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Feasibility Study of Solar Photovoltaic Electricity for Rural Irrigation

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ABSTRACT

Every year there produce only a limited amount of electricity in Bangladesh and that is quite insufficient to meet up our demand of electricity. So the people of Bangladesh are suffering a lot due to lack of electricity. The suffering reached an extreme level during the irrigation period .In the irrigation period a huge amount of produced electricity consumed by electric pump. At present the electricity supply for irrigation is inadequate, solar energy can play an essential role to bridge the gap.

In remote areas where electricity facility is not available PV pump can be a good choice. Not only that we can use the electricity produced by the solar array to run some agricultural instrument which can save a lot of fuel cost. Besides this in the time and after harvesting or if we want, using the battery storage we can get the electricity facility.

The solar irrigation system may help to save 760 MW electric power and 800 million litter diesel each year if the conventional irrigation pumps are transformed into solar power ones. Our system will help rural people to enjoy uninterrupted clean energy and we believe this service will boost economic activity in the rural areas which leads to green development.

Keywords: Solar Pump, Irrigation, MPPT, PVP.

I. INTRODUCTION

Solar energy is a clean renewable source of energy, and it does not hamper environment and human lives, economic disasters which may contain oil, coal sludge spills, devastating gas pipeline explosions and coal mine, unexpected nuclear accidents, and water supply pollution from natural gas fracking. Its use promotes better health through reduced coal plant secretions pollution. Water pumps, motorized by photovoltaic (PV) panels, are being used regularly to pump water for local usage, to irrigate landscape and crops, to cattle, and deliver potable water. The benefit of using solar energy for pumping the water is that main measures of water are essential during day time & that too during time when the sun is on top, and during these times the PV panels generate supreme energy and hereafter the water capacity. These solar pumps can be mounted anywhere, slightly located farms, woodland, or locations which are hard to influence and are not associated to national electric grid. The use of solar irrigation pump in developing countries is suppling a practical solution to meet water needs of the individuals. Simultaneously, one can also protect the environment by ducking or minimizing the scorching of fossil fuel for energy production. The solar irrigation pumping technology is commercially accessible, has-proven record of dependability, require, least skilled manpower once in action, maintenance and operation cost is also very minimal and reasonable.

OBJECTIVE

The objective of this paper is to represent the overall PV pumping scenario for irrigation purpose in Bangladesh. The major two part irrigation and PV pumping both are discussed largely here. The government of Bangladesh is planning to install close to 19,000 solar-powered irrigation pumps by 2016, in a bid to expand the country's irrigated land area and boost food production, while limiting its reliance on fossil fuels. [1]

The initiative is being indorsed as an ecologically friendly approach to enlightening food security for the country's fast-growing people more than 160 million. The new pumps will run on a combined 150 megawatts (MW) of power generated by solar panels, which is projected to save the government nearly $100 million in fuel-subsidy costs over 20 years.

Today Bangladeshi growers rely on approximately 266,000 electrically powered water pumps - which consume nearby 1.3 GW - to irrigate 1.8 million hectares (4.3 million acres) of harvest land.

An additional 1.4 million diesel-run pumps are activated during the peak growing period to irrigate 3.5 million hectares (8.5 million acres) of land, consuming 900,000 tons of fuel, based on Bangladesh's power and energy ministry.

Once installed, the planned 18,760 solar-powered pumps – which will be accomplished by farmers' associations - will irrigate an additional 690,000 hectares (1.6 million acres) of land for cultivating vegetables and rice, without requiring diesel fuel or any grid electricity. Ultimately the government hopes to swap some of the land now irrigated with diesel and electric powered pumps to solar pumps too – if it can catch financing.

Prospect of Solar Energy in Bangladesh

The prospects of solar energy application in Bangladesh are absolutely very good. We all are desperately aware of the point that Bangladesh is really in need of electricity, one deprived of which a country is sure to be residual in the 21st century. Presently, world is well-known of the point of the need of decreasing fossil fuels and other sources of inadequate energy and also is annoying to best use what nature is calm with its elements such as renewable solar energy. Hence, we should not and cannot disregard using renewable resources to produce our much desired electricity.

Bangladesh has confirmed that it aims to afford electricity for all by the year 2020, though at present there is a high unfulfilled demand for energy, which is increasing by more than 8% yearly. According to the master plan of Rural Electrification Board it had supplied electricity facilities to about 32% of the total rural population. It goals to reach 98 million rural inhabitants by 2020, which is nearly 84% of the total rural people. Satisfactory to address this goal only fossil fuel based power plant would not be capable to satisfy the mandate. It needs to guise for the different sources of energy for power production. Renewable energy machineries would be one of the significant emerging options. Bangladesh is located between 20.30 and 26.38°N latitude as well as 88.04 and 92.44°E longitude, which is a perfect location for solar energy deployment. Daily solar radiation differs between 4 and 6.6 kWh/m2. Solar Photovoltaic technology is a vital emerging choice for electricity generation. Therefore, densely populated steamy country like Bangladesh might be electrified by Photovoltaic grid system using the unlimited and pollution free solar energy without using any novel technologies. Reimbursement of electricity scarcity and reduction CO2 emission would be finished by introducing solar energy bases for electricity generation in large scale.

TECHNICAL ASPECTS OF THE PVP:

The Solar Photovoltaic Pumps all have the following common technical features:

1) There is a Solar PV Module, arranged in the form of an Array (the Solar Generator)
2) A Motor-Pump System which is connected either directly to the PV Panel (in case of Direct Current (DC) Motor
3) An Inverter, in case of A.C. Motors, including Mono-submersibles
4) Other Accessories, such as the Structure, Cables connecting the Panel with the Pump

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5) Hoses for Surface Water type Irrigation Pumps

The PVP used worldwide is of 5 basic types:

1) Surface Water DC Submersible type - suitable for low head and high flow
2) Surface Water DC Floating type - also suitable for low head and high flow
3) Surface Water Centrifugal Suction type - same as above, but has disadvantage of a foot valve
4) Deep Tube-well Mono-submersible type.
5) Deep Tube-well Turbine Type with surface Motor.

II. Solar photovoltaic water pumping system

The photovoltaic (PV) system is established on semiconductor technology that transforms sunlight into electricity. This is a verified technology but more costly than other electricity production methods such as a power plant based on oil, coal, natural gas also conventional hydroelectric transformation techniques. Fig 1. Displays a schematic diagram of a solar electricity based water pumping system. This piece provides a fleeting discussion of the key components of a SPVWP system planned for well water access for public, wildlife in remote locations and livestock.

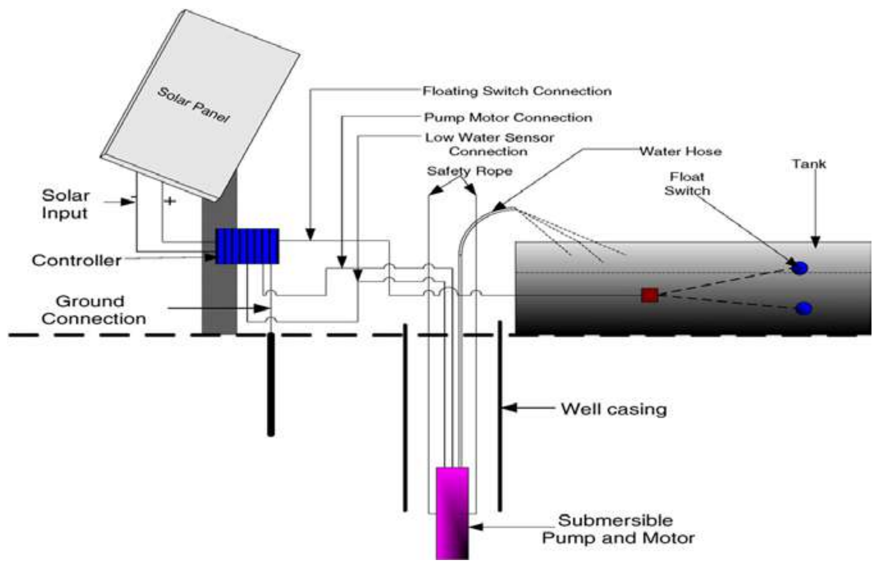

Fig 1: Schematic diagram of a solar water pumping system

Components modeling of PV water pumping system:

The main components of a Photovoltaic pumping system are illustrated schematically in fig 1.

Mainly a Solar PV System can be divided into three parts:

1. The photovoltaic array which converts solar energy to dc electricity.

2. The motor and pump subsystem comprising the components which convert the electrical output of the photovoltaic array into hydraulic power.

3. The storage & distribution system which supplies the water.

Limitations

- Low yield: Solar pumping is not suitable where the requirement is very high. The supreme capacity available with solar is too low. Though, the output of the solar DC pump is above a normal pump.
- Variable yield: The water yield of the solar water pump changes rendering to the sunlight. It is maximum around noon as well as minimum in the early morning & evening. This changeability should be taken into contemplation while planning the irrigation.
- Dry maneuver: The submersible water pump has an in-built guard against dry run. Though, the surface pumps are very complex to dry run. A dry run of 16 minutes or more can cause huge damage to a surface water pump.
- Water quality: As with any other pump, solar pumps work best if the water is clean, devoid of sand or mud. Though, if the water is not so fresh, it is desirable to clean the well before fitting or use a decent filter at the end of the submerged pipe.
- Theft: Theft of solar Photovoltaic panels can be a problematic in some areas. So the farmers need to take essential precautions. Preferably, the solar system should protected against theft as well as normal threats like lightning.

Perspectives of PVP Technology

In areas with extraordinary insulation levels, electricity from solar panel opens up new choices for pumping water. PV pumping systems are theoretically fit for use, helpful for the environment and are capable to yield cost rewards over diesel driven pumps, as long as assured site specific situations apply. Though, the high early investment costs are quiet the main difficulty to supply of PV pumps. Therefore it is essential to compensate for the high speculation costs by providing loans on promising terms via development banks or done other appropriate financing models. Moreover the purely financial appraisal, additional measures are needed for an overall assessment of PVP-technology. Lubricants and Fuel for diesel pumps often poison wells, groundwater and soil. By disparity, photovoltaic pumps are an ecologically sound and resource-conserving machinery. Contamination of ground-water and soil resources can be completely ducked when determining in favor of the PVP preference.

III. Practical Aspect in Field Level

Visited Area:

Location: Village - Camesori, Bolrampur, Thana: Atoari, Distric: Panchagarh, Bangladesh

System capacity: 6.48kWp Panel - total 36 (180Wp each)

Pump type: DC powered submersible, 5.5kW pump lifting water from deep tube well, lifting 76,000 litters water per hour, which being reserved in overhead tank

Beneficiary: Local tribal villagers

Total Cost: 22**,** 00,000 Tk

Financial support: Survival Welfare Foundation

Objective: 50 acors irrigation land & rural household purpos

Procedure: Here use two solar array modules each of which 18 panel divided into 3 parts.i.e total 36 panel 180 Wp each. Each part connected first series and then parallel to connect the controller for convert dc to ac to operating the pump. An inverter is used to conversion. This pump is operate 0-2900 rpm but minimum at 1100 rpm water is flow. Here the minimum voltage for pump is 380 volt and current rate 13.1Amp.

FIG 2: PROJECT SITE AREA VISIT

Future Work

Enlightening the cost effectiveness of Photovoltaic water pumping systems requires operational utilization of Photovoltaic energy. As irrigation is needed only in one season, rest of the 8 to 9 months is free to use for other purpose. Without using in other reason it will not be cost effective and the payback period will be larger. The main use can be electricity supply for lighting purpose. Other uses related to agriculture are also mentioned.

Our future work is to make the system more efficient. To increase the system efficiency we should use the total power produced by the system. After the irrigation period, we will use the produced power for different household purpose. And also the produced electricity can be connected to national grid.

Conditions for Grid Interfacing:

There are some conditions to be satisfied for interfacing or synchronizing the SPV system with grid or utility. If proper synchronizing is not done the SPV potential cannot be fed to the grid. The conditions for proper interfacing two systems are discussed below.

- **Phase sequence matching**: phase sequence of SPV system with conventional grid should be matched otherwise synchronization is not possible. For a 3 phase system 3 phases should be 120 degree phase separately from each other for together the system.
- **Frequency matching:** Frequency of the SPV system should be same as grid. Generally grid is of 50 Hz frequency capacity, now if SPV systems frequency is slightly higher than the grid frequency (0.1 to 0.5) synchronization is possible but SPV system frequency must not be fewer than grid frequency.
- **Voltage matching:** One of the vital point is voltage matching. Voltage level of both the system should same, otherwise synchronization is not possible.

Basic component of grid connected PV system:

A grid-connected system contains of 5 major components:

- A PV array
- An inverter
- The main service panel or breaker box
- Safety disconnects and
- Meters.

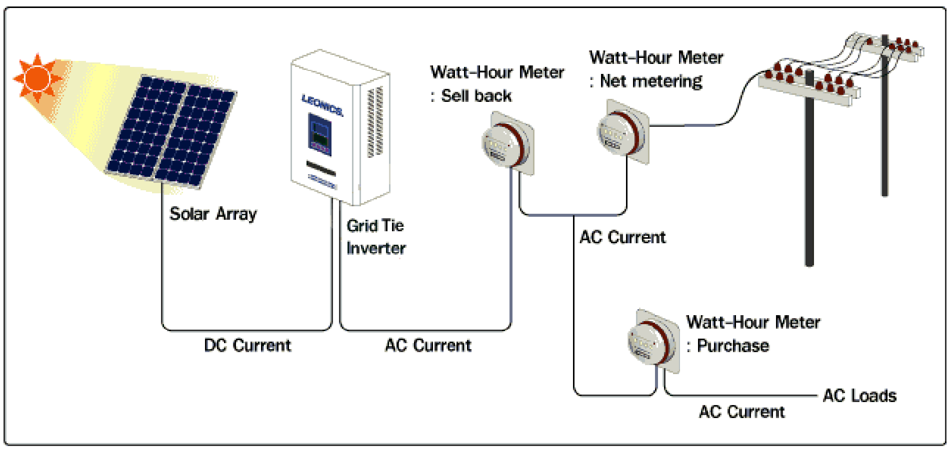

Fig 3: Block diagram of grid connected system

To understand how a battery-less grid-connected system works, let's begin with the PV array. The PV array produces DC electricity. It flows through wires to the inverter, which converts the DC electricity to AC electricity. (For more on AC and DC electricity, see "AC vs. DC Electricity" later in this article.) The inverter doesn't just convert the DC electricity to AC; it converts it to grid-compatible AC — that is, 60 cycles per second, 120-volt (or 240-volt) electricity. Because the inverter produces electricity in sync with the grid, inverters in these systems are often referred to as "synchronous" inverters. [2]

The 120-volt or 240-volt AC produced by the inverter flows to the main service panel, aka the breaker box. From there, it flows to active loads (electrical devices that are operating). If the PV system is producing more electricity than is needed to meet these demands — which is often the case on sunny days — the excess automatically flows on to the grid. [2]

As shown in the schematic, surplus electricity travels from the main service panel through the utility's electric meter, typically mounted on the outside of the house. It then flows through the wires that connect to the utility lines. From here, it travels along the power lines running by your home or business, where it is consumed in neighboring homes and businesses. After the electricity is fed to the grid, the utility treats it as if it were its own. End users pay the utility directly for the electricity you generate. [2]

Grid-connected photovoltaic system.

Grid-connected PV systems are designed to work in parallel with and interrelated with the electric power grid. The primary element in grid-connected PV systems is the power conditioning unit (PCU) or inverter. The PCU converts the DC power formed by the PV array to AC power reliable with the voltage and power eminence necessities of the utility grid, and automatically breaks supplying power to the grid when the utility grid is not thrilled. A bi-directional line is made among the PV system AC output circuits & the electric utility network, normally at service entrance or an on-site distribution panel. This allows the AC power produced by the PV system to either supply on-site electrical loads, or to back-feed the grid when the PV system output is greater than the on-site load demand. At night-time and during other times when the electrical loads are bigger than the PV system output, the equilibrium of power mandatory by the loads is expected from the electric utility. This safety piece is essential in all grid-connected PV systems, and guarantees that the PV system will not remain to operate and get back into the utility grid when the grid is repair or down for maintenance service.

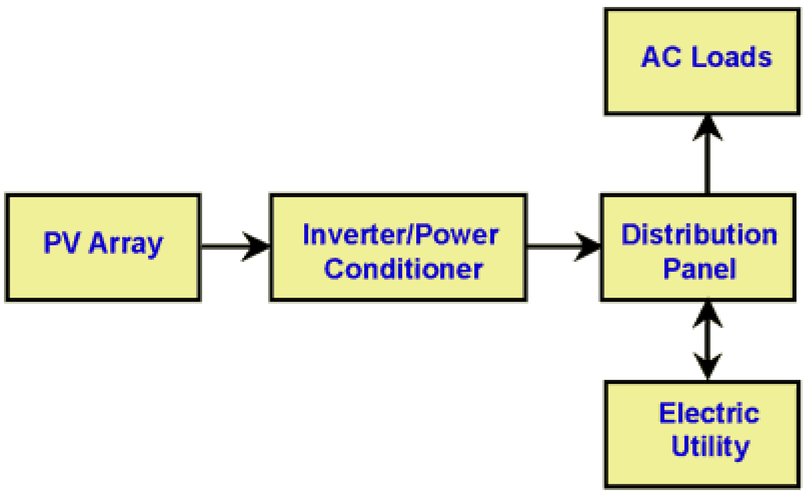

Fig 4. Diagram of grid-connected photovoltaic system.

How grid-connected PV systems work

PV modules use semiconductor materials to generate dc electricity from sunlight. A large area is needed to collect as much sunlight as possible, so the semiconductor is either made into thin, flat, crystalline cells, or deposited as a very thin continuous layer onto a support material. The cells are wired together and sealed into a weatherproof module, with electrical connectors added. Modern modules for grid connection usually have between 48 and 72 cells and produce dc voltages of typically 25 to 40 volts, with a rated output (see box) of between 150 and 250 Wp.[3]

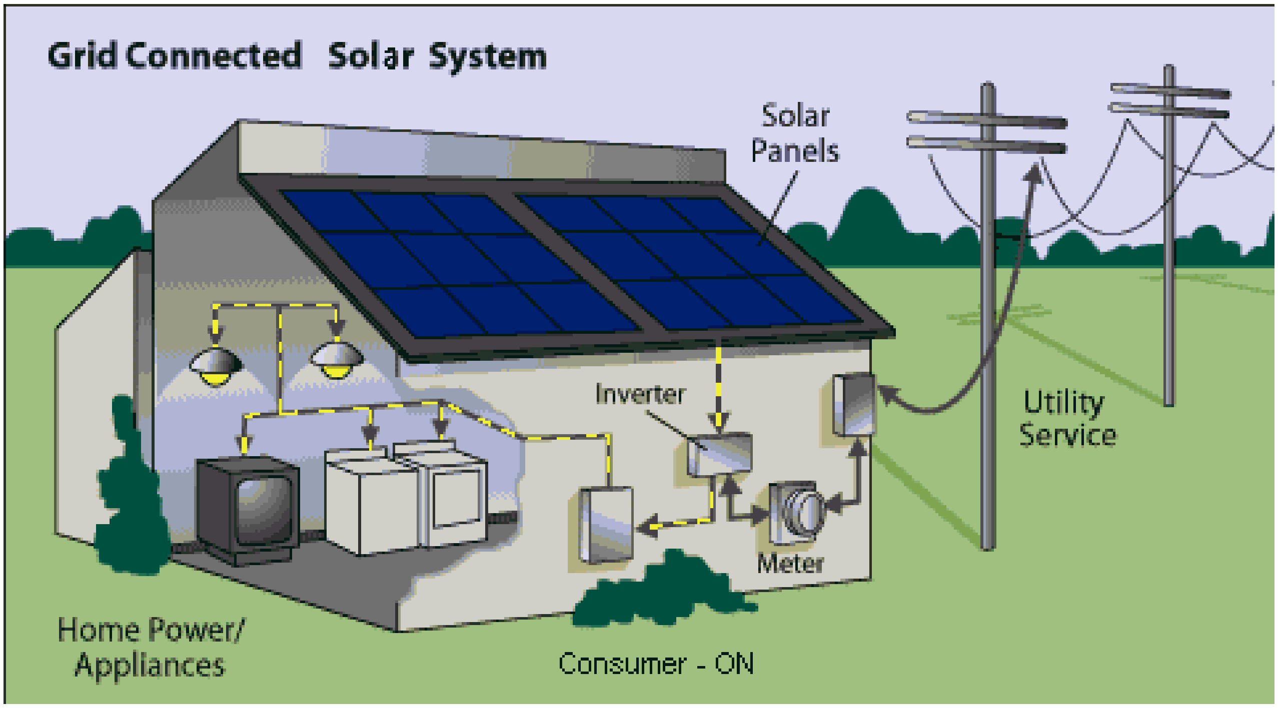

Fig 5: Grid-Connected Solar System

In order to supply electricity into a mains electricity system, the dc output from the module must be converted to ac at the correct voltage and frequency. An electronic inverter is used to do this. Generally a number of PV modules are connected in series to provide a higher dc voltage to the inverter input, and sometimes several of these 'series strings' are connected in parallel, so that a single inverter can be used for 50 or more modules. Modern inverters are very efficient (typically 97%), and use electronic control systems to ensure that the PV array keeps working at its optimum voltage. They also incorporate safety systems as required in the country of use. [3]

What are the benefits of grid-connected PV systems?

By reducing the need for fossil-fuel generation, grid-connected PV cuts greenhouse gas emissions (and other air pollution), because no emissions are produced during PV operation. In the past there has been concern about the greenhouse gases emitted ('embodied') in the manufacture of PV systems, particularly in the production of ultra-pure semiconductors. With current production techniques, these embodied greenhouse gases are saved within two to four years of use of grid-connected operation, depending on the amount of sunlight. [4]

PV is the easiest renewable electricity source to incorporate into buildings. The electricity is supplied at the point of use, thus avoiding the losses which occur in electricity distribution (these average 7% in the UK). It can be used at any scale – from less than a kWp on an individual home up to MWp scale systems on large public buildings - and is simple and reliable. Because of this, it is a valuable way to raise awareness of electricity supply and use, and helps highlight the potential for renewable energy. [4]

APPLICATION OF SOLAR PHOTOVOLTAIC PUMPS (PVP) AN INTEGRTATED RURAL WATER SUPPLY:

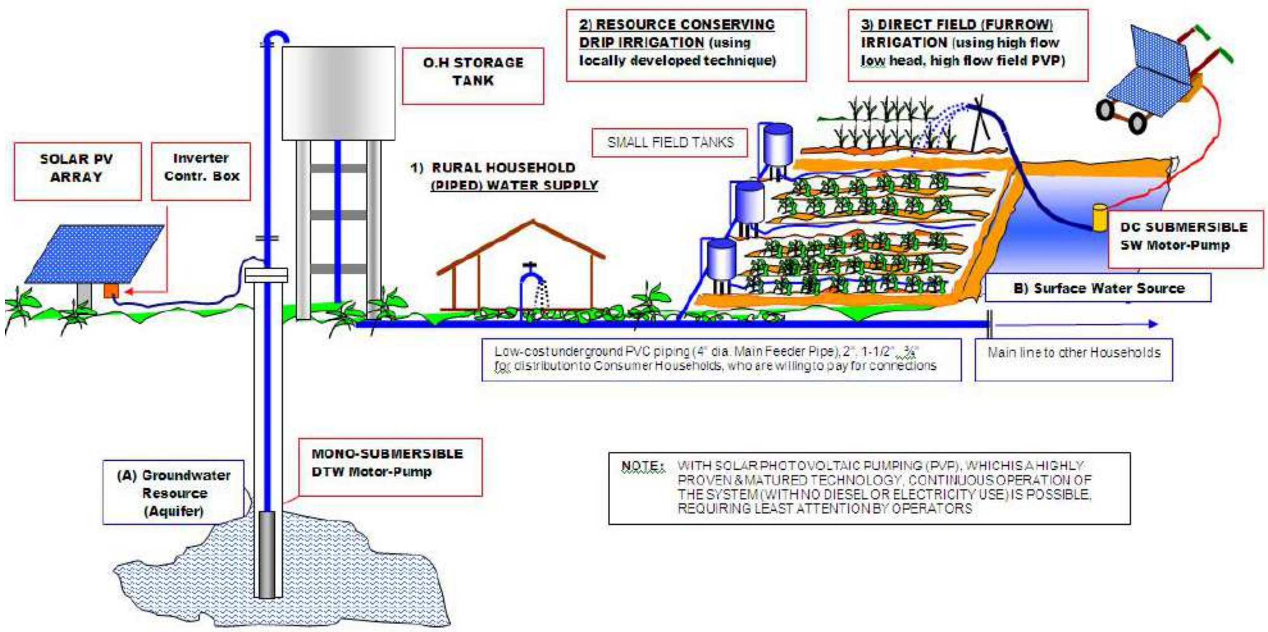

Fig 6 : APPLICATION OF SOLAR PHOTOVOLTAIC PUMPS (PVP) AN INTEGRTATED RURAL WATER SUPPLY & IRRIGATION PROJECT

IV. Conclusion

Maybe the utmost challenge in realizing a sustainable prospect is energy consumption. It is eventually the basis for a big part of the universal economy, and more of it will be essential to increase living standards in the developing country. Nowadays, we are mostly reliant on nonrenewable fossil fuels that have been and will remain to be a main cause of climate change and pollution.

Bangladesh will be the foremost victim due the climate change of the earth. So we should take the step 1st to protect the climate change. Photovoltaic technology alongside with other renewable energy will be a noble start. Such as Bangladesh is a land of cultivation and a large percentage of the water pump is operated by diesel for rural irrigation purpose it will be an operational step to interchange these pumps by PV pump at least in those areas where electricity facility is not available. These will help not to irrigate the land but also the electricity supply.

Presently, solar energy conversion technologies facade cost and scalability sprints in the technologies mandatory for a complete energy production system. To afford a truly extensive primary energy source, solar energy must be converted, captured, and kept in a cost-effective manner. New improvements in biotechnology, nanotechnology, and the materials and physical sciences may permit step-change tactics to cost-effective, universally scalable systems for solar energy use.

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