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SOLAR CELL APPLICATION IN ELECTRIC CAR: A REVIEW

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ABSTRACT
This review discusses the development of the application of solar cells in electric cars. Electric cars work with the basic principle of driving the dynamo with an electric current that is stored with batteries. Solar cells in electric cars are applied to charge the batteries contained in electric car batteries. Car manufacturers are competing to produce and design a variety of hybrid cars to meet the need for renewable energy. The technology developed at this time is to maximize solar cells in electric cars. This technology also allows increasing the mileage of electric cars that use solar cells. The solar cells developed also try to be combined in the structure of the electric car framework. One of them is implementing transparent solar cells to replace electric car glass. Solar cells used in electric cars try to harvest the electrical energy from the sun as much as possible.

KEYWORDS: Solar Cell, Electric Car, Application, Renewable Energy, Battery

1. INTRODUCTION
Solar cells in electric cars began to be developed in 1955 as the first prototype of the idea of solar cell application in cars. Then in 2009, Toyota produced the first hybrid car combined with solar cells on the roof of a car named Toyota Prius (Riley, R., and Tate, J., 2016). Another manufacturer developing solar panels for electric cars is manufacturer Ford. Ford's C-MAX Solar Energy Concept in 2014 was the MVP of plug-in electric vehicles (PHEV) (Schamel, A., Schmitz, P., d'Annunzio, J., and Iorio, R., 2013).

Figure 1. Toyota Prius (Riley, R., and Tate, J., 2016)

Figure 1 showed a hybrid car from Toyota by applying solar cells to the roof and top of the engine.

ISSN: 2582-6271

Vol.1 No.5; 2020

Figure 2. Ford C-MAX Solar Energy Consept (Schamel, A., Schmitz, P., d'Annunzio, J., and Iorio, R., 2013)

Figure 2 is a hybrid electric car produced by Ford as an MVP concept car that uses solar cells on the roof of the car. The latest development of the application of solar cells for electric cars is the Hyundai Sonata Hybrid 2020, which applies solar cells on the roof of the car.

Figure 3. Sonata Hybrid 2020 (Shirk, M., Gray, T., and Wishart, J., 2014)

Figure 3 is a development of Hyundai hybrid cars manufactured in South Korea. However, there are also car manufacturers that apply almost 60% of solar cells to all parts of the car body, like car manufacturer Sono by producing the Sono Sion hybrid car in Figure 4 and is an electric car that can fill battery cells with solar cells. The roof, hood of the car and almost the entire body of the car are equipped with highly efficient monocrystalline solar cells. The car can travel at a maximum speed of 140 km/h. Fully charged battery power can be 250 kilometres with a charging capacity of 50 kW DC. The car weighs up to 1.4 - 1.6 tons including batteries.

Figure 4. Sono Sion 2018 (Joti, K., Dadhich, M., and Sirohia, 2019)

2. DEVELOPMENT

Development of solar cell applications in electric cars is still underway. As reported for the development of solar cells for Prius electric cars, solar cells are added to the structure of the car with thin and more efficient cells. From the results of tests conducted, solar cells can produce 3.0 kWh/m2/day where shown results can reduce vehicle emissions by 63% (Masuda, T., Araki, K., Okumura, K., Urabe, S., Kudo, Y., Kimura, K., ... and Yamaguchi, M., 2016). The application of solar panels in cars is limited due to constraints in space availability and high production costs (Song, Y., and Zhang, S. ,2019). However, it can be observed that solar panels can be useful for power generation in cars and the real benefit is that solar power generation will help electric vehicles to expand the range of its travels. The integration of supporting components for electric cars is sourced not only from solar cells but from plug charging and regenerative braking (Kanumilli, C., Singh, A., Ganesh, A., & Srinivas, M., 2016).

Plug-in charging typically, charging equipment for plug-in electric vehicles is classified based on battery charging rate. In addition, charging time varies depending on the battery level that runs out and the type of battery used. In this system, level 2 AC, a 230-volt power supply is used to charge the battery, which is usually used in residential, commercial purposes. Basically, a 230-volt supply can charge an electric vehicle battery up to overnight.

Regenerative braking is a mechanism, which converts the vehicle kinetic energy into electric energy by slowing down the vehicle. This increases the range of cars without pollution. However, the main drawback

ISSN: 2582-6271

Vol.1 No.5; 2020

of using regenerative braking is that it does not provide braking torque at zero or near-zero speeds. Therefore, mechanical braking is also used in vehicles.

3. ELECTRIC CAR TYPE

Basically, electric cars have categories designed for different purposes. This type of electric vehicle is in place for private cars or commercial vehicles of public transportation. Here are the general categories of electric cars used now.

3.1 Start-Stop

The motor is stopped when idle in this type of electric vehicle and restarted when necessary. Around 2-4 percent of fuel is saved by this kind of implementation.

3.2 Hybrid

The engine fails when there is a slowdown and totally fails in a lightweight hybrid implementation. There is also a recovery of light energy when applying the brakes. On small on-board batteries, this energy is stored. The initial power supply is also tiny due to the weak on-board battery. Around 10-15% of fuel is saved by this method. Electric motors are used to provide electric launch and pure electric drive at low speeds in a complete hybrid architecture. The internal combustion engine, therefore, is reduced in scale. The use of full regenerative braking is also present. Fuel production is improved by 20-35 percent by this kind of method.

3.3 Plug-in Hybrid

An advanced form of a total hybrid electric vehicle is a device. Many elements of this nature are the same as fully hybrid electric vehicles. The vehicle will operate in load depletion and cost restraint mode in this form. The pure electric drive is used during the charge depletion mode, reducing fuel consumption by 40-60%. Fuel consumption is decreased by 20-35% when in the cost restraint mode. In this type of electric vehicle design, the size of the mounted battery is important for the Plug-In Extended Range Vehicle (PERV). This type of vehicle can run, even at higher speeds, in full electric drive mode. There is no fuel consumption during the full-electric mode. However, the battery is only ideal for short journeys.

3.4 Pure Electric Car

No internal combustion engine is needed in this kind of vehicle. The batteries used have a large capacity in this type of vehicle. Batteries ranging from 40 to 100 kWh are usually used to power electric vehicles of this type.

There are two common architectures that can be used for hybrid electric vehicles to build and run. In

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Vol.1 No.5; 2020

certain instances, the combination of these two architectures can also be used. Electric vehicles that incorporate solar panels are hybrid electric vehicles for the time being. This is because the device supports other innovations that are still being further developed.

4. SOLAR CELL CAR SYSTEM

The SPEV (Solar-Powered Electric Vehicle) component has many essential components needed to run the SPEV. Some important components are shown in Figure 5 and Figure 6. An explanation of each component is provided in the following subsections.

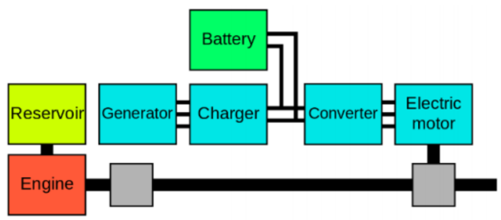

Figure 5. System Diagram Blocks

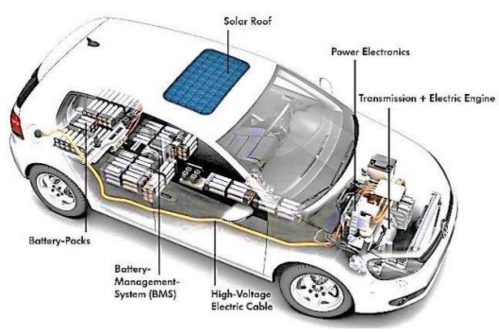

Figure 6. SPEV Components

4.1 Battery

The battery used to drive the SPEV varies from the batteries for the SLI (Starting, Illumination, and Ignition). SPEV batteries are designed for longer periods to provide more power to the electrical system. The battery is used in charging support mode or charging depletion mode. The SPEV battery pack is a mixture of series and parallel-connected cells. In battery packs, individual cells used are made of different anode and cathode materials. The battery used most frequently is lithium-ion batteries.

ISSN: 2582-6271

Vol.1 No.5; 2020

4.2 Electric Motor

An electric motor is an electromechanical device that converts electrical energy from batteries into mechanical energy to drive the wheels. The electric motor used in most EV is a 3 AC induction motor. There are two main parts of the induction motor, stator, and rotor. The stator consists of several slots where the reel is carried out with a wire conductor. Rotations are performed in such a way as to produce a rotating 3-phase magnetic field when the air conditioning supply is connected to them. The rotor of the motor is a cylindrical core with a slightly tilted parallel slot for the conductor. When the AC power supply is given to the stator, the rotating magnetic field is produced in the circuit due to the electromagnetic field (EMF) induced in the rotor. Therefore, the rotor begins to rotate in the same direction as the magnetic field (Gurung, A., and Qiao, Q., 2018).

4.3 Motor Controller

A control device that controls electric vehicles is a motor controller. At any given time, its primary function is to provide the motor with power. The performance of vehicle engines, battery packs, operators, etc. are also tracked and retained. By modifying the output aspects of the battery and motor, the motor controller helps to achieve the optimal EV effectiveness (Gurung, A., and Qiao, Q., 2018).

4.4 Inverter

The inverter is an electronic power system that transforms energy, stored in a battery, from a DC into an AC, which is then used to drive an electric AC motor. It also automatically matches the voltage in the key control set to be added.

4.5 Solar Cell

Solar panels are a mixture of modules known as solar cells, which are smaller. To produce electricity from sunlight, solar cells can utilize photovoltaic effects. In solar cells, the conversion of energy takes two steps. First, light is absorbed by semiconductors, cell materials and pairs of electron holes are formed when sunlight is shed on PV cells. As electrons and holes are separated, electricity is produced. The electron goes to the positive electrode, and the negative electrode goes to the vacuum. In the form of p-n junctions, most PV cells use semiconductor materials (Humada, A. M., Hojabri, M., Mekhilef, S. & Hamada, H. M., 2016).

4.6 On-board Charging System

To charge the engine, the device is used. To charge the battery fast and efficiently, plug-in power sources are connected to this device. With a contract stop or a rechargeable charge at the station, the power source can be connected.

ISSN: 2582-6271

Vol.1 No.5; 2020

5. SOLAR CELL CHARGING

The development of electric car charging stations was also developed. Stations are designed with resources derived from solar cells. The technology has also been applied to several major countries. Economics also takes on the role of electric car hatching by charging free on charging with solar cells built in strategic buildings such as malls and offices.

Figure 7. Charging Station

Continuous electric vehicle charging to recharge the car battery. Workplaces such as factories, office buildings, and industrial areas are great places to allow solar energy replenishing were areas under rooftops, and car parks can be used to install photovoltaic panels. The resulting power is used directly for charging, without the need for a storage system.

Figure 8. System of Charging Station

Due to variability in the properties of PV generation, network connections are essential to ensure reliable power supply for vehicle charging. In general, employee vehicles remain there for 6-9 hours in the parking area and the long charging period results in fewer EV charging requirements and also paves the way for network support through vehicle-to-grid (V2G) technology. While in off-grid systems, vehicle-to-home (V2H) technology is possible (Khan, S., Ahmad, A., Ahmad, F., Shafaati Shemami, M., Saad Alam, M., & Khateeb, S., 2018).

6. SOLAR CELL CAR IN INDONESIA

The development of electric cars in Indonesia with solar cells has been developed. In Figure 9, an electric car named Widya Wahana was displayed by Institut Teknologi Sepuluh Nopember Surabaya (ITS) team in 2015. This type of car is a hybrid car that can be used in electric plug-ins. Widya Wahana V is equipped with solar cells that can generate electrical energy to run Brush Less DC Motor (Nugraha, A., 2017; Hidayanti, F., and Adi, K.A.M. (2020).

Figure 9. Widya Wahana V Car

This electric car has a load of 290 kg and can be charged by one driver. Its cars can travel at 90 km/h.

7. CONCLUSION

In summary, the development of solar cell applications in electric cars attached to hybrid cars. The main reason is that solar cells have not been able to fully replace the charging needed to completely replace the car with fuel oil. However, the rapid development of solar cells in terms of economy and technology allows integrating solar cell systems into hybrid vehicle systems. Similarly, the development of cars with solar cells developed in Indonesia.

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Vol.1 No.5; 2020

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