Design and Construction of Smart Solar Bicycles by Presenting a New Transportation Architecture Model Based on Renewable Energies in The Corona Era

Meraj Rajaee*, Farima Nasiri

Department of Electrical and Computer Engineering, Shariaty Technical and Vocational University, Tehran, Iran
* Corresponding author: mrajaee@tvu.ac.ir

Abstract

The increasing growth of urbanization and population and consequently the growth of traffic and movement of city residents with motor vehicles in and out of the city, cause many problems including traffic, air pollution, increasing greenhouse gases and environmental damages. This is while many in the smart transportation industry are waiting to see how street experiences with less traffic and clean air can be transformed into sustainable change. The possibility of transportation innovation will be the most important option for this success. Electric bicycles are now considered as an alternative for car transportation in metropolitan areas. In this article, a new type of electronic bicycle is designed and manufactured. Due to the prevalence of the Corona virus in the world and the need to follow health protocols, a disinfection box for bicycle tracks is used. The door of this device will be opened and closed automatically in order to avoid the driver's hand colliding with the body of the device. For this purpose, the user or cyclist uses a special RFID tag and the power supply of this electronic bike is through solar cell technology.

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1. Introduction

Given the current state of the corona virus, many people are reluctant to return to high-traffic areas, which is inevitable. One way to do this, despite public transportation, is to create a safe route for active mobility in cities. In such a way that people can adapt to their new state. Bicycles can help reduce air pollution and energy consumption, costs for taxes, the need for a driver's license, parking while providing a healthier lifestyle for users. In addition, bicycles are one of the most cost effective and affordable modes of transportation (for example, additional costs or high maintenance costs for services such as cars). [1]

An alternative to a regular bike is an electric bike. A small electric motor and a rechargeable battery are used to assist the power provided by the cyclist. The battery can provide the energy needed for high acceleration in difficult cycling conditions, such as climbing steep slopes and overcoming wind resistance, thus increasing travel efficiency [2]. Recent innovation is the development of the solar ebike. Solar bikes are electric bikes in which photovoltaic (PV) solar cells are mounted on their wheels or other parts of the body of an e-bike that can charge their battery when parked and when traveling. The presence of fine dust in the sky causes the deposition of dust on the surface of photovoltaic panels and greatly affects the efficiency of photovoltaic panels. To reduce these effects and increase efficiency, cleaning systems are used that minimize the need for water and manpower. [3]

2. Construction history

The first solar-powered bicycles were introduced in the 1980s, but with a difference that they towed solar panels like a trailer. At present, with advances in solar technology, solar cells or plates are mounted on wheels that rotate up to 30 degrees to receive sunlight and they work well even in non-sunny conditions, such as rainy days. An ebike can travel up to 25 kilometers per hour

depending on the country's regulations, with an engine power of up to 250 watts, a 24-volt, 36-volt or 48-volt battery and depending on the speed, e-bikes can have different specifications.

3. Modeling of solar cell

This section refers to the structure of a solar cell and examines its related parameters. To model a single solar cell, we need a current, a diode and two resistors. The diode has its own shunt and series resistance. When the cell is subjected to sunlight, direct current is generated and it varies linearly with incoming solar radiation [4]. The value of the reverse saturation current is we can find out with the help of the a few important factors. The expression is as follows:

$$I_s = \mathrm{I_{sc}}/(\mathrm{e}^{\mathrm{q}\cdot\frac{\mathrm{V_{oc}}}{\mathrm{a.k.t}}} - 1) \quad (1)$$

Here Voc is the open circuit voltage of the cell. Thereafter we focus on the current through the shunt resistance. The expression of this current is very simple and can be written in terms of output voltage & current of the solar cell and the shunt & series resistance. The expression is:

$$I_{\mathrm{sh}} = (V + IR_{se})/R_{sh} \quad (2)$$

So, we can now write the full expression of the output current of the cell using all the sub-equations as following:

$$\mathrm{I} = \left[I_{\mathrm{r}}\left(\frac{\mathrm{I_{sc}}}{I_{\mathrm{ro}}}\right)\right] - \left[\left\{\frac{I_{\mathrm{sc}}}{\mathrm{e}^{\mathrm{q}\cdot\frac{\mathrm{V_{oc}}}{\mathrm{a.k.t}}} - 1}\right\}\cdot\left\{\left(\mathrm{e}^{\mathrm{q}\cdot\frac{\mathrm{V}+IR_{se}}{\mathrm{a.k.T}}} - 1\right)\right\}\right] - \left[\frac{\mathrm{V}+\mathrm{I.R_{se}}}{R_{sh}}\right]) \quad (3)$$

Here if we put the constant values of k, q & a as mentioned earlier, the expression can be rewritten as:

$$\mathrm{I} = \left[I_{\mathrm{r}}\left(\frac{\mathrm{I_{sc}}}{I_{\mathrm{ro}}}\right)\right] - \left[\left\{\frac{I_{\mathrm{sc}}}{\mathrm{e}^{1.034*10^{-4}\mathrm{T}} - 1}\right\}\cdot\left\{\left(\mathrm{e}^{\mathrm{q}\cdot\frac{\mathrm{V}+IR_{se}}{1.034*10^{-4}\mathrm{T}}} - 1\right)\right\}\right] - \left[\frac{\mathrm{V}+\mathrm{I.R_{se}}}{R_{sh}}\right]]) \quad (4)$$

4. Bike sharing systems

Further studies aimed at recognizing the corona crisis in travel behavior have been done or are being done by examining pre-corona conditions during the corona conflict and predicting post-corona behavior. The number of special shared bicycle systems in the metropolises are increasing every year as smokeless shared bicycles are existed in more than 600 cities around the world up to now. In Tehran also as a metropolis, the mentioned bicycle system has been created. The shared bike in Washington was probably1.28 million $ In Australia, with implementation of this plan on trips of less than five kilometers, about 1.5 kilograms of carbon dioxide emissions have been eliminated. Due to the use of new energy to regulate optimal distance from others to provide Corona conditions health protocols and reduce environmental pollution, today in addition to using solar panels on bicycles, the roofs of shared bicycle stations located in cities are also used to install solar panels to supply the required power. A smart city is an urban area that uses a variety of IoT sensors to gather information and then uses that information to manage municipal assets, resources and services. This process involves the collection of information from citizens, devices and urban resources that are analyzed and processed to monitor and manage traffic in vehicles and transportation systems, power plants, municipal facilities, information systems and other social services. In this regard, some proposed models for using these plans in smart cities are introduced as green transportation system. [5], [6]

5. Solar road bikes

In many countries, with planning and feasibility, the focus is on providing the bike path with bike lanes that can avoid closeness and companionship at close distances with others. Studies have shown cities that have previously devoted spaces to bicycles performed better than other cities in maintaining social distance in this Coronavirus epidemic.

The world's first solar bike lane was installed in the Netherlands to provide power to traffic lights, electric vehicles and homes. While the amount of solar energy generated by the road is relatively small, when this length reaches 110 meters, it is expected that enough energy will be provided for 3 houses. Instead of the usual paths, this path is made of a solar cells' layer that made of silicon crystal and a coating of unbreakable glass. Of course, on this surface, a very thin layer is installed to increase the friction of the road surface to ensure the safety of cyclists and pedestrians on it [7]. As shown in Fig. 1, the pv modules are compressed between the glass layers and the concrete slabs. Because heat affects electrical performance, the anti-slip layer at the highest part changes the radiation on the cells, affecting the temperature of the pv modules and acting as a heat insulator.

As shown in Fig. 2 The use of 2.5 by 3.5-meter solar panels with 1 cm layer of glass under which crystallized silicon solar cells are installed is the basis of this invention to receive the maximum energy. Safety issues have also been considered and standardized. One of the drawbacks of these roads is that they cannot be angled to sunlight, so they are 30% higher than the solar panels installed on the

roofs. They produce less energy. In addition, the use of this technology is not cheap. [8]

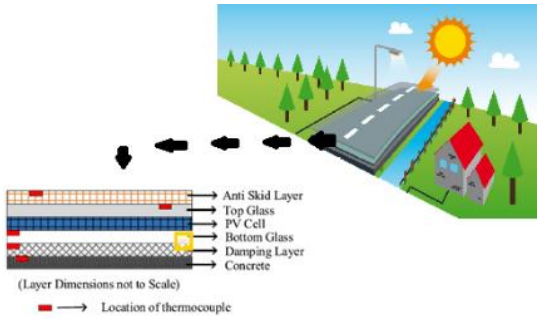

Fig. 1. Layers of plates installed on the solar road

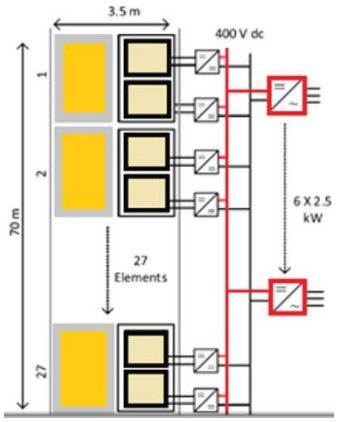

Fig. 2. Geometric and electrical map of the location of the panels on the solar road

6. Solar bike parking

One of the most important aspects of urban bicycle systems is its maintenance, which when used as a vehicle, a suitable place for parking should be considered to protect the bike from water, pollution and dust, collision with other bicycles and most importantly security against bicycle theft. One of the factors that can become an important issue is safety and comfort for bicycle owners. Anyone who owns a bicycle is more concerned about the issue of bicycle theft. Even with the new modern bicycle lock technology available in the markets today, the rate of bike theft is still at the alert level. [9]

The function of the solar bicycle parking model (green parking) is that through the network system, by installing a location sensor on the bicycle body, the location of the bicycle can be informed. It is also possible to know the amount of solar energy stored in the bicycle parking compartment so that users can use this stored energy to charge hybrid bicycles. As shown in Fig. 3 The parking lot is equipped with an intelligent locking system using radio identification system technology that ensures the safety of the bike when parking and because the locking system is activated wirelessly, the locking operation takes place without any direct contact with the environment, which is a measure to reduce the transmission of Coronavirus.

Fig. 3. Geometric and electrical map of the location of the panels on the solar road

Fig. 4. three-dimensional replica of a secure bicycle parking compartment with a secure lock for each bike

Solar smart bike parking is a new concept for the bicycle storage system. As shown in Fig. 4 The environment will be completely covered by the roof and the sun will be placed on top of it. The purpose of the roof rack for the bike rack is to protect the bike and has a solid base that can support the solar panel system. [10] In this case, solar energy will be the main power source of the entire bike gear system. Also, the bike lock system especially designed for purposes such as security and convenience. This system is divided into four main groups:

- Power system (solar photovoltaic system, charge control, battery)
- Power distribution system (DC-DC, DC-AC, power protection)
- Application system (lighting system, security camera, motion sensor)
- Built-in system (microcontroller, digital locking system)

7. Solar bikes with wireless control

As you can see in Fig. 5 The bike is built using solar energy to be monitored and tracked by a wireless sensor network mounted on the bike. The bike is located through the wireless network to access information such as brightness, ambient

temperature and information about the capacity to store electricity through the Internet interface. [11]

Fig. 5. Prototype bicycle with solar energy 12V / 50W

Table.1.
Specifications of a solar bike made of 12v/50w

Title	*Amounts*
Module efficiency	ŋ>16%
Module temperature	25 C
Module size	3*54*83 cm
Module weight	6.5 Kg
Maximum power	50 w
Maximum voltage	18 v
maximum current	2.77 A
Open circuit voltage	22.38 v
Short circuit current	3.52 A

8. Remote controls

Nowadays, considering the issueof smart cities and the use of IoT systems as much as possible to upgrade the remote control system in electric bicycles by connecting to the network wirelessly via connecting to a mobile phone or other smart gadgets like this, information such as ambient temperature, speed and distance traveled, information about the amount of electrical energy storage, use of electronic locks to ensure the security of the bike against theft and etc can be observed and controlled. To ensure the level of bicycle security against theft for example, the technology of radio identification system can be used to lock the bicycle.Up to now, various technologies in the field of automatic identification have been designed and implemented: the use of barcodes, two-dimensional codes, smart cards, fingerprint systems and etc.

The performance of the radio identification system technology depends on two devices, tags and readers, which use radio waves to communicate with each other. Active and semi-passive tags use internal batteries to strengthen their circuits. An active tag actually uses its battery to send radio waves to the reader, semi-passive tags depend on the reader itself to supply the energy they need. [12] They are also more expensive because they have more hardware than passive tags. Semi-passive and active tags are used for expensive items which are read from longer distances. These tags emit high frequencies from 850 to 950 MHz that can be read from a distance (about 30.5 cm) or even a little more. If these tags need to be read from a greater distance, extra batteries can increase the tag reading range even up to 100 meters. Passive tags generally use the reader as a power supply. [13] These tags are read from a distance of approximately (6 cm). These tags have a lower production cost.

According to the importance of what has been said about smartening and subsequent command to operate the bike lock, the innovation presented in the design of the solar smart bike is the use of radio identification system technology. Execution of the command to lock via the RFID tag is done by approaching the tag to the module (reader) that is installed inside the chamber on the bike rack. The information is read and the lock is unlocked. [14] This smart lock is powered by using solar energy.

9. Proposed model

The proposed system differs from the previous systems not only in the structure but also in the performance. The point of difference is the total performance and capabilities that may exist in other systems individually, but in this case, there is all togetheras well. The existence of some similarities between systems seems natural and inevitable.

Due to the fact that the Corona virus has had the highest mode of transmission among people by contact, so that in this proposed model there is no need to make contact and touch the user with the device. Also, in this design, a special disinfectant box is used. The bike is designed and built to allow the disinfection of objects inside the box through UV light, insulates the inner walls and the space inside the box and Fig. 6 shows the location of the UV lights.

Due to their wavelength, UV lamps have antiseptic properties and have the ability to disinfect equipment. This allows the goods to reach the consumer in a sterile and hygienic way. A potentiometer is used to adjust the switching distances of radiation so that the frequency of radiation can be adjusted as needed. [15] Power supply of this box through modules Photovoltaic is on the bike strap that was used to supply the electrical energy needed to power and operate the control unit with Arduino unit and smart lock with RFID module. The door of this device to avoid the driver's hand colliding with the body, opens and closes automatically when the user or cyclist uses a special RFID tag. The function of this box is to sterilize the goods and items to be transported. By adding a lithium polymer battery and the charge control circuit, (the specifications are given in detail in Table 2, the radiant energy of the sun that is radiated to the solar cells during the day can be stored in the battery so that it can be accessed when there is no sunlight and also this source helps to use

the smart lock system and provide the bicycle light at night by using 14 LEDs placed on the handlebars of the bicycle as shown in Fig. 7 .

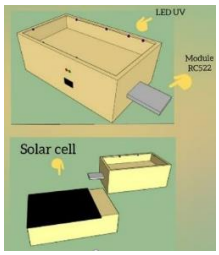

Fig. 6. The exact location of the UV LED

Fig. 7. Making a maquette of a smart solar bike with a sterile box mounted on the bike

The circuit used in the bicycle has the ability to charge the battery by solar energy. It can also be charged through city electricity. The full charge time is an average of 3 days to install the device in the sun and the time full charge by city electricity is 5 hours, which can be seen by turning on the green light on the device. Each time a full charge, the device stays on for 12 hours.

Putting all the above together, a model is presented which is called the green transportation architecture model in the Corona era, that makes cities smarter. Green transportation can be used to protect the environment and also to minimize the possibility of transmitting Corona virus, it introduces a solution.

10. Conclusion

The purpose of this project is to use new energy sources, especially solar energy, along with smartening and sterilization inside the chamber installed on the bicycle, and a step towards compliance with health protocols and the development of green transportation. By using this plan in the transport fleet by bicycles (using bicycles to use healthy nature and clean air without fossil fuels and using solar reacceptance energy) two problems in our society today will be solved. The proposed model of the solar smart bike, which was presented, used an innovative technology to prevent the transmission of viruses or germs to the outer surfaces of the disinfection device, so that instead of using touch keys, a wireless detection system was used. In this design, new innovations have been used to make the bicycle lock smart and use the technology of radio identification system, lighting system to provide the light needed by the cyclist and a sterile cargo box installed on the bike rack as you can see in Fig. 8. It is worth mentioning that all the components and systems of this bike are powered by the absorption and storage of solar energy.

Table.2.
Elements used to make a solar bike

Equipment	*Values*
Microcontroller	ARRDUINOUNO
RFID module	RC522
Servo motor	SG90
News alarm module	active
Lithium polymer battery	3800mA
Lithium battery charger module	1mA
Lithium battery charger	SY3500
Solar Cells	6V-160mA

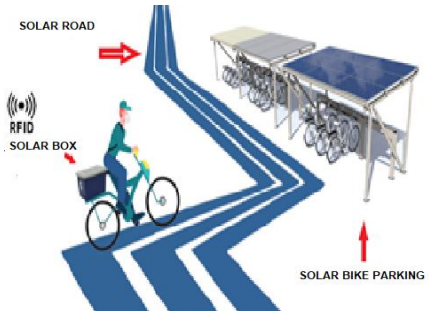

Fig. 8. Implementation of solar smart bike with sterile box and presentation of green transportation architecture model in corona era

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