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Solar Powered Mobile Charging Unit

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Abstract: Mobile and other smart devices keep on running all the time anywhere and everywhere, draining its battery. Recharging mobiles need certain time and suitable place. Sudden shutdown of mobile phones due to lack of charge, creates huge embargo for people who is in rush to workplace, market, school, college, office, train and bus station and so on. It would be great if we could facilitate these people with instant smart device charging opportunity through renewable energy harvesting, which they can avail whenever they need, on the go. Several researches have been done so far to fulfill this issue of providing itinerant charging facility to smart devices. Among those developments, some are portable while others are stable large charging stations but the common feature among those is that power generation of these systems are fully or partially based on one or more renewable resources of energy for example solar, wind, hand crank generator driven by physical movement etc. Most of these are for public use but some can be intended for commercial purpose too. This article reviews the types/ varieties of renewable sources that have been used for development of portable or stationary mobile charging stations, along with the features the system comprises.

Keywords: Renewable energy; Charging station; Portable power supply; Solar canopy mobile charging station.

I. INTRODUCTION

Natural disasters such as flood, hurricane, tornado, and land sliding are violent, uncontrollable and unpredictable around the world. Bangladesh is not an exception in this aspect. During *Sidr'*2007, over 450,000 houses across 30 districts were destroyed [1]. 4 districts out of those 30 were marked as "severely affected" and further 8 was marked as "moderately affected" with an estimation of 2.3 million of damaged household [2]. According to a report of UNICEF affected no. of population was about 3.2 million [3]. Many people were without food, shelter, drinking water, sewage system and medical services for days, even weeks. The worst ever blackout took place as the national power grid collapsed. Total 26 power plants failed which took 2days to restore full supply and more days to restore power to southern districts. Moreover the entire telecommunication system went down during the *Sidr* attack [3].Even at present days, failure of power plants during disaster means power cut or blackout at coastal areas for couple of days even for week. After a disaster both public and private organizations conduct relief activities and supply food medicine, shelter and other life supporting products. Emergency medical services run on fossil fuel based generators to provide electric power when the utility grid is down. But that is for emergency use only; though use of fossil fuel is never a fruitful solution for producing electricity. Now a days, our daily living is technology dependent and connectivity of internet over mobile phone and overall telecommunication is as necessary as our prime needs. Smart phone gives us all the facilities we need through its various built-in applications or gadgets. To run smart phone or any telecommunicating device to get connected with the world, powering those devices is obvious because all of these devices use rechargeable batteries which need regular charging. So, we cannot think even for a day without electricity and situation gets worst during long load shedding. We must need to find a sustainable alternative way to produce electricity other than using traditional electric generators burning fossil fuel-based energy sources (Gas, Coal, and Oil) which is responsible for running down of fossil fuel reserves and harming environment as well as lives by greenhouse gas emissions together with other environmental concerns [4]. Renewable energy is obviously the one and only solution to this up growing crisis [5].

Bangladesh due to its geographical location, has abandoned source of solar energy rather than wind and other sources of energy. Solar radiation here varies from 4 to 6.5 kWh/m2 in various districts [6]. Government of Bangladesh aims to increase the share of renewable energy in electricity generation from 5% to 10% by year 2021 and for that, it was planned to generate 1,740 MW of additional power from solar only [7] [8].

To replace conventional energy sources, solar photovoltaic systems has been given highest priority as the most effective among all other renewable sources of energy [7]. Solar systems are highly reliable and have almost maintenance free setup. However the limitations of higher investment cost and lower energy conversion efficiency lagging behind its potentials to come in front [8]. Solar energy is a harmless, abandoned source of energy getting involved into newer applications of our daily life. This paper reviews some of such applications of solar energy; where solar powered charging units are developed to be used as emergency response power supply unit.

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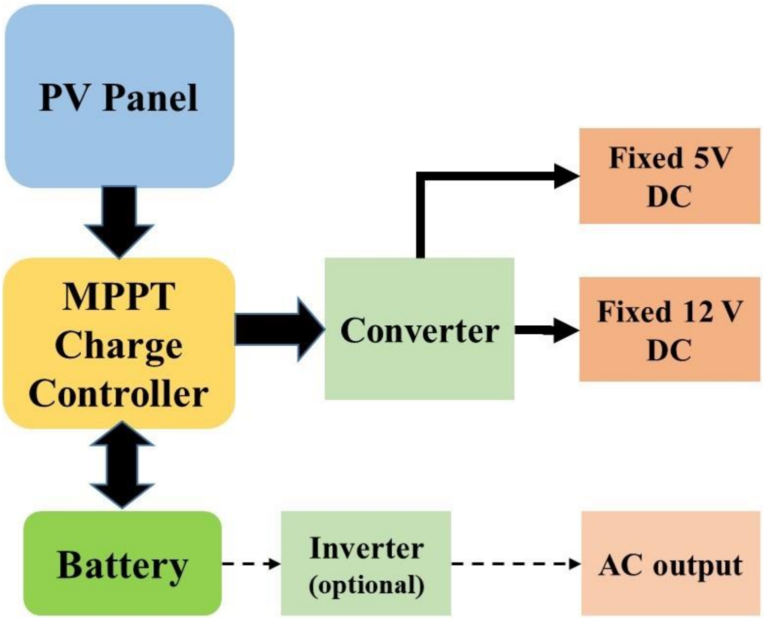

Fig. 1. Block diagram of general system configuration

Solar powered charging systems in general have some common features whereas, inclusion of additional features depends on system output and demand, system location and solar hour of installation area. In general all the solar system have some features in common as shown in fig. 1. These are:

- Solar Photovoltaic: A solar cell, also called photovoltaic cell, is a device that directly converts solar radiation into usable electricity based on the photoelectric (or photovoltaic) effect [9]. The total capacity and no. of solar panels need to be installed depends on the power required from the system.
- Charge Controller: A charge controller performs regulation of voltage and current in between solar array and battery and keep batteries safe from overcharging and prevent deep discharging [10]. Thus it helps to extend the battery lifetime, also.
- Battery: Lead-acid batteries are widely available, comparatively cheap but because of its heavy weight, liquid electrolyte and frequent maintenance requirement, those are suitable for large, stable charring stations. Lithium-ion batteries are expensive but yet it is best for both portable and stationary solar systems for its dry, portable and maintenance-free electrolyte and longer lifespan.
- Inverter: Solar system outputs DC voltage only which can be converted to AC by using additional inverter and AC loads can directly be charged through the system. Large systems involve charge controllers of bigger capacity with built in inverter facility.
- Converters: Use of converters depends on output voltage requirement.

II. RESEARCHES DONE EARLIER

A number of researches have already been done based on the theme of using solar energy to charge small but essential portable items, on the go. Researchers portrayed several ideas to implement stationary or portable solar charging station for using as an alternative to grid power. Each invention has different dimension and application. Depending on the application, a range of electric equipment have been used. For convenience, a classification (tree) has been portrayed in fig.2, categorizing such studies done earlier around the world in possible sections and sub sections.

Our main focus is to study various ideas of using solar energy for smart phone /device charging all over the world. Matter of portability has been taken as first distinguishing criterion. According to those, charging units can mainly be of two types: Portable or stationary.

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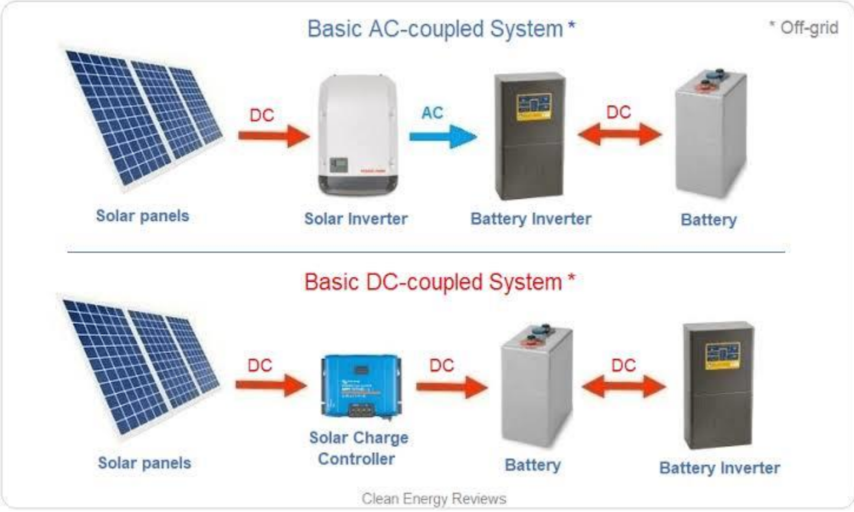

Fig. 2. Probable classification of solar powered charging unit

A. Portable Solar Mobile Charging Unit

a) *Hybrid/ Dual Mode mobile Charger*: Charging smart devices while travelling has always been a challenge. Solar panel can serve the purpose during sunny days but cloudy weather or in absence of enough battery storage can create major hindrance in the way of power generation. As a solution to this problem, Atiqur Rahman et al., in their paper "Portable Dual Mode Mobile Charger with Hand Crank Generator and Solar Panel" have carried out an awesome idea and developed dual mode portable mobile charger, combining two sources together namely, solar panel for using during day time and hand crank generator to use at night or when solar insolation is not available [11]. They used DC generator of 12V/600mA, connected with gear train driven by direct physical movement of hand crank. Solar panel of 6 watt (6V/500mA) produced DC power enough to charge 1000mAh battery of Nokia handset (Model 1208) fully within 2 hours. Blocking diode was used to protect solar panel and generator from reverse voltage coming from battery. Whereas current limiter was also used to save the battery from accidental huge current. The circuit includes rectifier that converts AC power to DC so that mobile phones can be connected easily through charging port for DC battery charging [11].

Another solution to this problem has been given by Pawan Vijay et al., in their paper "Wind and Solar Mobile Charger" where they have shown that both wind and solar units work efficiently together as renewable source in replacement of expensive portable chargers. Authors used Dynamo to convert rotational (mechanical) power of wind turbine into electrical power (DC) through commutator. Dynamo was able to produce voltage ranging from 8V to 10.5V for turbine rpm 280 to 380 respectively. According to the study outcome, wind generator could produce 9V. On the other hand, 12V, 5-watt solar panel was used generating max 16.5V at 400 mA when the sunshine is at its peak [12].

b) *Only Solar powered mobile charging unit:* Portable solar charging system can be carried anywhere and can be used to serve several purposes. Design, equipment, construction and implementation of the system can vary based on application. A system can only be designed to provide DC power without including converter or a system can serve both AC and DC power with the addition of a simple converter. Some systems can only be used at day time without having any large battery backup on the other hand system can be designed to use both during day and night time with large battery storage supporting 2/3 days of autonomy. According to the system output or type of application solar powered mobile charging unit can be subdivided into following categories:

i. *Only DC output :*

• *Without large battery storage for longer backup hour*: Hribhu Chowdhury and Md. Tazul Islam have developed a multiple battery charging system containing solar panels connected directly to rechargeable batteries; storing energy to those by fetching abandoned solar energy [13]. Later the fully charged batteries can charge batteries and devices of variable voltage requirement. For example, it can charge cellphone batteries of 5V and 3.7V and pencil batteries ranging from 3-9V. This charger might also come in handy to charge other type of batteries such as automotive batteries and IPS. Salim Mudi in "Design and Construction of a Portable Solar Mobile Charger" has constructed a solar charger that outputs voltage of 5V and an average of 800mA current and with that capacity it can charge a 4800mAh mobile phone battery fully within 4-5 hours. A blocking diode has been used as rectification unit to ensure unidirectional current flow from backup battery to mobile and not in reverse direction [14].

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In “Solar Powered Mobile Phone Charger for Farmers” authors have developed a hat/cap system solar mobile charger for outdoor workers like farmers, labors, rickshaw puller etc. A single hat containing 30 polycrystalline silicon solar cell arranged in a special way to produce required current to charge a mobile phone used by outdoor workers. A single solar cell has maximum power capacity of 0.172W and maximum voltage of 0.512V. Authors took the measurement of current and voltage during the charging of mobile phone via Bluetooth module remotely. Practically, the solar hat/cap showed promising performance by charging a mobile phone of 900mAh capacity, from 7% to 67% within 105 minutes [15]. Another project work was done conveying the idea of portable solar cap that is wearable and can charge mobile or rechargeable batteries (power bank) on the go. Authors of “Design and Construction of a Portable Charger by using Solar Cap” have constructed and tested the system. According to the authors, the amount of time solar cap took to charge a mobile phone fully is almost same as the time the phone requires to be fully charged from utility grid/ main. Moreover, after charging the device fully, battery or power bank was connected to the same USB port to store charge for further use [16].

Backpacks with mobile or other smart device charging facilities are now been used widely and getting popular day by day. The system can be sustainable, environment as well as user friendly and economical if solar energy is harvested and stored in rechargeable batteries and then further used to charge mobiles while walking or carrying the backpack. Both harvesting and charging can be done simultaneously and that is too while the user is walking or doing something else. This idea of solar backpack mobile charger was executed by Mojisola R. Usikaluet al., in “Design and Construction of Backpack Mobile Charger” [17]. During their experiment, solar cells of 5W and 12 V were glued above the backpack and found to power the circuit with maximum output voltage of 12 V at no load and 11.25 V under load condition. At the mobile charging end voltage found to vary from 4V – 5.1 along with peak current of 240 mA. With that output, mobile charging was found good.

• *Both direct and back up charging with large battery storage:* In a research project funded by Research and Training Center (RTC) of Patuakhali Science and Technology University (PSTU), a small Solar Powered Portable Charging Unit (SPPCU) has been developed and tested [18] by Chowdhury et al. System was designed considering to be used as emergency response for disaster prone areas or long term power cutoff situations created by natural calamities. People of Bangladesh, living in coastal/rural areas generally face after effects of natural calamity more terribly or as usual load shedding occurring more frequently; as compared to people living in city areas. Developed system is a completely portable, compact wooden hard case

containing 30W solar panel bolted at the top, where panel itself acts as cover/ roof for the case, a 14 Ah LiFePo4 battery, a charge controller and a mobile charging USB port with built in converter (12v to 5V). System includes voltage regulator with display circuit to adjust output voltage from solar panel to any value between 1-12V, and thus it is capable of serving a wide range of DC electric appliances.

Fig. 3. Solar powered portable charging unit [18]

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The upper part of the hard case can be opened and inclined to any angle required to obtain maximum solar insolation. The system charging efficiency has been tested for two types of mobiles (smartphone and button phone). The system includes a battery that have capacity to serve for longer backup hour and also have controller that can deal with power more than installed.

So, it's possible to run other household small electric appliances on demand. System is small sized and light weight. Moreover, it carries expensive but space saving, low maintenance, deep discharge Li-ion battery with better longevity which makes the system almost maintenance free and user friendly.

ii. *Both AC and DC output:*
Authors of the paper "Emergency Portable Solar Power Supply" have suggested Emergency Portable Solar Power Supply (EPSPS) which Provides electric power to various loads by harvesting and storing solar energy. Apart from regular solar systems, the EPSPS provides both AC and DC (USB) power with the help of an added relay board/ switch.
To ensure system monitoring, checking battery status and powering the system on/off remotely through mobile; system includes an Arduino Uno with Bluetooth module. According to the authors, the EPSPS can supply 100W of AC/DC power at 12V and can run for 2days without charging if the battery gets charged once for at least 6 hours [19].

Similar study was done by Wang et al. where they have designed a system which can provide emergency power (both AC and DC) to life saving medical utilities by harvesting and storing solar energy. That is, the system is able to provide both 12V AC power for emergency medical equipment like miniature PSA oxygen concentrator and 5V USB for electronic equipment (mobile phone, GPS device, rechargeable light, etc.) [20].

In the paper "Development of Portable Case Solar Battery Charger", authors have designed a portable solar charger unit that is suitable to carry away and AC/DC electric power can be drawn on demand [21]. Furthermore, the frame of the solar panel was designed to facilitate the inclination of solar panel in accordance with the position of the sun so that it can obtain maximum sunshine all day long. Along with portability, the system is capable of controlling the output voltage of solar panel with an additional variable resistor and can also show the battery voltage level with the help of an indicator circuit with LED display [21].

B. Stationary Solar Mobile Charging Unit

a) Hybrid dual source mobile charging station: Authors in "Wind and Solar Mobile Charger," have represented their system as portable hybrid solar charger. But the system as it has been shown, seems little difficult to be carried out because of its fixed type wind turbine with large stand. This type of hybrid system can be considered for large scale power generation. Windy regions receiving average bright sun hours can be benefitted much through this type of installation. There is huge scope to work with this theme [12].

b) Standalone / Only Solar sourced charging station:

• *Coin system solar powered mobile charger*
(Commercial purpose based on coin insertion): Solar powered mobile charging stations in public places can be used for educational or business purpose. Some experiments have dealt with charging mobile phones through solar energy on the basis of detection and measurement of the weight of inserted coin. In "Solar Energy Based Mobile Charger", weight of the coin is monitored and compared with the preset standard value, stored in the system. Atmel"s 89c52 microcontroller controls the whole operation of measuring, comparing and detecting of right coin. Controller also selects the type of the mobile inserted and depending on coin value, the system charges the mobile for a certain duration of time. It also shows charge completion message through LCD display [22].

While in "Coin Based Solar Mobile Charger" author Aparna D. Pawar [23] have under taken image of the inserted coin as detecting factor and through image processing by MATLAB, coin detection was done. On insertion of exact coin, system stores the coin in collection box showing message to plug in the mobile phone and charging proceeds according to the value of the coin. On the other hand, wrong coin gets rejected and goes to refund box. The microcontroller used in the system which controls the whole procedure is ARM 7 TDMI with large storage capacity. Similar study was done by authors of "Mobile Charger based on Coin by using Solar tracking System" [24] with the exception that their system adopts coin diameter as the detection criterion. ATMEL 89c51 a 40-pin micro controller has been used there to control the system performance. All the three researches of [22] [23] and [24] included solar tracking through LDR controlled by the microcontroller embedded in the system; for better, extended solar hour.

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- *Solar canopy mobile charging station without battery backup:* Smart mobiles are now indispensable elements of our current lifestyle. Smart phone comprises complex but powerful software and hardware circuitry for all of its apps or gadgets supporting its performance which causes a lot of power consumption. Use of data packet service which keeps on running even when the phone is not in use causing quick draining of battery and the people then suffer from low battery problem within a couple of hours after the battery was fully charged.

Thus, mobile goes out of charge state frequently at any time during day or night and users on the go rushes to nearby shops or restaurants to charge phones. Canopy solar charging stations can put an end to these sufferings where green solar energy will be converted to electrical energy which can be used to charge mobiles and other portable electronic devices. There are several installations of solar canopies abroad, without battery backup that supports mobile phone charging during day time only.

- *Solar canopy mobile charging station (with battery backup):* In "Design and Implementation of Solar Powered Mobile Phone Charging Station for Public Places" Udayalakshmi J K and Sheik Mohammed S have proposed a solar powered mobile charging unit containing two regulator circuits converting 12 V DC power from solar panel to 4V and 5V DC able to charge smartphone and button phone respectively [25].

Proposed system is a stable /stationary setup that can be installed in public place. The regulator circuit was connected to a DC source to test mobile charging efficiency and it was found good. Proposed system was designed considering 50W solar panel with 20 Ah battery storage. The design, development and implementation of the system was presented and discussed in the paper. The hardware part of the system was implemented and tested. Similar system was proposed by another group of researchers in "Solar Powered Charging Station" [26]. The idea was developed by students who estimated 100 w of 12 V solar panel with 70Ah of deep cycle batteries for the entire system. They proposed a bi – directional stepper motor for solar tracking, too. System also included charge controller and inverter. The proposed system could not be installed due to lack of sponsorship.

A Solar mobile charging station with large battery storage capacity that is capable of charging any smart device (Laptop, mobile, Tab etc.) through AC port or DC (USB); has been installed at Patuakhali Science and Technology University (PSTU) campus. Laptops used by students serve educational purpose mainly whereas smart phones or other smart devices can support learning partially or can be used for other purposes like social networking. Most of the solar canopy charging stations developed till date support charging of smart phones only (DC output) whereas charging of other smart devices specially laptops are truly necessary for students or working persons living in remote areas, suffering long term black outs.

The installed "Green Canopy Smart Device Charging Station" at PSTU campus by Chowdhury et al. includes 600W solar panel, 200Ah tall tubular battery which is of low maintenance with greater longevity, 850VA MPPT charge controller with built-in inverter ensuring maximum power conversion, storage with DC to AC inversion facility and other electrical entities like circuit breaker, outdoor socket protector board, motion sensor light etc [27]. System has enough capacity to charge 1 or 2 laptops, and 3 or 4 mobile phones altogether simultaneously along with that while charging 4-6 devices simultaneously, the system can also charge the storage battery at its required rate of charging current. Battery capacity has been installed so large that it can support 3 hours of charging during night (as long as students of residential halls are allowed to stay out) for 2 days of autonomy i.e.; the system has capability of providing uninterrupted power during cloudy weather continuously for 2 days (working hours only) if the battery gets fully charged for once only [27].

III. CONCLUSION WITH FUTURE PLAN

Advancement of renewable energy is the only way out to overcome the emerging energy crisis. Sunny places, bus stops, market places can be facilitated by installing solar canopy style charging stations. Even windows of train or buses can be partially covered by solar panels serving electric power to passengers while travelling.

Both sunny and windy places will be suitable for placing solar and wind hybrid systems. Such hybrid systems can serve for 24 hours, both day and night without the need of installing large battery storage. Office places can be equipped with solar powered, portable, emergency response charging units which can be used during load shedding.

This will save lots of money by reducing lot and will be inspired more to use renewable energy, saving generator usage that burns expensive diesel fuel and will grid power and keeping environment pollution free and genuinely save the environment from further pollution. healthy. Establishment of solar canopies more and more and use of portable solar charging unit will be a revolutionary idea of application of renewable energy. People will be benefitted a

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