# Exploration of the application of solar energy technology in the field of new energy vehicles

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**Abstract.** Due to the harsh effects of fossil fuels on the world, researchers are paying more attention to the application of new energy sources. This paper explores the possibility to support electric vehicles with solar energy by demonstrating the design of a solar cooling system and a solar parking lot in a large flat area and workspace. The use of solar energy in electric vehicles can help control some systems such as cooling systems. Solar panels are used in some large flat parking area to collect and invert solar energy for parking electric vehicles' charging. Solar panels are able to help charge electric vehicles during the workday by setting them on the surface of working area. However, due to the limitations of solar energy, solar panels are very much in need of good weather and direct sunlight. Therefore, solar energy cannot be the only source to support other powered vehicles. In the future, developments in other areas such as inverters and converters, solar panels, and nanotechnology may make the use of solar energy in green energy vehicles possible.

**Keywords:** Solar energy application; Electric vehicle; Solar charging system.

## 1. Introduction

Fossil fuels are the main source of energy consumed globally due to their low cost of development and use. It is estimated that about 74 percent of the global population depends on energy provided by the combustion of fossil fuels [1]. However, there are negative impacts associated with fossil fuel use, such as too much carbon emissions caused by burning fossil fuel and leads to global warming. To maintain ecological balance and save human health, people start trying to attempt energy transformation to shift the main source of energy from fossil fuel to green energy, which has less impact to the world. As one of the energies use that is close to lives of people, the energy transformation of automobiles has always been an important concern for scientists. In that case, the application of solar energy on the vehicle has become a hot topic.

As a green resource with great development potential, people have already started building solar power stations to collect solar energy. The most recent research of solar energy vehicles is focusing on create photovoltaic system on its roof, hood, or some other place of the car [2]. However, limitations on solar panel area and potential dangers make it difficult to use solar energy as a direct energy source for new energy vehicles. Therefore, some people choose to utilize solar energy to assist other power systems of new energy vehicles. For example, in order to reduce the consumption of electrical energy, solar cooling system is introduced in the car cabin [3]. Another example is that in order to reduce the vehicle's energy cost, solar power could be applied into the system according to the advantages and disadvantages of solar energy.

Except the direct application of solar energy to the vehicle, some scholars have also tried to start from the perspective of solar energy as an auxiliary energy source such to charge other energy type vehicles. Since the basic method to directly collect the solar energy is to use the solar panel, some research works on the possibility of rooftop photovoltaic. Which use the building surface around the charging station to expand the solar energy collection area to improve collection efficiency [4].

Combined with the above information, this paper is going to discuss the solar power's direct and indirect application in green energy vehicles area, then analysis the possibility of solar energy work as alternate energy source in electric energy-powered system and work as energy supply sources for car charging stations based on current research and its future development.

## 2. Solar energy as an energy support for electric drive systems

With the advancement of technology, it is not difficult to collect solar energy using solar panels. However, since it is impossible to cover multiple solar panels together to improve efficiency under the same area, it still needs to use a lot of area to collect the solar energy needed for a solar energy-powered vehicle. Therefore, it is tricky to only solar energy to drive a vehicle. It is well known that electric vehicles store enough electricity from charging stations in advance to drive the car. The electrical energy stored in the battery is the only source of energy for the energy consumption system of the new energy vehicle (including auxiliary systems such as the air conditioning system). These auxiliary systems will consume more power. Therefore, one of the applications of solar energy to the electric vehicle is to use solar energy to help drive those auxiliary system.

### 2.1. Mechanism of solar energy in electric vehicles

The main idea of using solar energy in the electric vehicle is to apply the solar panel to the cars and store energy in the vehicle. And the energy could be controlled to use in different vehicle system. Pan et al. [3] gives a design about the use of solar energy to control electric vehicle cooling system (Figure 1). In this design, the solar energy mainly be collected by using four pieces of solar panel. Those solar panel could change their angle based on the direction of the sun. To control the best angle to capture the solar energy called Solar Collector Mechanism (SCM), which works in direct current (DC) motor. The solar panel could be folded when it's not been used and expand to be used. The collected energy will go through wireless power transfer unit and connect to DC/DC converter. In the converter, the converter can send the electricity directly to the cooling device or send to the controller to control the cooling device. When the vehicle is in the outside, the solar panel could be controlled to expand to collect the solar energy, while the solar energy could be stored into the capacitor. While temperature sensor detects the temperature is higher than set temperature, the cooling system could be opened and start cooling down the interior temperature. However, in this design, the solar energy could be stored in a super capacitor or directly be used in the cooling system. However, those stored solar energy cannot be used to charge the electric vehicle. The efficiency of solar panel is limited with terminated area, which means it may not be able to output the useful energy for electric vehicle's motor. The peak-produced power from the solar panel is only 2.181W while the resistances stay at 3Ω or 5Ω [3]. Which is too low to be used in the electric vehicle's motor system. However, this efficiency is enough to be used in cooling systems.

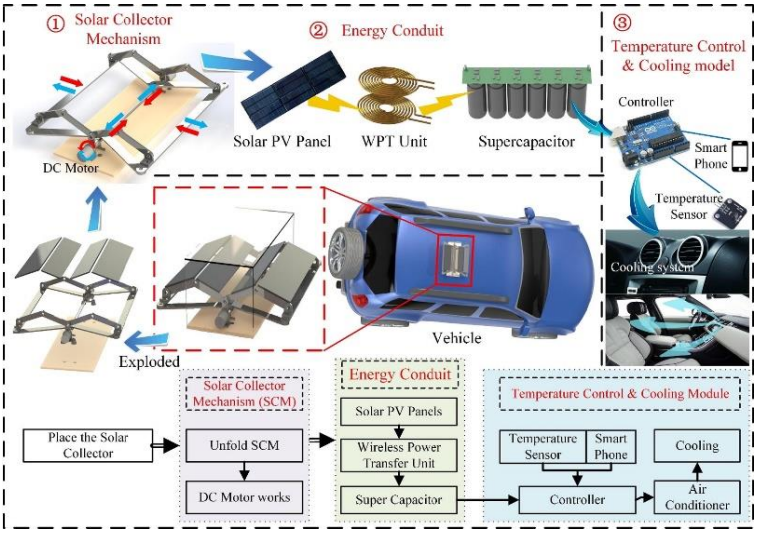


**Fig 1.** A principle of solar energy-controlled cooling system of electric vehicle [3]

### 2.2. Problem facing today

The solar powered-cooling system in electric vehicle shows a great possibility of being put into use. However, this system should be considered with the driving environment. In some cities with

high building that might block the sunshine, the solar panel cannot collect the energy with normal efficiency. Naveed ur Rehman analyzed the possibility of solar energy applications in public bus [5]. The results shows that it's possible to use PV panels on rooftops of buses to achieve the demand for its electricity. But the actual application needs to consider the volume of solar radiation in common bus routes. Except that, the weather could also affect the efficiency of solar panel. Therefore, to ensure the efficiency of solar panels in different environments and weather can always be sufficient to support the use of AC systems in electric vehicles become a major issue.

## 3. Solar energy as energy supply for charging stations

Although it's not enough for stored solar energy in supercapacitor to be used in vehicle motor system, solar energy can still assist the electric vehicle in other section. Electric vehicles need to be charged everyday because of the battery limitations and the charging time varies depending on different electric vehicles. Based on the research, electric vehicle charging time could be separated in three period: 8 AM when the workday start, lunch time when people are having meal outside and afternoon when people finished their work [6]. In those three periods, two of them happened during the day, which makes it possible to charge electric vehicles by solar energy. Therefore, the application of solar energy could be considered on electric vehicle charging station.

### 3.1. Mechanism of solar energy in charging stations

The basic idea of the solar energy-charging station is to install solar panels at the locations in open parking lots, where solar energy can be collected. During the day when the car come and park in the parking lots, the solar energy could be collected and directly charge into electric vehicle. Those solar energy could be stored or directly supplied to parked vehicles. Because larger and flatter spaces are more suitable for solar panels to collect solar energy, some large shopping malls, parks or places with large flat ground parking lots can reduce the chance of solar panels be blocks and help improve energy collection efficiency. Those design work in large area also consider the application of electric grid [7]. Based on that idea, Raquel Figueirdo et al. [8] gives a design of solar parking lots (Figure 2).

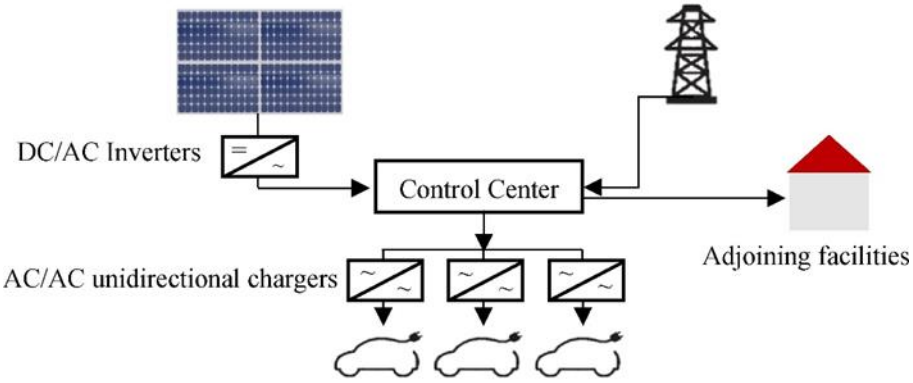


**Fig 2.** A simple system design for solar energy parking lot system [8]

Raquel et al. [8] separate the whole system to five parts: solar energy collection, system control center, electric grid, vehicle charger and some nearby buildings. In solar energy collection, the photovoltaic system contains DC/AC inverters to invert the direct current generated by solar panels to alternating current for electric vehicle. The inverted AC will run through the control center, which can control the direction of energy based on the energy management strategy management system. The energy could be controlled to charge for electric vehicles through the AC/AC unidirectional chargers or recovering excess energy for adjoining facilities. In this design system, the photovoltaic system mainly serves for charging vehicles. If there are lots of extra energy, the power could be celled to other facilities locates nearby. Moreover, this system can also buy extra power from electric grid to support the charging once the energy from solar panel is not enough. While the vehicle come into the parking lot, it could be directly charged. On the other hand, while the solar power is not enough,

the control center can also control the volume of charging to ensure maximum utilization of solar charging.

Although this design works for large, flat parking lot, it's quite hard to find many parking lots that meet this design in the workplace. Therefore, this design is only suitable for large building with large places. In working area of urban, lots of parking lot does not have too much flat area. Therefore, another design from Chandra et al. [9] gives a better option for working area and the mechanism diagram is displayed in Figure 3. As show in figure 3, this design also connects solar panel and AC grid as the power source. After convert or invert the current, Electric vehicle can get energy from isolated EV charger. In this design, the solar panel can be built over the roof of the building or solar carport, which depends on the location of the parking lot. Compared to the design from figure 2, this design can set the solar panel on the building to help increase the efficiency of solar panels. Since people always spend more time in workspace, electric vehicle will have more time to charge in the working area. Based on different country's sunshine, the solar panel can change its size and angle to get best efficiency [9].

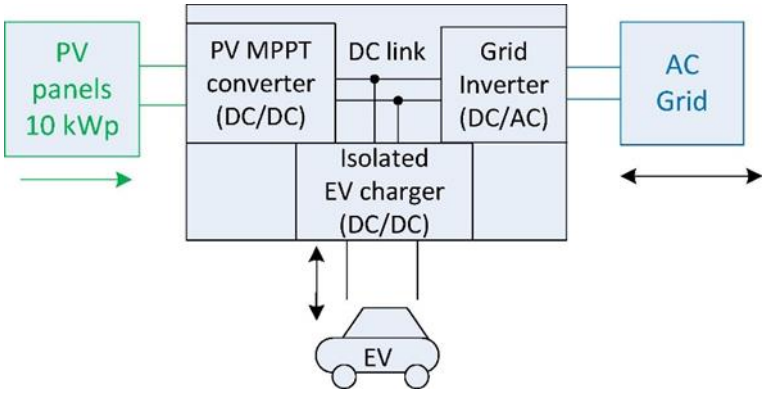


**Fig 3.** A design of solar power charging system for workplace [9]

### 3.2. Problem facing today

In those design, although the solar energy could be stored in an efficiency way, it is still hard to only use solar energy to help charge the vehicle. Based on the data given by G.R. Chandra Mouli et al. [9], while the storage power is 30kWH, the battery shows almost full or run out in about 70% of the whole testing period. This also happens with 75kWh storage power, where there was no energy or full 65% of the time. Those data prove the stored solar energy can be quickly run out and then they must use the energy from electric grid. The large area power system design shows economic problem: since the price to store the solar energy is too expensive, it is hard to apply the energy storage system in a large area. On the other hand, the solar panel has its age of use, therefore, this design also needs to consider about the maintenance costs of large solar panels.

## 4. Solar energy as energy supply for charging stations

With nowadays development of solar panel, it's quite simple that solar energy is still hard to be used for assisting electric vehicle or used in charging station. However, since solar energy shows success application in other area, it's still possible to apply solar energy in electric vehicle area. For example, in electric bicycle design, the solar energy could be used to charge with less power losses [10]. If the design of the station for electric bicycle could be learned for electric vehicle, solar charging system might have better efficiency and less power losses. The research in other area may be able to help solar panel to get better efficiency in order to make solar energy's application in vehicle area become true. Ngoc Hai Vu et al. [11] designed a better vehicle-used flat solar panel, this design can be applied on the roof of the vehicle with higher efficiency. Moreover, in the simulations of this design, it proves that the system can collect 4.48 kWh during summer in one day. Some other technology such as nanotechnology can provide some new way to collect or produce solar energy and

the research shows its possibility. With the application of others like nanotechnology, each solar panel unit can collect more solar radiation with the same area, which means the efficiency of solar collector can have higher efficiency than traditional collector [12]. T-Raissi [13] also gives a new idea that to use hydrogen as a fuel or transportation energy to transform and store the solar energy.

## 5. Summary

This paper uses the example of application of solar energy in electric vehicle and solar energy application in electric vehicle charging station to present the idea that the possibility of solar energy to be applied in other energy-powered vehicles. By using solar energy in electric vehicle, it can help control some system such as cooling system. Or using solar panel in some large flat parking plot to collect solar energy for charging those parking electric vehicles or set solar panel on roof of workspace to help charging electric vehicles during the working period. However, due to the limitation of solar energy, solar panel highly need a good weather and direct contact with sunlight. Based on that, solar energy cannot be the only source for supporting other power vehicle. In the future, the development of other area such as inverter and converter, solar panel, nanotechnology may make the application of solar energy in green energy vehicle possible.

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