SOLAR EV CHARGERS AND SUPER FLOW BATTERIES FOR AN EFFICIENT ELECTRIC VEHICLE

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Abstract— *Solar Energy is a sustainable source of energy, it is an infinite and clean source of energy that is free and ecofriendly. So it is a very efficient & free from environment pollution for surrounding. The problem is "Are electric vehicles an eco-friendly mode of transportation and can electric vehicles replace traditional vehicles in terms of pollution?" In this paper, I have reviewed Solar Energy that is produced from Sunlight and discussed the latest energy storage battery technique for BEV solar chargers. This paper gives an overview of advancements in Solar BEV Chargers and battery storage techniques for electric vehicles. The study shows that to replace BEV charging energy-based methods, solar chargers have been evaluated to be the best option. Solar Energy is one of the cleanest options available in the present time for automobiles. The cost of solar energy installation has constantly reduced which is motivating many people to invest in solar energy for various types of uses. As more and more EV's using Li-ion technology go into "thermal run-a-way" that means they burn up like a pack of firecrackers. Your new car will be a total loss. Using Super Flow Battery Technology this would never happen. Flow batteries are attractive and are perfectly suitable for their applications in electric vehicles. From the last many year's many government organizations and automobile companies and other stakeholders that are involved in the industry have explored various new schemes and opportunities to combine solar energy and electric vehicle. A new trend is introduced in the market that involves solar electric vehicle charging. With this, they not only aim to increase the use of an electric vehicle but also to find the best sustainable option to replace the depletion of fossil fuels.*

Keywords: Solar power generation; Photovoltaics; Solar PV; electric vehicles; energy storage; EV chargers;

I. INTRODUCTION

A large amount of sunlight that falls on the earth's surface is enough to power the whole world. The sun provides enough energy in one minute to produce the world's energy needs for one year.[6] The amount of sunlight that falls on the earth is about half of the total radiation. In the last 20 years, the price of solar energy has largely dropped. For example, the solar panel cost has decreased from about $26,000/kw in 1982 to about $2000/kw in 2019. Over the past many years, electric vehicles (EV) have gained a huge attraction because of their best alternative fuel and gas-powered vehicles. Since 2010, more than 1.4 million EVs have been sold in us alone by 2019.

Figure 1: Solar EV charging station

However, EVs require a charging station to charge their batteries. While EV's are a Pollution-free source of transportation, the electric power that is used to charge the batteries of the electric vehicles is taken from the regular fossil-fueled or coal power plants, which affect their appeal to be the eco-friendly mode of transportation. Recently, a trend was started to reduce this problem which used solar power to charge the electric vehicle and the designing of the solar-powered EV charging station as shown in **Figure 1**. It consists of solar modules to be installed on the rooftop of the charging stations, solar canopies on the top of parking stations. This will benefit the vehicle in two ways it will charge the vehicle as well as provide the shade to the vehicle. In this paper, I have reviewed how solar EV charger is beneficial and cost-efficient to the user and the environment and also I have discussed a new type of batteries which when combine with solar EV chargers can lead to a fast and efficient electric vehicle.

II. EXPLAINING GRID-CONNECTED ROOFTOP SOLAR PV SYSTEMS:

A. Solar PV

A solar PV system is an energy generation system that uses solar energy to produce power, it harnesses an amount of solar radiation and converts it into electricity using the photovoltaic principle. [7](pg. 1884-1888). The electricity produced by the solar plant can be stored, or supplied to the load directly or can be transferred into the grid using the net metering system. The solar power plant is the best clean and renewable energy source for household, commercial, and industrial applications.

There are two types of PV plants:
a) **Ground-mounted Projects:** In ground-mounted, PV modules are mounted on the ground instead of the mounting structure. All the components like inverter, junction box, and cables are connected on the ground.

b) **Solar PV Rooftop**: In rooftop-mounted projects, solar panels are mounted on the roofs of the buildings or houses using proper mounting structure instead of ground. It can be installed in any building whether it is commercial, residential, or institutional.

In grid-connected, the PV system is directly connected to the grid. The grid acts as a backup option when the PV system cannot produce the desired power, the extra power can be taken from the grid as shown in **Figure 2**, and when there is excess supply through the system, the power can be transmitted to the grid. PV panels, panel mounting structures, inverter as shown in **Figure 2.** [2] (pg 5)

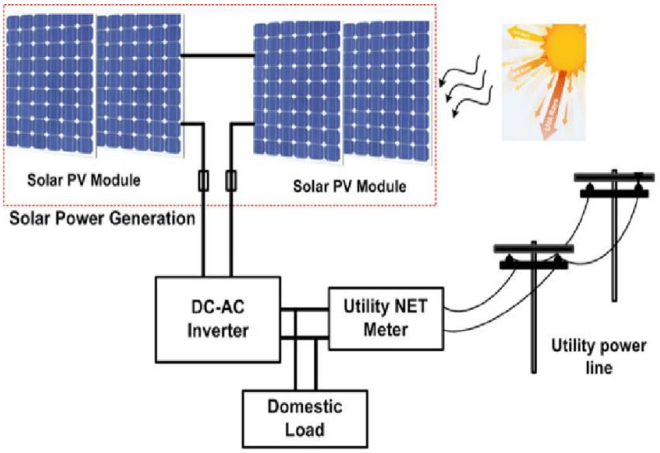


Figure 2: grid-connected solar PV system

B. The operation of a photovoltaic (PV) cell requires 3 basic attributes:

• Photovoltaic material such as silicon is used to catch the solar radiation that falls on the earth from the sun [1] (pg 4-5)
• The negatively charged particles or electrons gets excited when radiation falls on them. When it gets exciting, the current in the material starts flowing to cancel the effect, and this electricity is stored. As shown in **Figure 3** [1] (pg 4-5)
• An array of solar cells, known as the panel, converts the solar energy into the direct current (DC) electricity.

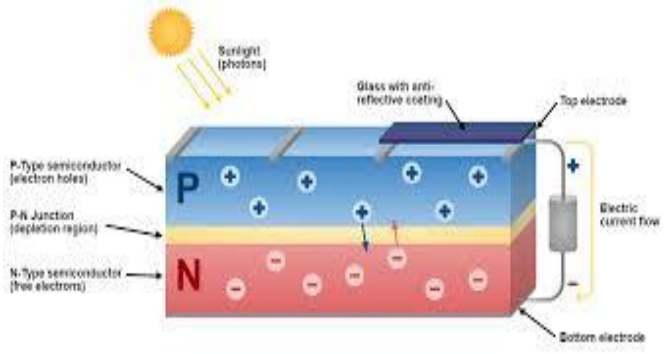


Figure 3: Internal of Reaction of Solar energy

C. Working Of Solar Energy

PV modules convert solar radiation into direct current electricity using the silicon material. The direct current then passed into the DC charge controller through the panel using the wires and then it flows into the inverter which converts it into the AC electricity. The AC electricity is then supplied to the ACDB from where it is supplied to the household load. The excess electricity generated is transferred to the grid using the net meter and vice-versa. [7] (pg. 1884-1888) (i.e. night) as shown in **Figure 4**. From this system connected to the inverter.

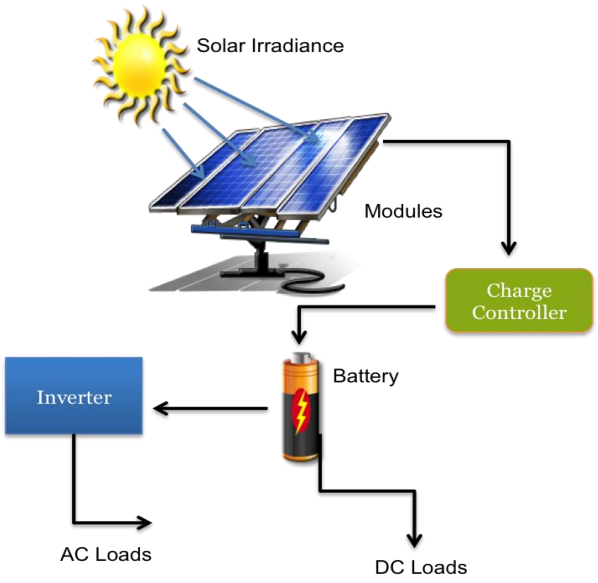


Figure 4: Working of the solar PV system

D. Modeling Of solar PV system (PV panel and components)

The solar PV system consists of many components ranging from solar cells to net meter. The no. of components are different in the grid-connected and stand-alone PV system. The conversion starts with the PV cell, which is a semiconductor material. It has two types of particles: the positive and the negatively charged particles. This cell technology is used in designing solar cells and a solar PV system with high energy conversion technology. The sunlight is absorbed by the photovoltaic cell and then the electrons get separated from it.
The following are the components of a solar PV system.

- ***Photovoltaic panel and array***

PV module consists of the solar cells which are made of silicon, the function of the solar cells is to convert the solar energy into electrical power. Generally, a solar panel consists of 72 solar cells which are connected in series. The solar panel is generally made of silicon and other materials such as ad cadmium telluride. And the efficiency is between 15-20 %.[3] (pg 8-9) When solar panels are connected in series they are known as a string. And when strings are connected in parallel they are known as arrays.

- ***Solar Inverter***

The DC energy which is generated from the panels is transferred into the inverter and then it converts the DC power into AC power. We usually use string inverter in the photovoltaic system. The inverter capacity ranges from 15 to 50 KW. [6] And having the operating voltage range up to 1500 volt. Inverters also perform energy monitoring and controlling functions in a solar system.

- ***Balance of System***

In a photovoltaic solar system, the solar panel is the brain of the system. All other parts which contribute to the functioning of the system are known as the "**Balance Of System**" usually denoted by the **BOS**.[6] (pp. 94-113) These will include wiring, mounting structure, fuse and switches, distribution boxes, etc.

III. PROBLEM STATEMENT AND METHODOLOGY

A. ARE ELECTRIC VEHICLES PURELY GREEN MODE OF TRANSPORT:

"EVs are not a solution to pollution. They just transferred the problem from the fuel to the chimneys. They are not the clean source of transportation unless and until green mode of power is used for charging purposes. The solution to this problem lies in renewable energy". From the last many years the term "**range anxiety**" has come into the view with the introduction of electric vehicles. But with the introduction of PHEVs, HEV's the term is replaced by "**charging anxiety**", because of the development of batteries which can store more energy within the same space. With the increase in pollution and the adverse effects of fuel vehicles, there is a continuous demand for electric vehicles, [10] which is going to be increased in the future.

An obstacle faced by most EV manufacturers and consumers is the availability of a plug point for charging when on the go. There positively may be an ought to move from the GRID primarily based charging stations to standalone off-grid solutions for charging. [4]

This issue can be solved by a simple technique that is to harness and use the huge amount of solar power that is easily accessible to charge our vehicles.[9] "**Solar EV Chargers**" are the solution to this problem. As you can see in **Figure 5**, how solar chargers can give a 100% pollution-free environment.

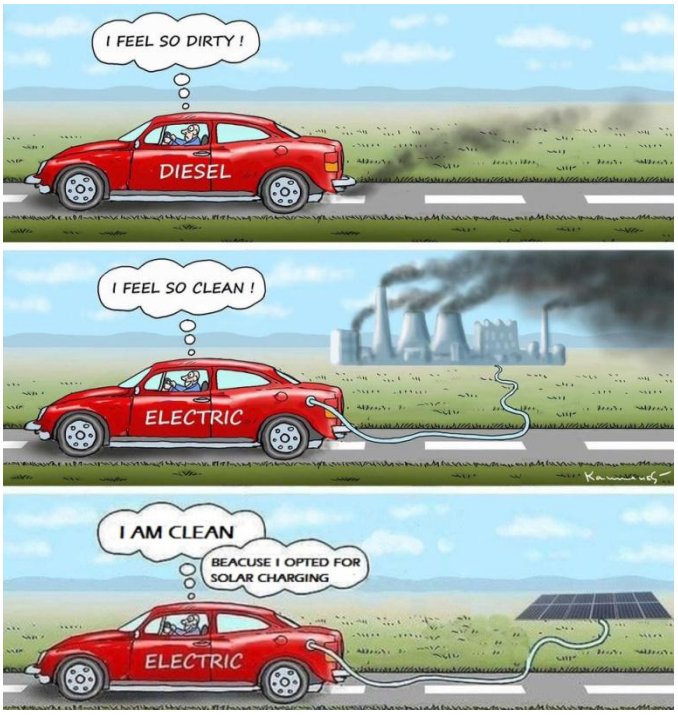


Figure 5: Electric Vehicle Vs Diesel Vehicle

The benefit of using Solar Energy as a source for battery charging for EV's:

- The average life that is defined for solar panels is no more than 25 years. And the components such as inverters and batteries may need replacement after 10-15 years after the installation.
- Solar energy is a clean and unlimited source available free of cost for the charging of electric vehicles.[12]
- The installed rooftop systems at home not only help saving electricity costs but also provide the convenience to control the charging schedule.
- A large percentage of solar panels could be recycled using different treatments after the end of their life, which makes it a cheap source of energy. The leftover could be used for a lot of other different processes. [10]
- The prices of solar installation have been reducing continuously, which is encouraging s lot of people to adopt electric vehicles and solar panels for a green mode of charging.

Some best techniques to increase the efficiency of solar EV chargers:

- The use of a mobile charging system with a rooftop solar PV system and canopies should be encouraged for charging the batteries of electric vehicles.
- The use of moveable and motor controlled solar panels that are attached with the tracker to provide more access to the sunlight at any point of the day. These motor controllers get the input from the microcontrollers and are very effective in providing access to sunlight.[5]
- The following is the use of microcontroller manufactured by Texas Instruments, model:- C2000, NXP P89V51RD2 [5] used in the solar mobile station:
  - It uses **MPPT controllers** which ensures the maximum efficiency of solar energy generation.
  - They help in storing the excess electricity that is generated from the solar PV system in the underground batteries.
- The microcontrollers used in mobile solar charging stations are programmed with a technique known as Pulse Width Modulation (PMW) which aligns the solar panels in such a way that they receive maximum sunlight.[8]
- The microcontrollers are also programmed to operate a bi-directional motor, which is used to control the solar PV trackers and can be tilted at some angle where maximum sunlight can be received.

Annual savings using a Solar EV charger:

Let us assume we drive a car 12,000 miles in a year.

If we go to a filling station for refueling, it just takes about 8 minutes only to fill up the tank:

25 miles per gallon;

$3.5 per gallon (as per US price)

$0.14 per mile

$1,680 per year

Whereas if we use solar EV chargers to charge the electric vehicle:

4,000 kWh per year;

$0.12 per kWh (as per 2019 tariff)

$0.03 per mile

$480 per year

You can save **$1,200 per year** from charging your EV with solar.

B. ARE ELECTRIC FAST MODE OF TRANSPORTATION:

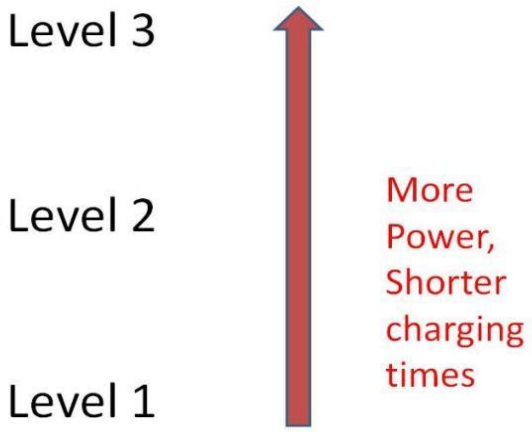
As the demand for electric vehicles is increasing day by day, the term "**range anxiety**" is now obsolete and a term has been introduced "**charge anxiety**".[13]

The Society of Automotive Engineers (SAE) has provided three different charging levels with respect to different charging conditions. They are known as level 1; level 2; level 3 or dc fast charging.

Figure 6: charging vs diesel station

- **Level I Charging**: Level 1 charging is similar to battery charging. It uses a standard household circuit with a power output of 120V. If we use level 1 charging to charge the electric vehicle, the battery can be fully charged in 8 to 12 hours, depending on the battery type and size. It is best suited at home and charged overnight.

- **Level II Charging**: It is also the same as level 2 charging, the main difference is of the output power. In level 2 charging the power output is 240 volt AC. It can charge the vehicle in 4 to 6 hours (depending on the size of the battery and power conditions). It is generally used at parking lots commercial charging stations to make fast and easy charging of the vehicles.



- **Level III- DC Fast Charging**: A level 3 charger is known as the DC fast charger and it is the fastest charging method than the other 2 levels. It uses a 480 V plug to charge the vehicles. And can be extended up to 500V. By using the DC fast charging mode the vehicle can be charged in just 20 – 30 minutes, depending on the size of the vehicles.

Fast charging is the latest method in the electric vehicle industry to overcome the problem of charging anxiety. Whether it is a road trip or everyday use, fast charging is preferred. A lithium-ion battery can be charged up to 80% in just 15 minutes with some conditions such as it doesn't get overheated. 15 minutes is much more efficient than normal charging options. And the average time to fill the fuel in the tank is 8 minutes with some conditions that there is no traffic congestion at the station. So, 15 is quite comparable.

So just imagine if you can charge your vehicle in just 3-4 minutes. And it can give you hundreds of miles. Here is the solution to the problem…

SUPERFLOW BATTERIES.

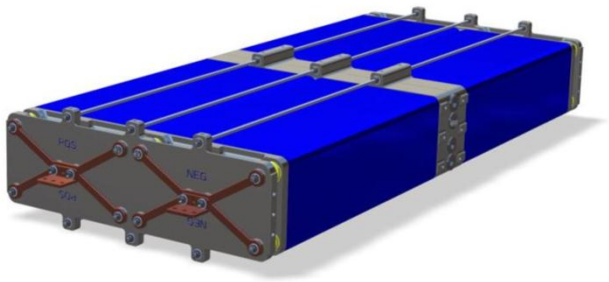


Figure 7: Super Flow Battery

Specifications of superflow battery:

- No degradation to the life of the battery. IP68 rating
- Charge in **~3-5 minutes** using fast chargers, and 30 seconds by replacing the discharged electrode with the charged one.
- The cycle life of the flow battery is very long and they do not require much maintenance.
- Flow batteries can be discharged and charged >10,000 times without replacing the Cells or the electrolyte.
- Because of the long cycle of life, the replacement is not needed every 5-10 years as in the case of Li-ion batteries.

As more and more EV's using Li-ion technology go into "thermal run-a-way " that means they burn up like a pack of firecrackers and burn so hot, that firemen have no choice but to let the Li-ion Battery burn out. Your new car will be a total loss.

Using Super Flow Battery Technology this would never happen. Super Flow Battery technology can control the reaction temperature and will never go into "Thermal Run-a-way".

Advantages of flow batteries:

- The capacity of the superflow battery or the power is dependant on the size of the electrode and is directly proportional to the size of the battery.
- The energy capacity of the battery is directly proportional to the size of the storage tanks.
- The design can be made according to the use or application.
- There is no chemical reaction between the electrode, hence they are more stable.
- They can be charged and discharged at the same time, without affecting the life of the battery.

Disadvantages of flow batteries:

- The system of a flow battery is very complex, a lot of components are needed such as pumps, sensors for temperature, and flow management system.

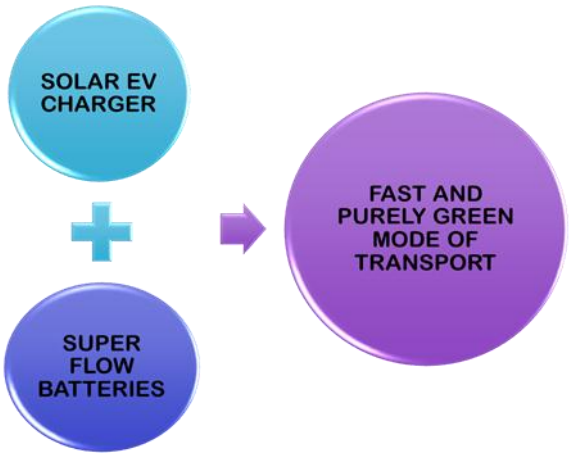
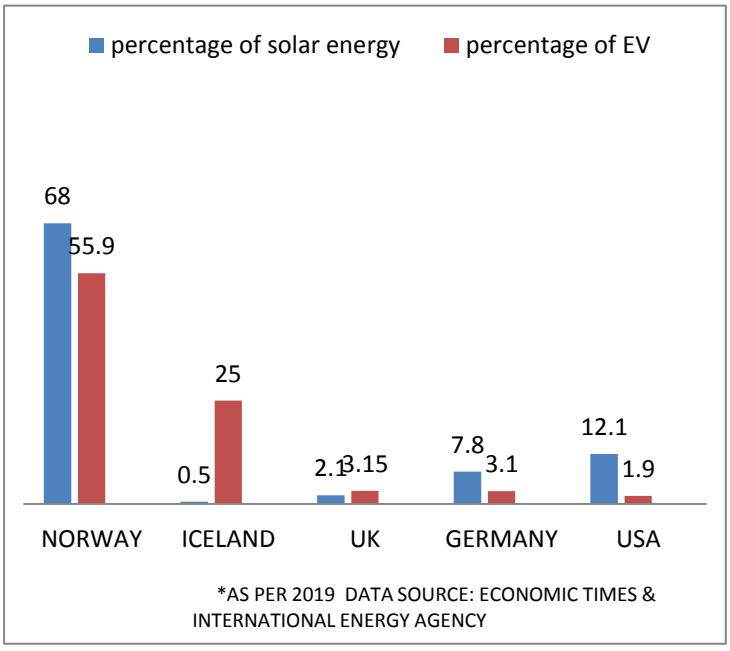


Figure 8: Combination of Efficient Electric Vehicle

IV. RESULTS AND FINDINGS

The installed PV capacity in the world is increased by 115 GW in 2019. In 2018 it was 17.5 percent less than that of 2019. Whereas, in 2020 the capacity is expected to be increased by 125 GW.[11] It is clear from the data that the solar PV installation capacity is increasing every year. The total capacity in 2019 was 594 GW, which is to be increased to 1583 GW by the year 2030, with continuous addition by China, USA, India, etc.

Table 1: Solar energy and EV graph



The Electric Vehicles Market is projected to succeed in 26,951,318 units by 2030 from AN calculable 3,269,671 units in 2019, at a CAGR of 21.1% throughout the forecast amount. The electric vehicle market has witnessed fast evolution with the continued developments in the automotive sector. Favorable government policies and support in terms of subsidies and grants, tax rebates and different non-financial edges within the sort of circle lane access, and new automobile registration (specifically in China wherever ICE engine new automobile registration area unit prohibited in some urban areas) the increasing vehicle vary, higher accessibility of charging infrastructure and proactive participation by automotive OEMs would drive the world electrical vehicle sales

V. CONCLUSIONS

Solar energy is at the top of the list when we talk about renewable energy resources. It is the most available energy source in almost every region of the world. In this paper, I explored the benefits of combining solar power and electric vehicles. The problem of pollution can be solved by installing solar charging infrastructure at parking lots and charging stations. The solar energy market has witnessed a continuous expansion over the last many years and is growing exponentially. With the combination of solar EV chargers and superflow batteries, both solar energy utilization and customer satisfaction will increase. And it will lead to sustainable energy development.

As per my results if solar energy is used for EV charging will lead to a great decrease in the depletion of fossil fuels, that were used to produce electricity conventionally. The study shows that to replace BEV charging energy-based methods, solar chargers have been evaluated to be the best option. And with this new battery technology more and more people will tend to buy electric vehicles, because of zero investment for charging purposes and time-saving.

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