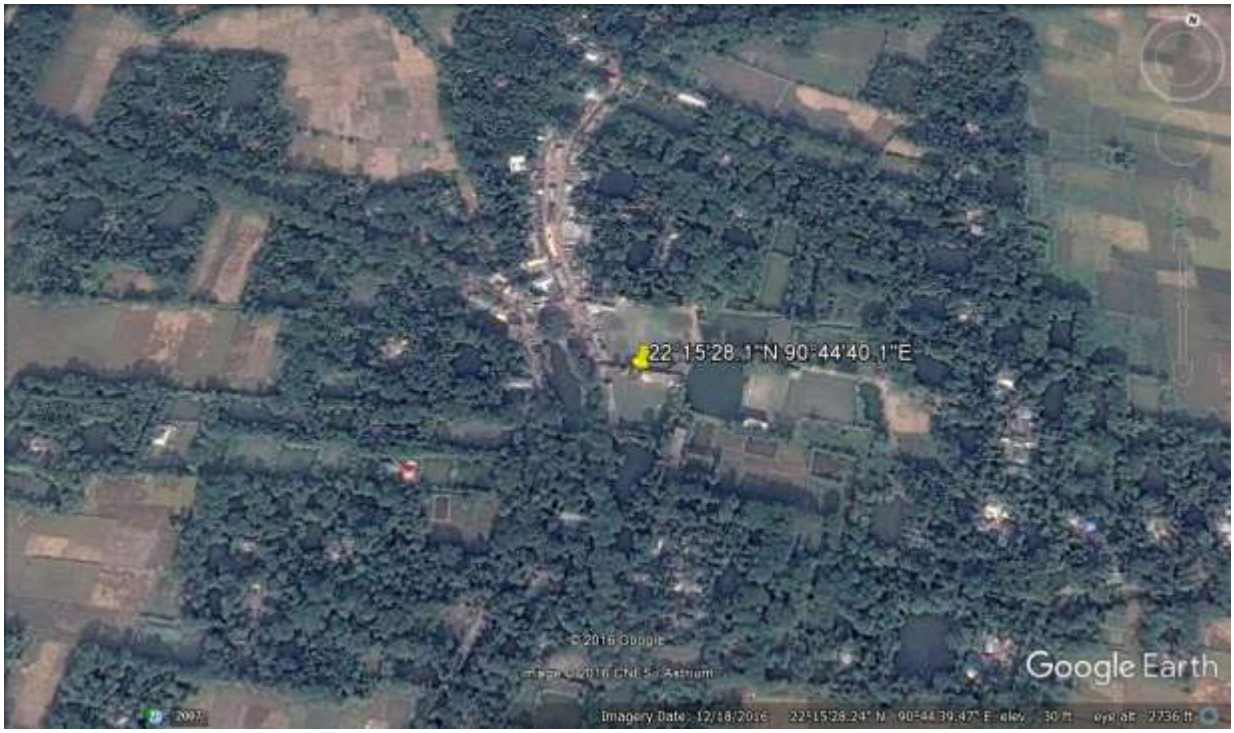

Figure 2: Google Earth view of the school position

The project covers the area in the costal belt of Bangladesh that comprises the districts Satkhira, Khulna, Bagerhat, Pirojpur, Barisal, Patuakhali, Barguna, Bhola, Lakshmipur, Noakhali, Feni, Chittagong and Cox's Bazar. Contract of the construction of 109 shelters has already been awarded and procurement of a future 80 (approx) shelters is currently under process.

To recapture the objective of the pilot project, the IDB–Fael Khair Program initiatives were tied up with the social cause to support people who are victims of cyclone attract and lost.

Bestway Powertech Ltd. is a Bangladesh-based Company working in the renewable energies. We have recently installed the first of a planned 150 schools and storm shelters in the south of Bangladesh. These facilities will provide emergency shelter, lighting and drinking water during storms or other natural disasters.

Due to the capital constrained nature of this application we were in search of a cost effective means of powering the necessary water pumps with off-grid solar power. After studying the

array of power technologies in the marketplace we decided to deploy the system utilizing SunTech Drive's PicoCell controller at it's core. We opted to go with this particular design for several reasons. The PicoCell is the only solar controller that allowed us to configure 50% fewer PV panels to power the 2HP pump in our overall design. This also generated savings in associated soft costs such as racking, cabling and setting of the PV array itself. It also represented a far simpler system design. Rather than having to specify and integrate separate devices such as a MPPT controller, inverter, variable frequency drive and voltage boost system, the PicoCell delivered all of the same functionality in one compact, inexpensive and fully integrated device. Since their controller also works with any pump regardless of voltage, phase, frequency, etc., we felt confident that we would be able to replace the pumps at the end of their useful life without having to redesign the associated power electronics.

Their technical team was very helpful in assisting us with our original design and proof of concept testing. We look forward to continuing to partner with SunTech Drive to deliver off-grid solutions to our global customer base in the future.

2 About the school:

Name: North Ramaganj High School

Address:

Lalmohan, Bhola, Bangladesh
Headmaster: Mr. Md. Kamal Uddin
Phone: +8801719-764800.
Education Level: Primary to Secondary

- **Total number of Students: 288**
- **Total Male Students : 113**
- **Total Female Students :175**
- **Total Teachers: 11**
- **Total Office Staffs: 04**
- **Total Water dispense tabs: 22**
- **Total Sinks: 05**
- **Total Toilets: 11**
- **Water reservoirs: 12590 Ltr**

Figure 3: North Ramaganj High School Cum Cyclone Shelter building

3 Organization and Company involvement:

SL	Name of Organizations	Engagement with the Project
1	**Islami Development Bank** Dhaka, Bangladesh	Technical Assistance and Grant
2/a	**IMC Worldwide Ltd.**	Bangladesh
2/b	Bestway Powertech ltd.	Local Contractor
3/a	**SunTech Drive, LLC USA**	Pump Driver Manufacturer
3/b	**Solar World AG, Germany**	Solar PV Module Manufacturer

4 A review on implemented System and engineering:

Core Work:

To drive the existing zet pump Brand: Pedrollo, capacity: 1 Hp installed at cyclone Shelter No. Z3-548, Ramaganj, Bhola and to ensure water lifting from ground level to the reservoirs at the rooftop of the building. There are two (2) chambers in the tank. One chamber is for collecting rainwater and is for sedimentation of rainwater. Another chamber is for storing clean water after sedimentation of rainwater. Capacity of sedimentation chamber is 3670 ltr. And capacity of clean water reservoir is 12590 ltr.

Concept Design:

Since there shall be a separate solar system of 2.5 Kwp capacity, therefore, proposed solar pump system could be designed as a integral part of the system. Considering this basic concept, the solar structure frame system for 2.5 Kwp was extended to support additional panels 1.54 Kwp dedicated for solar pump. The purpose of sharing the same mounting structure is to reduce cost and required time of installation.

The basic design of the total setup for solar pump driving system consists of 6 Solar Panels of 260 Wp Capacity Brand: SolarWorld AG, Germany and 1 Solar Pump Driver Model: PicoCell, Brand: SunTech Drive, USA and with connecting cables, circuit breakers and accessories. The driver was set up in the control room along other solar power devices for solar system for fan and light of the school.

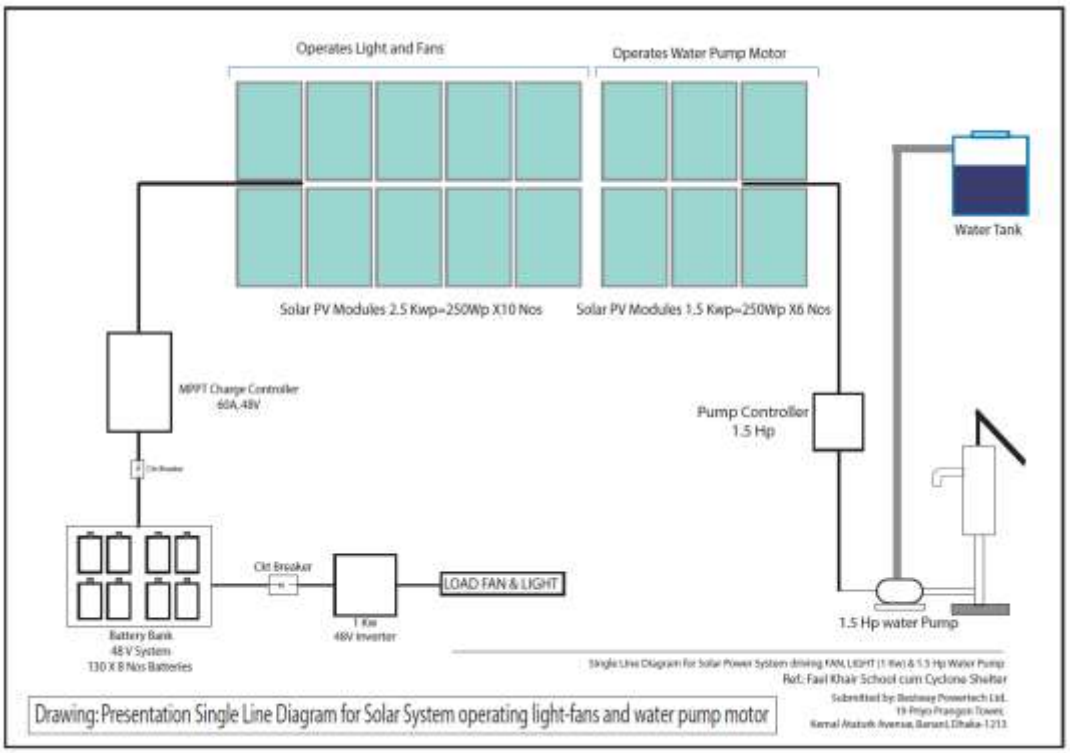

Figure 4: **Single Line Diagram of conceptual design for the Solar Pump driver installation**

Placement of Solar Panel on the Rooftop:

All Solar Panels, for Solar System and Solar Pump System, occupying the rooftop area was measured carefully and a layout design was developed before practical installation and civil work start. An approved layout by IMC Worldwide Ltd. was achieved and the panel placement was furnished accordingly.

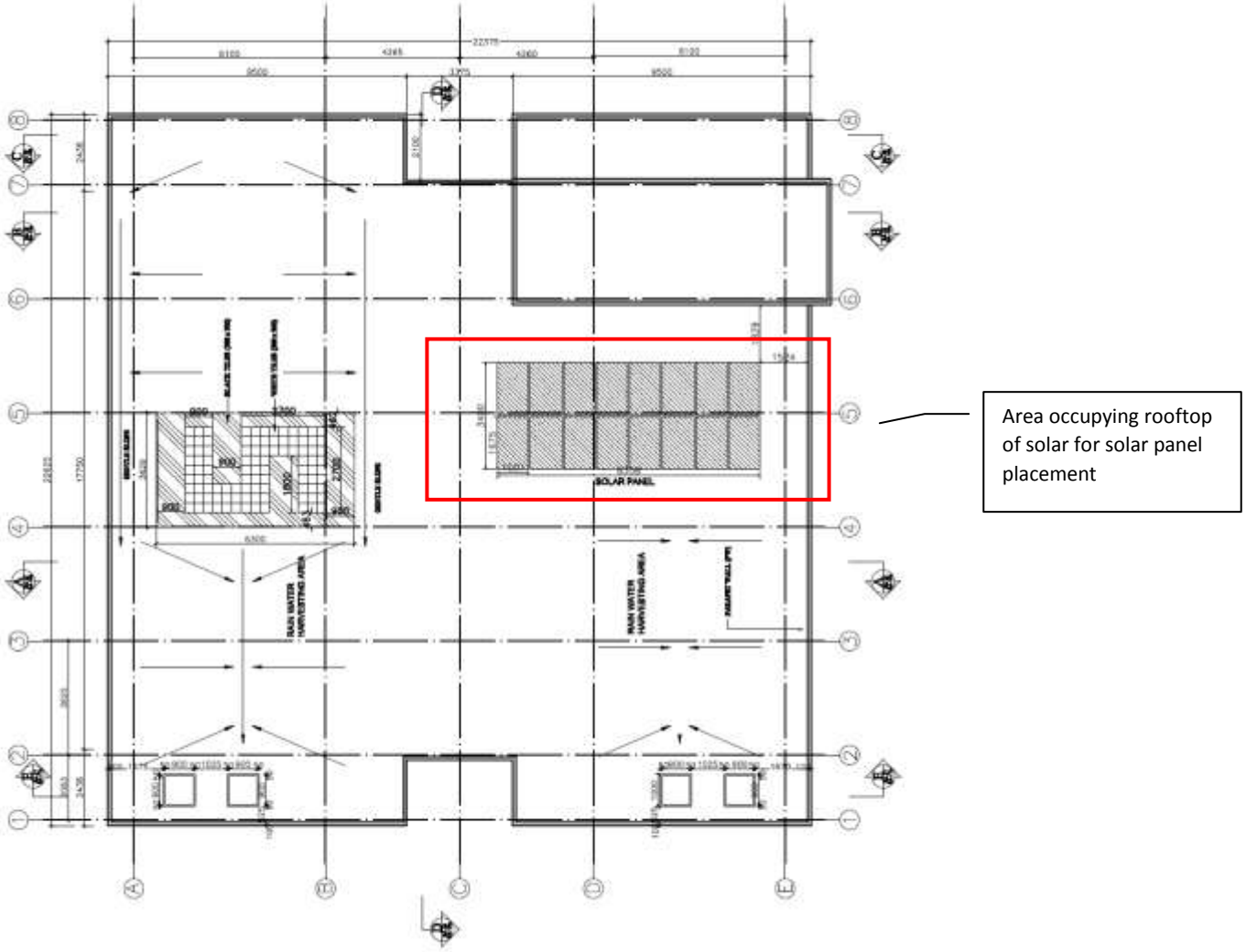

Figure 5: Solar Panel Placement area within red marked border.

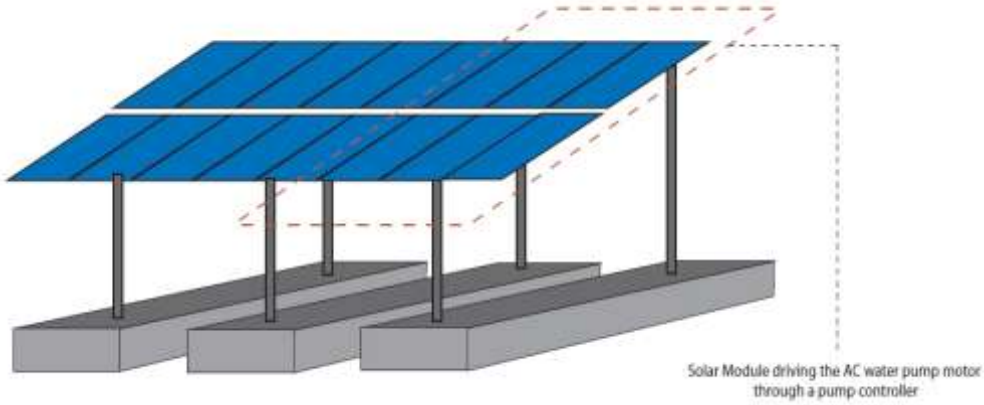

Figure 6: Part of Total Solar Modules used for pump driving.

Figure 7: Practical Panel Placement according to layout design

(Red marked panels are dedicated for Solar pump driver)

Picture above shows how the panels are set up as integral part of the Solar system for light fan operation in the school. All structure frames are hot deep galvanized. Total number of panel are 16, out of which 10 Panel are used for Solar power system for light and fan and 6 panels are used for driving the pump.

Specification of Pump:

Pump used for water lifting purpose is a jet pump, which has the salient feature to drag water from distant reservoir or pipe of tubewell. Existing pump is 1 HP capacity. The pump is installed at the ground floor.

Figure 8: Specification of the JET Pump brand: Pedrollo, picture was taken from the site

The Pump Driver:

The installed pump driver has capacity to drive pump AC motors up to 2 HP, 1 or 3 Phase. The Driver is imported from the USA and the brand is **SunTech Drive..** The driver is installed in the control room, adjacent to the other power devices for solar power system for light and fan.

SunTechDrive

SunTech Drive is introducing **PicoCell**, a unique off-grid controller based on advanced patented maximum power point tracking (MPPT) technology, which can run any grid-tied water pump or other inductive load directly off of solar PV panels. **PicoCell** decreases overall system's cost, by having up to 50% fewer solar PV panels. Now customers can accurately match the power of Solar PV with the power requirement of the pump. Hence, unlike other solar controllers, no more high PV voltage threshold required for having a VFD run the AC pump. The overall project savings are in the 20-40% range depending on the pump size.

Key Features:

Maximizes Solar Energy Harvesting:

- MPPT results in 98% efficiency conversion from solar
- Unit uses fewer PV panels to optimally run the pump
- No need for high voltage input on PV port, number of PV panels is flexible and scalable in order to match pump's power requirement

VFD – AC Motor Control:

- Full control of single and three phase AC motor pumps
- 95% efficiency on motor speed control capability
- Pressure regulation capability
- 50/60Hz compatibility for worldwide applications

Figure 9: "PicoCell" the 1 Phase pump driver

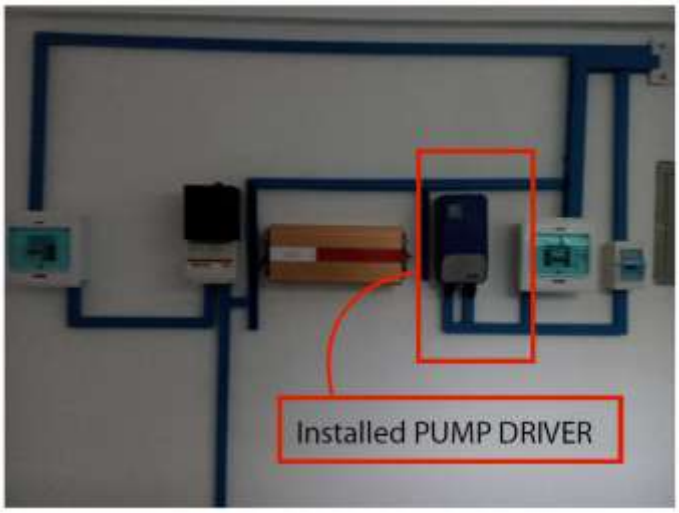

Figure 10: **The Pump Driver Model: PicoCell, Brand: SunTech Drive, USA**

Result:

- **Pump Run time:** Start 9:00 AM in the morning **and** End 3:00 PM in the noon.
- **Time required to full the water reservoir:** 2.5 Hours.
- **Total amount of water lifted in a single day:** 14000 Ltr.
- **Water Flow rate:** Continuous and almost steady as long as not shadow of clouds.
- **Auto Run:** Possible by adding sensor cables with the reservoir.

Figure 11: **The pump starts at 9:00 am and pumps until 3:00 pm.**

5 Effectiveness to contribute to new energy access:

Ensuring electricity demands depends on availability of fuel. Power sector development in Bangladesh has been hindered due to scarcity of indigenous natural gas, the primary fuel for power generation. Since nearly 90% of generated power used to come from natural gas, fuel diversification was important to ensure energy security. Under the above prospective renewable energy especially solar could be an important diversification for Bangladesh.

The proposed solar water pump project will help as capacity building tool for diversification of solar PV technology in remote rural areas in Bangladesh in near future, to bring new technology and to create new working places and improve livelihood in the future in the field of small solar generation systems, a sector that can be extended to the world of mini-water pumping stations for communities of remote areas in remote and to irrigation systems for agricultural needs.

6 Financial Sustainability

Three basic components of solar pump system are Solar PV Modules, Pump Driver and the Pump. Total financial budget was **U$D 2890.15** for these three components, necessary accessories and installation charge. All major components come with good warranty period, panel 25 Years, pump driver 02 years and pump 02 Years. Compared with diesel operated generator of 3 HP capacity, it was found that running cost of a diesel generator for 03 hours a day for two years is USD 3000 USD, and including cost of generator and yearly maintenance total costs stands at **USD 3712.50.** Cost of fuel was considered at flat rate for two years and 300 days was considered as operating days of generator in a year. It is evident from this simple calculations that Solar Pump System is very competitive compared to Diesel Generator and even economic.

7 Engagement with project beneficiaries:

Requirement of solar water pumps was utmost important in the school premises. The school has an average of 288 students, but with no water pumping for drinking as well as washroom needs. Small children had to struggle with the hand pump to get some water for their privy use. The female teachers were communicated about the concept of forming Women's Cooperative including parents of students and almost all female teachers and parents of the students were ready to be a part of it. As during cyclone time the shelter will be commonly used by all of them. Therefore, they must take care of it, like conducting periodic maintenance cleaning panels, watering batteries etc. Also it was defined that each school shall have lights and fans in school to be operated by solar energy stored in the battery bank, this environment in school shall enable the community based groups to have group discussion and gathering in late evening hours for community development works. The female teachers in these schools on behalf of Women's co-operative shall be responsible for the weekly maintenance of these systems. Also these teachers shall collect funds from the school management to use for service of the system, if needed.

8 Adequate risk management

The System do not require any notable risk management, all the students of the school had been advised not to carry any sharp items near the wires of the solar system, danger signs were fixed on walls of control room door and structure frames. Students were also advised not to play games like football and cricket on rooftop of the building considering safety of the panel. In order to create ownership of the system among the students, some cultural programs were conducted at the advent of clean energy at their own school.

9 Positive socio-economic impact

Socio-economic benefits are gaining prominence as a key driver for renewable energy deployment. This paper presents a simple analysis of the socio-economic effects of small-scale renewable energy deployment. Since all the students and teachers can have water within the reach of hand and can feel use of water like those in the cities, therefore, we can infer the there positive impacts on all the beneficiaries of the system, like improved-hygienic use of water, cleanliness in washrooms and healthy environment. Now, the parents of the students who are solvent will be interested to install a similar solar water pumps for their own use or for a number of homes grouped within a village and improve their livelihood, they can also greatly use the solar pump systems for irrigation purpose which has direct positive economic impact as the system stands at a very competitive cost against diesel generators.

10 Impact on CO2 reduction

The Solar Pumping system is entirely run without fossil fuel and the solar pump system of discussion can be used for agricultural irrigation purpose very effectively and in Bangladesh; there are 1.3 million diesel-run irrigation pumps which consume about 900,000 tons of diesel to irrigate 3.4 million hectares of land. Replacing half of this number of diesel pumps will have enormous impact of reducing is enormous impact on CO2 reduction.

11 Innovation potential for replication and up scaling

Photovoltaic water pumping system is one of the best alternative methods for irrigation which we all have recognized already. Using the innovative Solar Pump Drivers like "PicoCell" in irrigation sectors will have tremendous influence in saving operation costs of diesel pumps and environmental pollution caused by diesel generators will be prevented with renewable energy. Proposed system is easy to implement and environment friendly solution for irrigating fields as well. The minority of farmers, fortunate enough to own electricity-run pumps, also faces persistent power outages. This forces them to operate their pumps at night when electricity consumption decreases and power failures are less likely. In Bangladesh every year, diesel pumps consume 1 million tons of diesels worth $900 million. This is a costly amount, which the government subsidizes at the expense of other agricultural innovations.

It is worth mentioning that with this one solar pump installation, Islami Development Bank ordered to install same solar water pumping systems for 38 additional schools cum cyclone shelters under Fael Khair Program.

Conclusion:

Solar powered water pumping system could be an innovative, economic and environmentally friendly solution for not only household applications rather vastly for the agro-based economy of Bangladesh. This system mainly consists of solar panels, Pump Driver & AC pump. Solar panels utilize daily sunshine to generate electricity which in turn runs the solar pump to provide uninterrupted water supply. A simple arrangement of such technology can benefit all people of off grid areas and on grid and can bring tremendous change in everyday life. The Solar Pump system doesn't incur any operational cost, which is almost zero. Water is an essential substance, and Fael Khair project, if includes, can be more worth meaning if the students and the cyclone affected people taking shelter can use water more easily and conveniently.

12 Annexes:

(a)

(b)

Figure 12: (a) The Control room of installed components

(b) The students of the school and teachers left and right sight

Figure 13: A student of the school holding a glass of drinking water

Figure 14: Water dispensing basin in School.