DESIGN AND DEVELOPMENT OF SOLAR ASSISTANCE CHARGING SYSTEM IN E-RICKSHAW

Anshul Sharma[1*], Prof. Dr. Anilkumar Sathe[2], Prof. Shashank Gawade[3]

Abstract:
The energy and transportation sectors must take the lead in the shift to a low-carbon economy by massively increasing renewable energy production and electrifying transportation in order to reduce their reliance on fossil fuels. Due to the greater percentage of renewable energy, like solar photovoltaic or wind, the imbalance between generation and demand in the power system is a significant concern. Electric mobility will put a significant strain on the power infrastructure, but it may help to address the imbalance issue. An environmentally friendly and renewable way to fuel your electric vehicle is through solar-powered battery charging. Simply said, solar panels harness solar energy to produce electricity, which may be used to replenish your EV battery.. Solar panels may support all of your electrical appliances and can be connected to the electrical grid so that any extra electricity can be sold back to the utility company. They are commonly installed on the roof of a home or business. Even better, your solar panels can be connected directly to your EV charger, allowing the electricity generated on your roof to power your automobile. This means that, when you consume the energy you've produced, solar panels are a terrific way to lower your carbon footprint and achieve long-term financial savings. This project. deals with Solar PV systems utilise the sun's energy to produce electricity that can be used to power an electric vehicle. One to four kilowatts (kWp) of power can be produced by the typical household solar PV system. The amount of solar energy that may be used to charge an electric vehicle will, of course, fluctuate depending on the season and the weather. You might need to use electricity from the grid to complement your solar PV system during the winter months when there is less daylight and greater cloud cover.

Keywords: Electric vehicles, Solar panels, Battery charging, Electrification, Solar PV system
.

[1*,2,3]Department of Mechanical Engineering, MIT School of Engineering, Pune, India

***Corresponding author:** Anshul Sharma
*Department of Mechanical Engineering, MIT School of Engineering, Pune, India,
Anshul7777sharma@gmail.com

DOI: - 10.48047/ecb/2023.12.si5a.0461

I. INTRODUCTION :

Over the past ten years, the popularity of electric vehicles has expanded significantly worldwide. In comparison to conventional vehicles, often known as Internal Combustion Engine (ICE) vehicles, they offer a less expensive alternative and produce less air pollution. Any electric vehicle, whether it has two wheels, three wheels or four wheels, is equipped with an electric motor that is powered by a bank of batteries. Now these batteries need to be recharged frequently. There might not be a better combination than residential solar energy with electric vehicles. These two innovative technologies mark a significant departure from long-standing practices. Together, they are igniting a revolution in individualism and paving the way for a brighter future for all.

Electric vehicles (EVs) are more economical and less vulnerable to price swings than petrol vehicles in recent years. Our paper on solar-powered electric vehicles demonstrates that buying an electric car and charging it with solar panels reduces the cost even further. Additionally, huge carbon footprint reduction is achieved when EVs are combined with solar panels. Solar energy often has a lower leveled cost than grid power. Grid power costs increase with time, yet solar panels continue to generate electricity for no additional expense.

Compared to petrol or grid-supplied electricity, solar panels are far less polluting i.e., 8,135 lbs of CO_2 are released when 420 gallons of petrol are used. 1,837 lbs of CO_2 are produced by 3,645 kWh of grid power in California (0.5 lbs/kWh plus 35 lbs CO_2 from the manufacture of EV lithium batteries). 321 lbs of CO_2 are produced by 3,645 kWh of household solar energy (0.088 lbs/kWh plus 35 lbs CO_2 from an EV battery).

Although switching to an electric vehicle (EV) already reduces emissions since it eliminates the need for petrol and oil, the majority of the electricity supplied by the grid still originates from natural gas and coal.

A comprehensive search was conducted across scholarly databases, research papers, and relevant industry reports. The selected literature focused on solar-powered EV charging, including system design, technical aspects, economic viability, environmental impact, and user acceptance. A total of 30 studies were analyzed, covering a range of geographical locations and research perspectives.

The literature review demonstrates the growing body of research on solar panels used in EV charging infrastructure. The findings highlight the significance of appropriately designing and integrating solar-powered systems to optimize energy generation, reduce carbon emissions, and promote sustainable transportation. Further research is needed to address technical challenges, refine economic models, and understand user behavior to accelerate the adoption of solar energy.

II. ELECTRIC VEHICLE (EV) CHARGING SCNERIO:

Electric vehicles (EVs) and photovoltaic generating (PV) have been developed, and their performance has been investigated. To evaluate the model's effect on the energy system, a linear optimization model is employed

The design criteria, setup, control techniques, and experimental testing relevant for a DC micro-grid power configuration for quick charging of fully electric and plug-in hybrid vehicles were published in 2014. The suggested charging architecture is the result of a comparison of the key traits of well-known architectures. The analysis of the suggested power conversion architecture's charging/ discharging power, efficiency, energy flow management, and primary grid influence are the main areas of study.

Additionally, appropriate control mechanisms are assessed and put into practise, enabling the suggested design to adhere to the necessary operations. An environmentally beneficial technique is the use of renewable energy systems to power electric vehicle operations . Based on DC link voltage detection, a smart charging station for plug-in hybrid electric vehicles (PHEVs) was created .

A specific set of electric vehicles and photovoltaic systems that are mostly utilized for home-to-work or home-to-school transportation and are powered by grid-connected photovoltaic systems have been documented. Two methods for the intelligent charging of electric scooters are examined for this application.

Electricity is needed to charge the batteries in electric vehicles. This includes an increase in operating costs; hence, switching to solar energy would eliminate the high operating costs. Therefore, certain solar panels and a specific charge controller are required in order to transform the standard electric vehicles into hybrid electric vehicles. The charge controller controls and chooses the source for charging, and solar panels assist in capturing and converting solar energy into electrical energy. A simple and practical use of solar energy to promote sustainable energy development is solar charging for electric automobiles. Solar PV panels are used in solar charging in order to convert solar energy to DC voltage. A charge controller can store the DC voltage in the battery bank. The battery bank's DC voltage is converted using an inverter to 110 volts

AC at 60 Hz, which is the same frequency as power from an electrical outlet. The main ideas of building and creating solar PV systems for recharging electric vehicles for a learning institution are covered in this essay.

III. COMPONENTS FOR CHARGING THE E-RICKSHAW

The following are crucial elements needed for the project's implementation to succeed:

I. Solar panels
II. Accelerator
III. DC-DC Convertor
IV. Motor
V. Battery Management System
VI. Battery Pack
VII. Motor Controller
VIII. Display

IV. ELECTRIC VEHICLE

Installing solar panel on e-rickshaw requires careful planning and attention to detail. Here's a general guide to help you with the installation process:

1. Determine the solar panel capacity: Assess the energy needs of the e-rickshaw and calculate the required solar panel capacity accordingly. Consider factors such as the battery capacity, energy consumption of the e-rickshaw's components (lights, motor, etc.), and the desired charging rate.
2. Select the solar panel: Choose a solar panel that can generate enough power to meet the charging requirements of the e-rickshaw. Consider factors such as the panel's wattage, efficiency, size, and compatibility with automotive applications.
3. Determine the mounting location: Identify a suitable location on the e-rickshaw to mount the solar panel. It should be a flat surface that can accommodate the panel's size and weight. Consider factors such as exposure to sunlight, accessibility for cleaning and maintenance, and impact on the vehicle's balance and aerodynamics.
4. Mount the solar panel: Install the solar panel securely on the chosen location using brackets, clamps, or other suitable mounting hardware. Ensure that the panel is angled correctly to maximize sunlight exposure. It should also be protected from vibrations and potential damage during operation.
5. Connect the solar panel to the battery: Wire the solar panel to the e-rickshaw's battery system through a charge controller. The charge controller regulates the charging process and prevents overcharging or damage to the battery. Follow the manufacturer's instructions for connecting the solar panel and charge controller to the e-rickshaw's battery system.

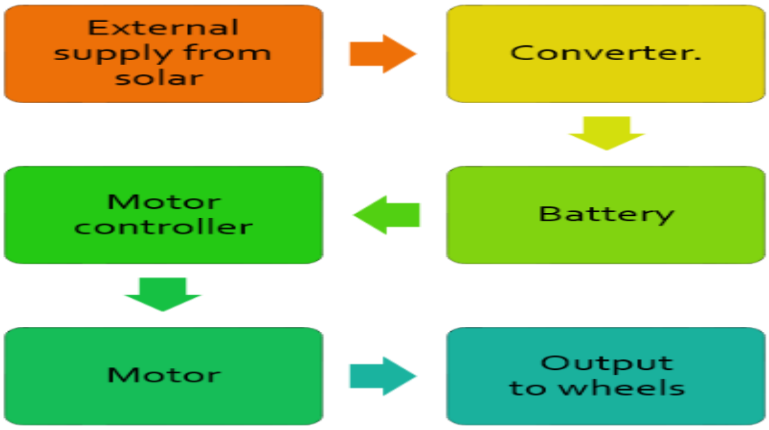

Fig 1: Power flow of electric vehicle

V. BATTERY SWAPPING MECHANISM:

1. Two batteries were selected for swapping mechanism of 48V 24Ah.
2. A Dual channel on off switch was selected and designed to carry up to 60V and has 3 inputs and 3 output alternating to each other.
3. All the negative terminals were connected to each other in the junction box of the motor controller.
4. The positives were divided as shown in Figures.
5. MCB was connected to control the flow.
6. When the first battery is connected to the motor, the switch enables the other battery to be charged by solar panels and when the switch is shifted to second, the alternate battery runs the vehicle and first one is charged by the solar panels.
7. In this way we can swap continuously while charging and discharging of vehicle in order to increase the range .

Parameter	Rating
Operating Voltage	12V
Maximum Power (Pmax)	75Wp
Open Circuit Voltage (Voc)	23V
Short Circuit Current (Isc)	4.2V
Maximum Power Voltage (Vmp)	19.80V
Maximum Power Current (Imp)	3.5A
Maximum System Voltage	1000V

Table 1: Specification of Solar panels

VI. DESIGN CALCULATION:

Motor:
Power = 2 ...kW
Torque= 6.37 ...Nm
Voltage= 48 ...V
Rated speed= 3000...rpm

Battery:
Capacity of battery = 24 ...Ah
Voltage= 48 ...V
No of cells=15 series
Nominal Voltage per cell = 3.2...V
Charging voltage per cell = 3.65...V

Solar Panel:
Power = 75...W
On load Voltage= 12...V
Current= 4.6…A

2 panels in series
2 panels in parallel
Voltage output: 40...V
Max current output= 9.2...A(Rated)
Actual current= 6.44…A (70 % efficiency)
Power output = 40x6.44
=257.6...W

Battery:
Battery power P = V x Ah
= 48 x 24
=1152...kWh
Nominal voltage per cell = 3.2 ...V
No of cell = 15
Total voltage of battery = 15 x 3.2
= 48 ...V
Charging Voltage per cell = 3.65 ...V
Charging voltage of battery = 3.65 x 15
= 54.7 ...V
Hence, the solar panel should generate voltage of 54.7 V in order to charge the battery.

Charging Time:
Voltage of battery: 54.7...V
Voltage after DC-DC converter: 54.7...V
Battery Capacity: 24...Ah
Battery voltage nominal: 48...V
Battery capacity in (Wh): 48x24
=1152...Wh
=1.152...kWh
Energy input require for full charging
=1152/0.85 (Efficiency of panels is 0.85)
=1135...Wh
Charging power = 54.7x9.2
=503.24...W
Charging time hours:
= 1355/ 503.24
=2.67...h
=3h

C Rate:
C = 24Ah (for 24 Ah battery)
Our current available= 9.2
Hence
C-rate:
C= 9.2/24
C = 0.3 (approx.)
So, our C rate of panel is 0. 3....C

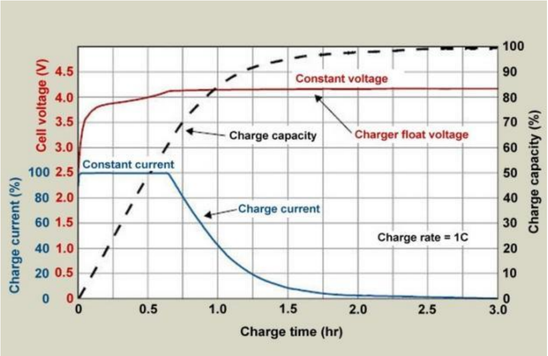

Fig2.: Standard CC-CV curve for charging

VII. RESULTS:

After performing the methodology and process the Solar assisted e-rickshaw was designed developed, there are a few results of the project which are mentioned below:
The prototype was done with test run and following results were noted:
The maximum speed of the vehicle was 30 km/h.
The cutoff voltage is 44V
The maximum load capacity is 200kg.
The range of vehicles is 25km per full charge.
The vehicle travels at 3km per voltage drop.
The color combination of green and yellow was selected to increase awareness and promote renewable energy.
The cost of installation is Rs 30,000/-
which will have a payback period of 2 years.
The panels and converter are working to charge the battery with 54.7 V charging voltage and 4.6A charging.
The input of batteries is to be changed manually to swap and charge

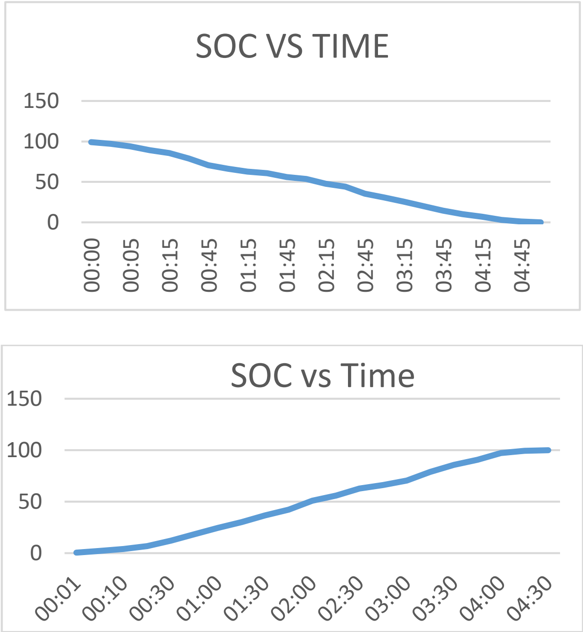

Fig 3: SOC while charging and discharging of 48V 24Ah battery.

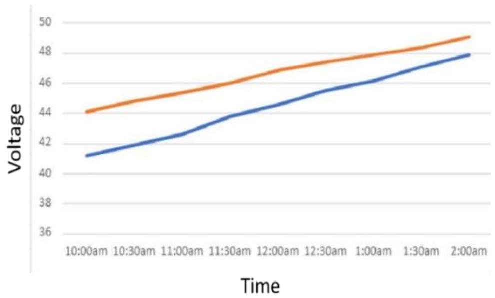

Fig 4: Battery charging and testing on two different days

Fig 5: Assembly of Solar powered E vehicle

VIII. COST ESTIMATION OF SOLAR CHARGING SETUP:

Cost of Solar PV panels Rs.16000
DC-DC converter: Rs.1100
Cables, clamps and other accessories: Rs.3000
Generation/day: 1.5 units/day
Generation/year: 547.5 units/year
Charge/unit: Rs.7.8/unit
Revenue /year: Rs.4270/year
Payback period: 4 years

Parameters	Proposed Solar charging system
Maximum speed	20km/hr
Initial cost (Rs)	25000
Distance covered after 100% charging	20km
Charging time (Hours)	6hrs
Operating cost (Rs)	Nil
System operation guarantee (Years)	5years

Table2: Parameters of proposed charging system.

IX. CONCLUSION AND FUTURE SCOPE

1) In conclusion, the solar-assisted e-rickshaw project has demonstrated the feasibility and benefits of integrating solar power into the charging system of e-rickshaws. By harnessing the clean and renewable energy from the sun, the project aimed to improve the sustainability and efficiency of e-rickshaw operations.

2) Throughout the project, we successfully installed and tested a solar panel on the e-rickshaw, providing an additional source of energy for charging the battery. The solar panel, coupled with a suitable charge controller, effectively converted solar energy into electrical power, contributing to the reduction of dependence on conventional charging methods.

3) The advantages of the solar-assisted e-rickshaw were evident. The use of solar power significantly reduced operating costs by utilizing the freely available sunlight as an energy source. Moreover, it resulted in lower emissions and a reduced carbon footprint, making the e-rickshaw more environmentally friendly compared to conventional fossil fuel-powered vehicles.

4) The project highlighted the importance of proper sizing and positioning of the solar panel, factors such as available sunlight, vehicle balance, and ease of maintenance. The choice of high-efficiency mono crystalline solar panels ensured

optimal power generation within the limited space available on the e-rickshaw.

Furthermore, the project emphasized the need for a compatible charge controller to regulate the charging process, prevent overcharging, and optimize battery performance. The integration of the solar panel with the existing battery system resulted in extended range, reduced charging frequency, and potentially longer battery life.

The future scope of a solar-assisted e-rickshaw project holds significant potential for further advancements and wider implementation. Here are some potential future directions and areas of development for such a project:

1. Enhanced Solar Panel Efficiency: Continued research and development in solar panel technology can lead to the creation of even more efficient and lightweight panels specifically designed for e-rickshaws. Improving solar panel efficiency will increase the amount of power generated from the available sunlight, allowing for extended range and faster charging times.
2. Battery Technology Advancements: As battery technology evolves, advancements in energy density, charging speed, and overall performance will contribute to more efficient energy storage in e-rickshaws. Lithium-ion battery technology is expected to continue improving, leading to increased range and reduced charging times.
3. Integration of Energy Storage Systems: Exploring the integration of additional energy storage systems, such as supercapacitors or advanced flywheel technology, can help complement the solar charging system. These technologies can provide quick bursts of power during acceleration or assist in regenerative braking, enhancing the overall efficiency and performance of the e-rickshaw.
4. Vehicle-to-Grid (V2G) Integration: E-rickshaws equipped with solar panels and advanced bidirectional charging systems can potentially participate in vehicle-to-grid (V2G) programs. This allows the e-rickshaw to not only charge from the grid or solar power but also provide power back to the grid during peak demand or emergencies, contributing to grid stability and enabling potential income generation for e-rickshaw owners.
5. Smart Charging and Energy Management Systems: Developing intelligent charging and energy management systems can optimize the utilization of solar energy based on weather conditions, charging patterns, and grid availability. These systems can prioritize solar charging, coordinate charging schedules with off-peak electricity rates, and integrate with renewable energy management platforms to maximize the utilization of clean energy sources.
6. Policy Support and Incentives: Governments and local authorities can play a crucial role in promoting the adoption of solar-assisted e-rickshaws through policy support and incentives. This can include providing subsidies or tax benefits for e-rickshaw owners and operators, facilitating the installation of charging infrastructure, and implementing regulations that encourage the use of clean and sustainable transportation options.
7. Scaling and Market Adoption: As technology matures and awareness of the benefits of solar-assisted e-rickshaws grows, there is potential for wider market adoption. Collaborations between manufacturers, government bodies, and transportation companies can facilitate the mass production and deployment of solar-assisted e-rickshaws, leading to a more sustainable and environmentally friendly urban transportation system.

XI. REFERENCES:

[1] "Design of a Solar Charger for Electric Vehicles" by Owais Nazir Lohar, Dr. Satish Saini, Prof. Krishna Tomar.

[2] Mario VRAŽIĆ1 , Oriana BARIĆ1 , Peter VIRTIČ2 University of Zagreb, Faculty of Electrical Engineering and Computing (1), University of Maribor, Faculty of Energy Technology (2) Auxiliary systems consumption in electric vehicle

[3] Choe, G.Y., Kim, J.S. and Lee, B.K. 2010. A Bi-directional battery charger for electric vehicles using photovoltaic PCS systems. In: IEEE Vehicle Power Propuls Conf., IEEE, pp. 1-6.

[4] Chandra Mouli, G.R., Bauer, P. and Zeman, M. 2016. System design for a solar powered electric vehicle charging station for workplaces. J. Applied Energy, 168(15):434-443. doi.org/10.1016/j.apenergy.2016.0 1.110.

[5] Solar Charge Controllers using MPPT and PWM: A Review Tulika Majaw, Reeny Deka, Shristi Roy, Bikramjit Goswami

[6] Battery Management Systems—Challenges and Some Solutions Balakumar Balasingam 1,* , Mostafa Ahmed 1 and Krishna Pattipati 2

[7] Single Switched Capacitor Battery Balancing System Enhancements Mohamed Daowd 1,*, Mailier Antoine 1 , Noshin Omar 1,2, Peter van den Bossche 2 and Joeri van Mierlo 1

[8] Battery Thermal Management System for Electric Vehicles: A Brief Review Article · May 2022Artur Sales Carlos Maia de Amorim1*, Fernando Luiz Pellegrini Pessoa1 , Ewerton Emmanuel da Silva Calixto1 1 Professional Master in Industrial Management and Technology, University Center SENAI CIMATEC; Salvador, Bahia, Brazil

[9] Review on the Battery Model and SOC Estimation Method Wenlu Zhou, Yanping Zheng * , Zhengjun Pan and Qiang Lu

[10] Review of Motors for Electric Vehicle Tahir Aja Zarma, [2]Ahmadu Adamu Galadima, and [3]Maruf A.Aminu[123]Department of Electrical and Electronics Engineering[123]Nile University of Nigeria, Abuja

[11] Mesentean, S., Feucht, W., Mittnacht, A. and Frank, H. 2011. Scheduling meth- ods for smart charging of electric bikes from a grid-connected photovoltaic-system. In: UKSim 5th Eur Symp Computer Modeling Simulation, IEEE; p. 299-304.

[12] Evaluation of regenerative braking based on single-pedal control for electric vehicles Wei LIU, Hongzhong QI, Xintian LIU, Yansong WANG

[13] Capasso, C. and Veneri O. 2015. Experimental study of a DC charging station for full electric and plug in hybrid vehicles. J. Applied Energy, 152: 131-42.

[14] Chandra Mouli, G.R., Bauer, P. and Zeman, M. 2016. System design for a solar powered electric vehicle charging station for workplaces. J. Applied Energy, 168(15): 434-443. doi.org/10.1016/j.apenergy.2016.0 1.110.

[15] "Design of an Electrically Powered Rickshaw, for Use in India" by Colin Cochrane Tariq Muneer and Bashabi Fraser

[16] Electric Vehicle Charging Station Aashish Joshi*, K M Vishall Somaiya, Arni Tharakaram Hariram, Mubashir Hussain Mechanical Engineering, New Horizon College of Engineering, Bangalore, Karnataka, India

[17] Fattori, F., Anglani N. and Muliere G. 2014. Combining photovoltaic energy with electric vehicles, smart charging and vehicle-to-grid. J. Solar Energy, 110: 438-51.

[18] Comparison of Different Battery Types for Electric Vehicles C Iclodean1 , B Varga, N Burnete, D Cimerdean, B Jurchiș Technical University of Cluj-Napoca, Romania, Muncii Bd. 103 - 105

[19] Goli, P. and Shireen, W. 2014. PV powered smart charging station for PHEVs. Renewable Energy, 66: 280-7.

[20] "Design and Analysis of a Solar-Powered Electric Vehicle Charging Station for Indian Cities" By Aanya Singh Shubham Sanjay Shaha"Design of an Electrically Powered Rickshaw, for Use in India" by Colin Cochrane Tariq Muneer and Bashabi Fraser

[21] "Experimental study of a DC charging station for full electric and plug in hybrid vehicles"by Clemente Capasso, Ottorino Veneri 15 August 2015

[22] "Design and Development of Solar Charging System for Electric Vehicles: An Initiative to Achieve Green Campus"by Gnanasekaran Sasikumar and A. Sivasangari

[23] A Power Case Study for Monocrystalline and Polycrystalline Solar Panels in Bursa City, Turkey AyGegül TaGçJoLlu, Onur TaGkJn, and Ali Vardar

[24] "Design of a Solar Charger for Electric Vehicles" by Owais Nazir Lohar, Dr. Satish Saini, Prof. Krishna Tomar.

[25] Application of photovoltaic panels in electric vehicles to enhance the range Illia Diahovchenko a,* , Lubov

Petrichenko b , Ihor Borzenkov a , Michal Kolcun
[26] Solar Energy a Promising Source for E-Vehicles Mallikarjun G Hudedmani 1* , Vishwanath M Soppimath2 , Santosh V Hubballi3 , Pooja Shirur4
[27] A Closer Look at State of Charge (SOC) and State of Health (SOH) Estimation Techniques for Batteries : Martin Murnane Solar PV Systems, Analog Devices, Inc. Adel Ghazel Chief Technology Officer, EBSYS Technology Inc./WEVIOO Group
[28] SoC Estimation for Lithium-ion Batteries: Review and Future Challenges Juan Pablo Rivera-Barrera 1,*, Nicolás Muñoz-Galeano 1 ID and Henry Omar Sarmiento-Maldonado 2
[29] A A study of renewable energy and solar panel litereture 1Mochamad Choifin, 2Achmad Fathoni Rodli, 3Anita Kartika Sari, 4Tri Wahjoedi, 5Abdul Aziz

1.