DRAWBACKS OF ROBOTIC CLEANING OR DRY-CLEANING ROBOTS

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ABSTRACT

One of the most effective ways to capture solar energy is through the use of solar panels. PV panels need to be maintained on a regular basis to remain functional, just like any other electrical equipment. The dust layers accumulate on the module surfaces over time, reducing the modules' efficiency. Solar modules can be cleaned dry or robotically without the need for water. Robots that clean solar panels employ dry brushes and air pressure to remove dirt from the panels' surface. Generally speaking, moist cleaning is more effective than dry cleaning. This is because the water used in wet cleaning acts as a channel for the release of dust particles. Water is not readily available everywhere, though, and this makes cleaning the modules challenging. In this sense, dry cleaning can be a fantastic substitute. Furthermore, wet cleaning PV modules on a regular basis appear to be rather difficult (since it involves a big amount of water, people, and capital expense).

Keywords: Drawbacks, Automatic Panels Cleaning, Photovoltaics (PV) Panels, Sun, Energy Generation, Dusts Cleaning

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INTRODUCTION

Since climate change and global warming pose a threat to the future of our planet, it is more important than ever to find environmentally beneficial alternatives to meet our energy needs. The generation of power from solar energy is one of the most effective clean, renewable energy sources. sun panels use sun energy to generate electricity. Solar panels are among the most inexpensive and low-maintenance

ways to produce electricity because they don't have any moving parts. Reference [4] conducted research on solar panel efficiency, which quantifies how much power a solar panel generates in respect to its theoretical maximum efficiency. The study tested a solar panel's cleanliness and tracking mechanisms in a variety of settings, including fixed and clean, filthy and fixed, dirty and tracking, and clean and tracking. It has been demonstrated that dust collection on the solar panels' surfaces lowers their efficiency, even with integrated sun-tracking. The increased rate of light transmission boosts the efficiency of the cleaned solar panel [5]. Compared to keeping the solar panel stationary and clean, tracking it can cause an efficiency loss of up to 50%. Large-scale power plants lose megawatts more frequently due to dust buildup on solar panels [6]. A 1% decline in proficiency may have a considerable impact on the Internal Rate of Return (IRR). In contrast, low-level dust buildup might not have a negative effect on small solar plants [7]. In the energy industry, photovoltaics (PV) is a new technology that converts solar irradiance—the radiant energy from the sun—directly into electricity. Here, the photovoltaic cells take the energy contained in the photons emitted by the sun and transform it into usable energy. The energy industry has seen a radical transformation because to PV technology, which has made it possible for the globe to move toward more sustainable energy practices [1, 2]. This opened the door for the photovoltaic sector to make tremendous industrial progress in earlier times, and it continues to do so as technology advances. One can observe a significant advancement in technology if they follow the development of laboratory scale models, experimental scale models, and current real-time running power plants in the PV business. In order to solve the issues with energy demand at the load centers themselves and minimize the need for lengthy transmission and distribution, these PV technologies have arisen and become a crucial component of many other sectors. Commercial PV technology development led to the creation of big utilities or multi-megawatt power facilities. Utility solar power plants are currently being developed in large and broad numbers on open spaces, rural and urban structures, and water surfaces. Building integrated photovoltaics (BIPV) and building applied photovoltaics (BAPV), a new type of PV technology, have been developed in recent years in response to improvements in PV technologies pertaining to contemporary infrastructure [3]. A study on various dust-removal methods has been conducted. For instance, [15, 16] suggested using a nylon brush with an automated robotic system to remove dust particles from the surface of solar PV panels, while [17] discussed the energy losses brought on by the deposition of dust particles on solar panels. The research conducted by prior researchers revealed a sizable level of power loss [18]. The intensity of power loss worsens when PV-based power generation is used on a big scale. Here, a low-power wide-area network (LPWAN) based on a network of ESP8266 node MCUs associated with a set of sensors in various configurations was attempted to be used to develop an automated cleaning system. The results of the experiment were successful enough to be implemented in large industrial-scale solar PV power plants. After a year of solar system installation, the solar PV panel's efficiency has dropped to 40% [19]. High temperature, panel pitch and orientation [20], deposition of dust, snow, sea salt, and bird droppings [21], among other factors, are blamed. Among these, the buildup of dust and other debris on solar PV panels causes a 50% reduction in system efficiency [22]. By offering a suitable cleaning method, these particles can also be removed from the panel's surface. A number of research projects were conducted to implement various software-based prototype cleaning techniques. The production was raised by around 35% by using arm controllers [51–55, 57–58, 60] and gear motor-based cleaning techniques. A microcontroller-based automatic dust cleaning system was created to clean the panel every two hours, increasing efficiency by roughly 1.6% to 2.2% [23– 29]. The operational cost is decreased and total efficiency can be raised by supplying a self-cleaning mechanism using software and hardware [30-41]. The cleaning mechanism works more efficiently when the accumulated dust on the panel can be identified and fed to it from the simulation. The performance of the PV panel was improved by a dust cleaning mechanism with a panel cooling system [42–45]. The overall system efficiency of solar street light panels with an automatic dust cleaning system that ran during the day and shut off at night was increased [46–49]. The majority of the established or proposed automated cleaning systems was found to be implemented with dry cleaning mechanisms to prevent short circuits and was permitted to run while dust built on the panels in the research investigations previously mentioned. Despite all of the benefits of solar panels, if impurities like dust, dirt, and dirt are allowed to accumulate, the efficiency of the panels could deteriorate. For solar panels to continue producing power at their peak efficiency, regular cleaning is

necessary. Solar panel cleaning by hand is time-consuming and dangerous, though. Therefore, by guaranteeing that the solar panels are kept clean without endangering people, an autonomously operated solar panel cleaning robot could play a significant role in maintaining the effectiveness of solar power production. The cleaning robot contributes to improving the effectiveness of solar panels in a variety of applications, including solar panels in homes and other industries, particularly in harsh areas like Iraq. In this work, a small mobile solar panel cleaner robot is created with the intention of being used in Iraq's small and medium solar panel plants. The components used in the suggested design are readily available. This robot uses two different types of brushes and DC motors to move. One that is hard for tough dirt and one that is moist and gentle for dusting and polishing. We'll be using a water tank, a pump, sensors, and high-friction tank track wheels. Its whole construction will consist of a controller circuit incorporated within a metal chassis. The mobile robot will be wirelessly controlled and observed via a smartphone application. The controller, an Arduino Mega, will behave in accordance with the information received and transmitted [8]. Ski lancer Solar Cleaning created a water-free Solar Cleaning Robot in 2017 to do away with the cost of water and the accompanying infrastructure, including tanker trucks, storage bins, hoses, and pipelines [52, 54]. Every day, it eliminates 99% of soiling. Three components are combined to ensure soiling is moved downward and off panel rows: controlled airflow over the panel surface, a specific microfiber that removes soiling gently, and gravity [9]. The Solar Clean robot, created in 2017, also ensured a secure and eco-friendly solar panel cleaning environment. It can also be used to clean solar panels in desert regions with intense temperatures right after sandstorms. The solar plant personnel may remotely check on the robot's cleaning and operation status via dedicated web and mobile apps [10]. HELIOS, a drone-mounted [50] autonomous cleaning robot service that performs fully automated solar panel cleaning, will be unveiled by clean-tech startup ART Robotics in 2022. A brush and vacuum are used to clean a small, light robot that navigates on its own utilizing edge detection and accurate location estimate. Additionally, the cleaning robots from the solar panels are both deployed and collected by the Helios Drone [11]. Cleaning the floating solar panels, where hand cleaning is practically impossible, is an essential function of the automatic robotic cleaner. The gear motors and motor driver power the robot, and it also has another motor with a cleaning membrane attached to it so that it can be washed with water. The camera records footage of the solar panels and transmits it to the cloud for storage and use in damage and cleaning analysis [12-13]. The majority of places where solar panels are deployed are dusty. The panel's surface is covered in dust, which has gathered and blocked the sun's light. The panel's ability to generate electricity is reduced. In this case, cleaning solar panels on a regular basis is necessary to maximize solar energy. In this study, a cleaning robot is created to regularly remove dust particles from solar panels. A rotary brush and water spray are being used by the robot to clean a solar panel. Additionally added to increase the panel's efficiency is sun tracking [56, 59]. This study proposes a potential method for reducing the impact of dust on a solar PV panel's surface. In largescale solar PV power generation, where many solar panels are connected in the form of arrays and each array requires a robot to carry out effective cleaning within the allotted time, a decrease in power output has been identified with an increase in particle deposition. An effective cleaning system in large-scale solar power plants requires autonomous automatic cleaning operation, self-control and monitoring of accumulated dust, as well as good coordination through networking between robots. In order to do the same thing, it is required to pick the appropriate communication technology for real-time wireless networking of solar cleaning robots that function over a broad area while consuming little electricity. Here, a low-power wide-area network (LPWAN) based on a network of ESP 8266 Node MCUs associated with a set of sensors was attempted to implement an automated robot cleaning system. The results of this attempt showed promise for implementation in large-scale industrial solar PV power plants [14]

Fig. 1: Dry Cleaning Robot

BENEFITS OF AUTOMATIC SOLAR PANEL CLEANING

1. Increased Energy Production People frequently consider the money we save by using the sun as a renewable energy source, as well as how solar panels can help the environment by lowering greenhouse gas emissions, when they think of solar panels. The majority of us are unaware that unclean solar panels can't produce as much energy as they could. An automatic solar panel cleaning system safeguards your investment by ensuring that the solar panels are always clean, this can enhance energy production by up to 30%.

2. Minimal Maintenance There is no further work needed after the RST Night Wash automated solar cleaning system is installed on a residential or commercial property. Our systems are constructed to order to meet the precise specifications of a specific residential or commercial solar array and to account for seasonal changes. Additionally, because there are no moving parts, it is simple for residential and business owners to benefit from consistently clean panels without worrying about having to fix or replace system components.

3. Protect Panel Warranty Unfortunately, some conventional techniques for cleaning solar panels can actually cause more harm than good. While maintaining solar panels clean is crucial for maximizing production, doing so incorrectly might result in damaged panels and voiding warranty coverage. RST Night Wash, on the other hand, was created in accordance with all standards and specifications set forth by solar panel manufacturers. Our method employs soft, filtered water to remove limescale buildup and cleans at night to reduce heat stress.

4. No Personal Injury Risk Working on roofs and climbing up there can be risky for both humans and panels. A robotic solar panel cleaning system, such as RST Night Wash, eliminates the need for roof access for cleaners to your home or business. This greatly lowers your responsibility as a property owner.

5. Completely Green A solar panel automation system that is entirely green is called RST Night Wash. We only utilize soft, filtered water instead of any chemicals or their byproducts. Additionally, it uses water very effectively, preventing any unneeded waste [61].

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1. When compared to water-based cleaning, dry cleaning is less efficient. This is because dust particles are more able to be transported away from the modules by fluids like water.

2. These kinds of robotic devices have a significant upfront cost. Consequently, it is not the ideal option for a home system.

3. The operation of these robotic cleaners requires electricity. The additional expense of this electricity mounts up.

4. Since robotics technology is relatively new, there is still a great deal of research and development (R&D) to be done in this field. Artificial intelligence and other sophisticated technologies are still needed for these machines [64].

CONCLUSION

Numerous articles on solar tracking systems and robotic solar panel cleaners have been examined for this project [62]. Their evolution and the quality of their panel cleaning have been noted. There is also discussion of the benefits of automatically cleaning solar panels [63]. The disadvantages of robotic dry solar cleaning are also covered.

REFERENCES

1. Jacobson MZ, Delucchi MA. (2011) "Providing all global energy with wind, water, and solar power. Part I: Technologies, energy resources, quantities and areas of infrastructure, and materials." Energy Policy 39: 1154–1169.

2. Mohammad Reza Maghami, Hashim Hizam, Chandima Gomes, Mohd Amran Radzi, Mohammad Ismael Rezadad, Shahrooz Hajighorbani. (2016) "Power loss due to soiling on solar panel: A review." Renewable and Sustainable Energy Reviews 59:1307–1316.

3. Nallapaneni MK, Sudhakara K., Samykanoa M., Sreenath S. (2018) "Dust cleaning robots (DCR) for BIPV and BAPV solar power plants-A conceptual framework and research challenges." International Conference on Robotics and Smart Manufacturing (RoSMa2018) 133:746-754.

4. Abhilash, B.; Panchal, A.K. Self-cleaning and tracking solar photovoltaic panel for improving efficiency. In Proceedings of the IEEE—2nd International Conference on Advances in Electrical, Electronics, Information, Communication and BioInformatics, IEEE—AEEICB 2016, Chennai, India, 27–28 February 2016; pp. 1–4.

5. Barker, A.J.; Douglas, T.A.; Alberts, E.M.; IreshFernando, P.A.; George, G.W.; Maakestad, J.B.; Moores, L.C.; Saari, S.P. Influence of chemical coatings on solar panel performance and snow accumulation. Cold Reg. Sci. Technol. 2022, 201, 103598.

6. Anilkumar, G.; Naveen, K.; Kumar, M.T.V.S.H.K.P.; Kumar, G.V.B.; Palanisamy, K.; Patil, A.; Sachan, D. Design and development of wireless networking for solar PV panel cleaning robots. IOP Conf. Series Mater. Sci. Eng. 2020, 937, 012024.

7. Khadka, N.; Bista, A.; Adhikari, B.; Shrestha, A.; Bista, D. Smart solar photovoltaic panel cleaning system. IOP Conf. Series Earth Environ. Sci. 2020, 463, 012121.

8. Sufyan M., Thanoon L., Hassan M., Omar W. M. (2023) "UTU" Compact Solar Panel Cleaning Robot" International Journal of Advanced Natural Sciences and Engineering Researches 7(3):217-226.

9. Skilancer Solar - Automated Solar Panel Cleaning [Online]. Available: https://www.skilancersolar.com/.

10. F1A | SolarCleano [Online]. Avilable: https://solarcleano.com/

11. HELIOS – an automated cleaning service for solar panels – ART Robotics [Online]. Available: https://art-robotics.com.

12. Jaswanth Y., Dhatri S. P., Ramesh J. (2021) "Design and Implementation of Automatic Robot for Floating Solar Panel Cleaning System using AI Technique" 2021 International Conference on Computer Communication and Informatics (ICCCI -2021) Coimbatore, INDIA.

13. Wallaaldin. E., Yedukondalu G., Srinath A. (2020). Journal of Green Engineering (JGE) 10(10):1-17.

14. Anilkumar G., et al. (2020) "Design and development of wireless networking for solar PV panel cleaning robots" IOP Conf. Series: Materials Science and Engineering 937 (2020) 012024 IOP Publishing doi:10.1088/1757- 899X/937/1/012024.

15. Sitharthan R, Geethanjali M and Pandy TKS 2016 Adaptive protection scheme for smart microgrid with electronically coupled distributed generations Alexandria Engineering Journal 55(3) 2539-2550

16. Fathima AH, and Palanisamy K 2014 Battery energy storage applications in wind integrated systems—a review IEEE International Conference on Smart Electric Grid 1-8

17. Prabaharan N and Palanisamy K 2015 Investigation of single-phase reduced switch count asymmetric multilevel inverter using advanced pulse width modulation technique International Journal of Renewable Energy Research 5(3) 879-890.

18. Jerin ARA, Kaliannan P and Subramaniam U 2017 Improved fault ride through capability of DFIG based wind turbines using synchronous reference frame control based dynamic voltage restorer. ISA transactions 70 465-474

19. Sitharthan, R, Sundarabalan CK, Devabalaji KR, Nataraj SK and Karthikeyan M 2018 Improved fault ride through capability of DFIG-wind turbines using customized dynamic voltage restorer Sustainable cities and society 39 114- 125

20. Prabaharan N and Palanisamy K 2016 A single-phase grid connected hybrid multilevel inverter for interfacing photo-voltaic system Energy Procedia 103 250-255 IOP Conf. Series: Materials Science and Engineering 937 (2020) 012024 IOP Publishing doi:10.1088/1757-899X/937/1/012024 19.

21. Palanisamy K, Mishra JS, Raglend IJ and Kothari DP 2010 Instantaneous power theory based unified power quality conditioner (UPQC) IEEE Joint International Conference on Power Electronics, Drives and Energy Systems 1-5

22. Sitharthan R and Geethanjali M 2017 An adaptive Elman neural network with C-PSO learning algorithm-based pitch angle controller for DFIG based WECS Journal of Vibration and Control 23(5) 716-730

23. Sitharthan R and Geethanjali M 2015 Application of the superconducting fault current limiter strategy to improve the fault ride-through capability of a doubly-fed induction generator–based wind energy conversion system Simulation 91(12) 1081-1087

24. Sitharthan R, Karthikeyan M, Sundar DS and Rajasekaran S 2020 Adaptive hybrid intelligent MPPT controller to approximate effectual wind speed and optimal rotor speed of variable speed wind turbine ISA transactions 96 479- 489

25. Sitharthan R, Devabalaji KR and Jees A 2017 An Levenberg–Marquardt trained feed-forward backpropagation based intelligent pitch angle controller for wind generation system Renewable Energy Focus 22 24-32

26. Sitharthan R, Sundarabalan CK, Devabalaji KR, Yuvaraj T and Mohamed Imran A 2019 Automated power management strategy for wind power generation system using pitch angle controller Measurement and Control 52(3- 4) 169-182

27. Sundar DS, Umamaheswari C, Sridarshini T, Karthikeyan M, Sitharthan R, Raja AS and Carrasco MF 2019 Compact four-port circulator based on 2D photonic crystals with a 90° rotation of the light wave for photonic integrated circuits applications Laser Physics 29(6) 066201

28. Sitharthan R, Parthasarathy T, Sheeba Rani S and Ramya KC 2019. An improved radial basis function neural network control strategy-based maximum power point tracking controller for wind power generation system Transactions of the Institute of Measurement and Control 41(11) 3158-3170

29. Rajesh M and Gnanasekar JM 2017 Path observation based physical routing protocol for wireless ad hoc networks Wireless Personal Communications 97(1) 1267-1289

30. Palanisamy K, Varghese LJ, Raglend IJ and Kothari DP 2009. Comparison of intelligent techniques to solve economic load dispatch problem with line flow constraints IEEE International Advance Computing Conference 446- 452

31. Sitharthan R, Ponnusamy M, Karthikeyan M and Sundar DS 2019 Analysis on smart material suitable for autogenous microelectronic application Materials Research Express 6(10) 105709

32. Rajaram R, Palanisamy K, Ramasamy S and Ramanathan P 2014 Selective harmonic elimination in PWM inverter using fire fly and fireworks algorithm International Journal of Innovative Research in Advanced Engineering 1(8) 55-62

33. Sitharthan R, Swaminathan JN and Parthasarathy T 2018 March. Exploration of wind energy in India: A short review IEEE National Power Engineering Conference 1-5

34. Karthikeyan M, Sitharthan R, Ali T and Roy B 2020 Compact multiband CPW fed monopole antenna with square ring and T-shaped strips Microwave and Optical Technology Letters 62(2) 926-932

35. Sundar D Sridarshini T, Sitharthan R, Madurakavi Karthikeyan, Sivanantha Raja A, and Marcos Flores Carrasco 2019 Performance investigation of 16/32-channel DWDM PON and long-reach PON systems using an ASE noise source In Advances in Optoelectronic Technology and Industry Development: Proceedings of the 12th International Symposium on Photonics and Optoelectronics 93

36. Sitharthan R and Geethanjali M 2014 Wind Energy Utilization in India: A Review Middle-East J. Sci. Res. 22 796– 801 doi:10.5829/idosi.mejsr.2014.22.06.21944 IOP Conf. Series: Materials Science and Engineering 937 (2020) 012024 IOP Publishing doi:10.1088/1757-899X/937/1/012024.

37. Sitharthan R and Geethanjali M 2014 ANFIS based wind speed sensor-less MPPT controller for variable speed wind energy conversion systems Australian Journal of Basic and Applied Sciences 814-23

38. Jerin ARA, Kaliannan P, Subramaniam U and El Moursi MS 2018 Review on FRT solutions for improving transient stability in DFIG-WTs IET Renewable Power Generation 12(15) 1786- 1799

39. Prabaharan N, Jerin ARA, Palanisamy K and Umashankar S 2017 Integration of single-phase reduced switch multilevel inverter topology for grid connected photovoltaic system Energy Procedia 138 1177-1183

40. Rameshkumar K, Indragandhi V, Palanisamy K and Arunkumari T 2017 Model predictive current control of single phase shunt active power filter Energy Procedia 117 658-665

41. Fathima AH and Palanisamy K 2016 Energy storage systems for energy management of renewables in distributed generation systems Energy Management of Distributed Generation Systems 157

42. Rajesh M 2020 Streamlining Radio Network Organizing Enlargement Towards Microcellular Frameworks Wireless Personal Communications 1-13

43. Subbiah B, Obaidat MS, Sriram S, Manoharn R and Chandrasekaran SK 2020 Selection of intermediate routes for secure data communication systems using graph theory application and grey wolf optimisation algorithm in MANETs IET Networks doi:10.1049/iet-net.2020.0051.

44. Singh RR and Chelliah TR 2017 Enforcement of cost-effective energy conservation on single-fed asynchronous machine using a novel switching strategy Energy 126 179-191

45. Amalorpavaraj RAJ, Palanisamy K, Umashankar S and Thirumoorthy AD 2016 Power quality improvement of grid connected wind farms through voltage restoration using dynamic voltage restorer International Journal of Renewable Energy Research 6(1) 53-60

46. Singh RR, Chelliah TR, Khare D and Ramesh US 2016 November. Energy saving strategy on electric propulsion system integrated with doubly fed asynchronous motors IEEE Power India International Conference 1-6

47. Sujatha K and Punithavathani DS 2018 Optimized ensemble decision-based multi-focus imagefusion using binary genetic Grey-Wolf optimizer in camera sensor networks Multimedia Tools and Applications 77(2) 1735-1759

48. Krishnamoorthy S, Punithavathani S and Priya JK 2017 Extraction of well-exposed pixels for image fusion with a sub-banding technique for high dynamic range images International Journal of Image and Data Fusion 8(1) 54-72

49. Singh RR, Mohan H and Chelliah TR 2016 November. Performance of doubly fed machines influenced to electrical perturbation in pumped storage plant-a comparative electromechanical analysis IEEE 7th India International Conference on Power Electronics 1-6.

50. M. A. Baballe, M. I. Bello, A. Umar Alkali, Z. Abdulkadir, & A. Sadiq Muhammad. (2022). The Unmanned Aerial Vehicle (UAV): Its Impact and Challenges. Global Journal of Research in Engineering & Computer Sciences, 2(3), 35–39. https://doi.org/10.5281/zenodo.6671910.

51. Muhammad Ahmad Baballe, Mukhtar Ibrahim Bello, & Zainab Abdulkadir. (2022). Study on Cabot's Arms for Color, Shape, and Size Detection. Global Journal of Research in Engineering & Computer Sciences, 2(2), 48–52. https://doi.org/10.5281/zenodo.6474401.

52. M.A. Baballe, A. I. Adamu, Abdulkadir S. B., & Amina I. (2023). Principle Operation of a Line Follower Robot. Global Journal of Research in Engineering & Computer Sciences, 3(3), 6–10. https://doi.org/10.5281/zenodo.8011548.

53. Abdu I. A., Abdulkadir S. B., Amina I., & M. A. Baballe. (2023). The Several uses for Obstacle-Avoidance Robots. Global Journal of Research in Engineering & Computer Sciences, 3(3), 11–17. https://doi.org/10.5281/zenodo.8030172.

54. Baballe et al. (2022). "Pipeline Inspection Robot Monitoring System" Journal of Advancements in Robotics 9(2):27- 36.

55. M. A. Baballe, M. I. Bello, A. Abdullahi Umar, A. S. Muhammad, Dahiru Bello, & Umar Shehu. (2022). Pick and Place Cabot's' Arms for Color Detection. Global Journal of Research in Engineering & Computer Sciences, 2(3). https://doi.org/10.5281/zenodo.6585155.

56. Muhammad B.A et at., (2020) "Review on Impact of Installing the Solar Tracking System Its Challenges and Types" Artificial & Computational Intelligence/published online: December 2020 https://acors.org/ijacoi/VOL1_ISSUE5_08.pdf.

57. Abdulkadir S. B, Muhammad A. F, Amina I., Mukhtar I. B, & M. A. Baballe. (2023). Elements needed to implement the Obstacle-Avoidance Robots. Global Journal of Research in Engineering & Computer Sciences, 3(3), 18–27. https://doi.org/10.5281/zenodo.8051131.

58. 1Muhammad B. A, Abubakar SM. (2020) "A general review on advancement in the robotic system" Artificial & Computational Intelligence / Published online: Mar 2020 http://acors.org/ijacoi/VOL1_ISSUE2_04.pdf.

59. Muhammad A.B. (2021) "A Review on the Impact of Solar Power Energy" Global Journal of Research in Engineering & Computer Sciences Volume 01| Issue 01 | Sep-Oct | 2021 Journal homepage: https://gjrpublication.com/journals/.

60. Mehmet Ç. Muhammad BA. (2019) "A Review on Spider Robotic System" International Journal of New Computer Architectures and their Applications (IJNCAA) 9(1): 19-24 The Society of Digital Information and Wireless Communications.

61. https://www.rst-cleantech.com/blog/5-benefits-of-automatic-solar-panel-cleaning.

62. Sadiku A. S., Amina I., Aminu Ya'u, Abubakar S. M., & M. A. Baballe. (2023). Review of the Literature on Robotic Solar Panel Cleaning. Global Journal of Research in Engineering & Computer Sciences, 3(4), 21–25. https://doi.org/10.5281/zenodo.8197565.

63. Amina I., adiku A.S., & M.A.Baballe. (2023). Automatic Solar Panel Cleaning Benefits. Global Journal of Research in Engineering & Computer Sciences, 3(4), 25–31. https://doi.org/10.5281/zenodo.8222775.

64. https://solarfunda.com/solar-panel-robotic cleaning/#:~:text=%E2%9D%8C%20Dry%20cleaning%20is%20less,robotic%20systems%20is%20quite%20high.