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DEVELOPMENT OF AN IOT-BASED SOLAR BANANA DRYER MONITORING AND CONTROL SYSTEM

Pandit. S. Patil[1, *], Dilip R. Pangavhane[2], Sanjay P. Shekhawat[3], Dr Dheeraj S. Deshmukh[4] and Dr M S Deshmukh[5]

[1] Asst. Professor, Department of Mechanical Engineering, R. C. Patel Institute of Technology, Shirpur, Dhule Maharashtra (India)

[2]Professor and Head of Department Automobile Engineering, Government College of Engineering & Research, Avasari Khurd, Taluka - Ambegaon, District - Pune, Maharashtra (India)

[3]Professor and Vice Principal, S.S.B.T College of Engineering & Technology, Bambhori Jalgaon-Maharashtra (India)

[4]Associate Professor, Mechanical Engineering Department, G H Raisoni College of Engineering, Nagpur, Maharashtra (India)

[5]Associate Professor, Mechanical Engineering Department, AISSMS, College of Engineering, 1-Kennedy Road, Pune-01, Maharashtra (India)

Abstract: *IoT Technology has proved to be very important for many applications like Manufacturing, Automotive, and Farming. In this work, an attempt has been made to automate solar dryer and monitor dryer air velocity, humidity, and temperature at optimum drying level. Testing the performance of solar dryers involves the determination of temperature, humidity, drying time, and many other parameters. The main purpose is to accomplish automation of solar dryers through IoT, this tool can be used to track and manage dryer performance remotely, making it easier for users to understand the current situation of bananas being dried to achieve effective and efficient drying results. To control and monitor the solar dryer system an ESP8266 Node MCU and three DHT22 Digital Temperature and Humidity Sensors are used in the dryer using a smartphone. The percentage difference for the readings of temperatures for solar collector shows that there the temperature varies from 0.19% to 1.37% that error may cause due to environmental conditions as well as calibration of instruments. The variation in the percentage of reading for humidity in solar collector range from 0.64% to 4.59% which is much greater. The values of the temperature for banana drying temperature 0.32% to 3.11% with ± 1-2°C. For the readings of Humidity in the banana drying chamber the percentage error is also a little high since the humidity is calculated from the Humidity meter. During the 14pm, the humidity shows the highest percentage with 1.41% in the reading variation between sensor and humidity meter.*

Keywords: *Internet of things, Monitoring, Node MCU, Solar Dryer, Temperature sensor, Humidity.*

1. INTRODUCTION

In the new age, IoT changing our lifestyle from how we perform our daily activity to how we behave. IoT is a colossal network with a connected device. IoT permits to get the perception of an object over networking infrastructure. These devices gather and share data about how they are used and in the environment in which they are operated. Use of IoT in solar dryer permits us to perceive and control different parameters. There is a bright future for the solar drying of different food products. The international market will be further encouraged if the quality of the dried product can be maintained with matching standard global requirements.

High precision and capacitive type Sensor performance is used based upon the ability to detect the physical state of banana inside the dryer. The sensors used in this system for the study are DHT22 Digital Temperature and Humidity Sensor Module AM2302. This sensor has a high temperature and relative humidity measuring range. The ESP8266 Node MCU CP2102 board is highly amalgamated. This chip is designed for the requirement of a new connected world. The smart monitoring and controlling of drying conditions inside the dryer chamber is done with the help of a Wi-Fi networking-based Node MCU application processor. Banana drying system to monitor the effectiveness of banana integration using IoT, which can be accessed in real-time through a smartphone, keeping bananas away from spoiling. Internet of things offers many advantages over the traditional method of recording data and controlling drying conditions. Some researchers are opting for a data logger to record the temperature and relative humidity at different positions. By using this technology of IoT we can obtain a very large number of different variables data. We can record and obtain different parameters values for every minute. The virtual world connects physical entities and is controlled remotely through different applications which can sense, store and visualize many variables. In the solar dryer amount of heat carried away as well as the amount of moisture removed is intimately related to the velocity of hot air, relative humidity, and temperature. The Drying process is carried out when the atmospheric conditions are good in April. The IoT assist system monitors the process of banana drying which can be accessed in real-time with the help of a smartphone. It offers a complete and self-contained Wi-Fi networking solution, Programmable, allowing it to either host the application Interactive Low cost, Simple, Smart, WI-FI enabled data to the cloud server for mobile through the Blynk app. Blynk app was developed with the Internet of Things in mind. It can monitor systems remotely, display sensor data, storage services, simulate it, and do a variety of other interesting things. This research article describes an IoT-based solar drying system monitoring that can be accessed from anywhere in the world via the internet. The solar banana dryer is tested and monitored using IoT, the drying data was collected at the location having coordinates 21° 20' 53.56" N and 74° 52' 49.26"E. The moisture content of the fish dryers was then monitored every hour until it reached 10%. The development of IoT-based monitoring and the design of automated fish drying equipment using Fuzzy Logic. Fish drying is a prevalent problem nowadays; traditional hand drying of fish takes a long time [1]. 95% efficiency can be obtained for measuring temperature and moisture etc. parameters by utilizing a Raspberry Pi and the Flask framework. Smart Monitoring displays renewable energy use on a daily basis. This enables the user to do an energy use analysis [2]. IoT solutions are becoming more user-friendly. It is possible to operate the D.C motor from anywhere in the globe at any time using a mobile application and a NODEMCU. A method has been created to control DC motors from anywhere in the globe and assure effective power consumption. This system is mostly used for low-power applications [3]. The technology is suitable for usage in greenhouses and temperature-sensitive plants. This improved method is more efficient and advantageous to farmers. The Internet of Things (IoT) is critical in smart agriculture. Smart farming is a new concept, thanks to IoT sensors that can provide information on their agricultural areas [4,9]. Using just Open-Source technologies, create a flexible, adaptable, and competitive monitoring system [6]. The IoT-based monitoring system collects all measures at one-minute intervals through IoT sensors and saves the data on a distant cloud server. We can comprehend the operation state of the SWH and assess its overall performance based on the data obtained [7]. Zigbee wirelessly transmits data to a central server, which collects, saves, and transfers the data to the cloud via the GSM module. Additionally, data may be seen on the client's mobile device via the App [8].

There is many research has been done previously on use of IoT for the solar energy monitoring system, water quality monitoring, Solar water monitoring system medical and health care system and also in the field of agriculture. The application of monitoring solar dryer using IoT will prove to be a futuristic transformation for the proposed system. Solar dryer in the world is operated manually. The drying system usually runs for 3-7 days in order to dry the food product completely. The person operating dryer has to stand near dryer and keep checking the dryer condition and adjust the different parameters accordingly. In light of the changed drying process IoT is implemented for proper amalgamation and the farmer can access his dryer in real time using a smart phone and app. In the agricultural arena, IoT will introduce a new field of smart drying. So, there is major need in order to change drying system Smart solar dryer has transformed the traditional solar drying system by adding internet connectivity capabilities. This will attract the farmers producing large amount of food product in their farm and they will able to store and preserve their food products in better way using smart drying technique.

2. METHODOLOGY & EXPERIMENTAL SETUP:

2.1 Introduction to method of solar drying:

A solar panel, Charge Controller, battery, varistor, and Blower comprise the whole system. The solar panel (3W) receives direct sunlight. The solar panel's output is sent to the Charge Controller. The regulated supply of energy is delivered to the lead acid battery (12 V), the output of which is applied to the Varistor and through blower hot air is supplied in the sun drying chamber of rectangular shape with the entire environment is controlled with the aid of ESP8266 Node MCU and sensors. The extension board is also used to charge the ESP8266 Node MCU, which should be recharged on a continuous basis. Temperature sensor setting is also done on a computer, after which the programming is fed into the ESP-8266 Node MCU and the appropriate interconnection is established. The Wi-Fi connectivity of this NODE MCU is built-in. The MCU utilizes an internet server to send data from sensors to the mobile application. The drying chamber may also be operated remotely through the Internet using the NODE MCU and the Blynk app. Blynk is an Android app that allows you to limit your internet usage. Blynk was designed with the Internet of Things in mind. It has the ability to manage hardware remotely, display sensor data, record data, visualize it, and perform a wide range of other amazing things.

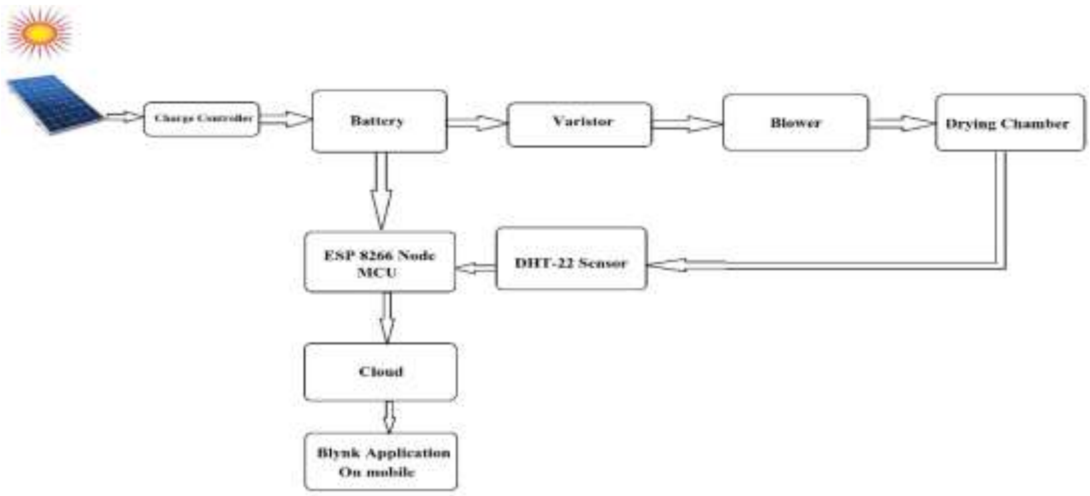

Figure 1 Solar Dryer monitoring system

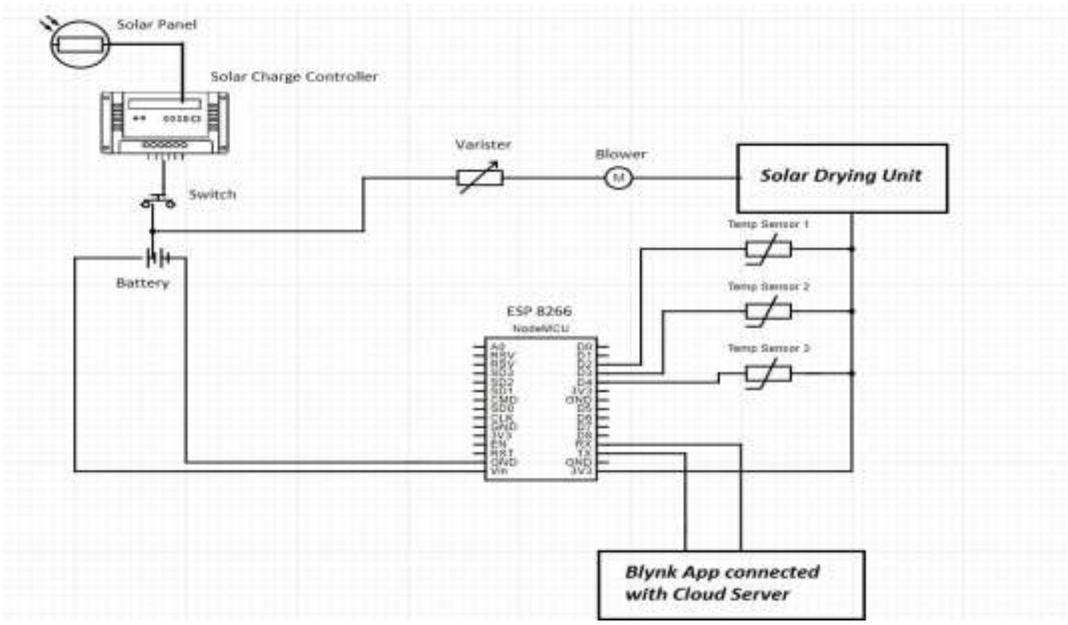

Figure 2 Circuit Diagram for controller

The Solar Dryer monitoring system is shown in the Fig 1. The different parameters such as temperature, Humidity and Velocity are being controlled and monitored using this system for the dryer. Temperature Sensor programming is also done on computer and that program is feed in the ESP-8266 Node MCU and connection is made. You can control the temperature and air flow from anywhere around the world. This system is demonstrated and powered with the help of Battery. We will receive massage from alert system from Blynk append then readings are recorded and displayed on the Blynk app application. The whole system will run and display Temperature through DHT-22 Sensor at different location in the dryer as well as hat pipe. Before uploading the code, the application is built and created new project in the Blynk application. All parameters are selected and setting is done in the app. The different on and off option and timing are set in the app. WI fi name and password is set in the program. Blynk authentication token sent by application is inserted in the program. Code is uploaded in the Node MCU and total wiring connection is made to different sensor and temperature sensor. The Wi-Fi connectivity of this NODE MCU is built-in. Data is transferred reciprocally from the mobile application towards the internet server.

2.2 Design & Working of the system:

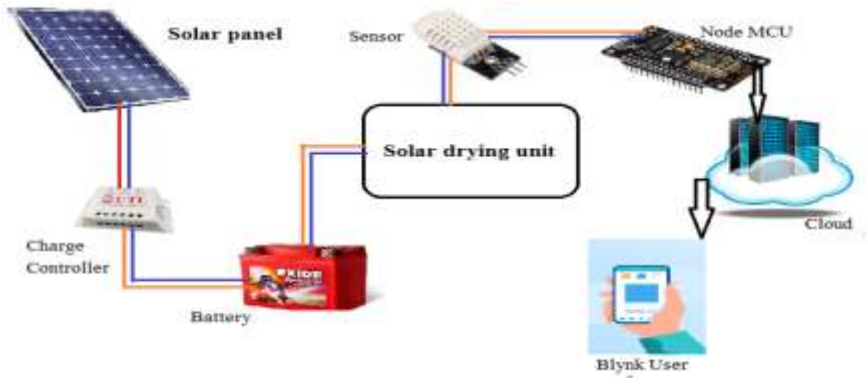

Figure 3 Design of the system

Table 1 The process yield and physical properties of the microcapsules.

Sr. No	Particular	Specification
1	Solar panel	250-watt
2	Charge controller	12V/24V-10A
3	Battery	12V
4	Temperature Sensor	-40°C to 100°C
5	Node MCU	ESP 8266

The working process of designed solar banana dryer system is illustrated in the form of following step:

a) Solar energy is captured by the sunrays falling on the solar pane which is consist of solar cells with +ve and –ve terminal and output energy is given to the charge controller.
b) In order to capture energy coming from the sun in best possible way is to store the energy in the batter with the help of charge controller. The charge controller is of 12V-24V_10A specification with maximum output it can sustain is 1000 W. A charge controller has switching converter to act as MPPT (maximum power point tracking) and thus charge up the battery.
c) After connecting solar charge controller to battery, the battery will be charged. The positive and negative terminals are connected output of the CC (Charge controller). When the charge controller is full charged it gives 13.7V Output. By multi-meter we can check the battery is charged fully or not.
d) The output of the battery is connected to the varistor which regulate the supply of voltage and current and it will also use to increase or decrease speed of blower.as the blowers generally run on 5-6 Amp current so varistor is needed to control the supply to blower.
e) Blower is used to supply hot air which is transferred through solar vacuum tube. The amount of hot air coming from the solar vacuum tube is collected in CPVC Heat pipe. This hot air is sent to the Banana drying chamber.
f) The DHT22 temperature sensor senses the output temperature and humidity and sends data ESP8266 Node MCU.
g) All the data from ESP8266 Node MCU sent to the cloud and which will be displayed in the form of graph through Blynk application on mobile which we can access from any location.

2.3 Configuration of hardware

The hardware setup of the recommended system is described here. The solar module with the help of charge controller may store solar energy as DC current inside the battery. Breadboard is utilized in order to develop the circuit. The charging required for the Node MCU and other hardware elements is supplied from the energy collected by solar panel. Node MCU Sense the current and voltage coming though analogue pins. The programming is done in 'C' and program is uploaded in the MCU. The sensors output is sent to the Node MCU through USB cable. The same data received from Node MCU is given to the server and displayed on mobile through Blynk app. The app displays all the information received from all three sensors for every minute. The whole solar banana drying process is controlled ad monitored using this system. The different elements utilized in the designed system are listed below into the Table-2 below.

Table 2: Technical Specifications of hardware

Sr No	Elements of System	Specification
1.	Solar Panel	38.8 Volt ,250 Watt
2.	Charge Controller	UTL SCC-12V-24V_10A PWM
3.	Battery	A 12V Dry
4.	Varistor	1-120V
5.	Blower	Runs on Motor with 5-6Amp
6.	Solar banana Drying Chamber	GI Rectangular Chamber 7ft*3.5ft.1.5ft
7.	Temperature Sensor	DHT22 3 to 5V Power
8.	Node MCU	ESP 8266

3. PERFORMANCE ANALYSIS AND MONITORING OF THE SYSTEM

Several sets of readings from the temperature and humidity sensors were collected, and the results from manual testing from the Thermometer and humidity metre were compared to verify that these systems are functioning properly. The sun drying chamber's drying temperature and humidity are being analyzed. On April 5, 2021, we executed the testing at the R.C. Patel Institute of Technology in Shirpur. The Table Shows the results obtained from Sensors, Thermometer and humidity meter.

3.1 Manual testing results:

Table-3. Result obtained by manual testing

Time (Hrs)	Dryer Collector outlet Readings		Banana Drying Chamber Readings	
	Temp(°C)	% Relative Humidity	Temp(°C)	% Relative Humidity
9.00	79.51	3.35	37.56	21.36
10.00	76.48	3.36	36.32	21.52
11.00	77.95	2.98	57.33	63.03
12.00	78.26	2.86	57.8	59.11
13.00	80.39	2.44	58.62	59.36
14.00	79.84	2.26	56.73	52.62
15.00	75.65	2.17	52.52	49.86
16.00	69.03	3.11	42.83	57.88
17.00	60.67	3.69	37.31	66.79

3.2 IoT based sensor results:

Table 4: Result obtained by IoT based sensors

Time (Hrs)	Dryer Collector outlet Readings		Banana Drying Chamber Readings	
	Temp(°C)	% Relative Humidity	Temp(°C)	% Relative Humidity
9.00	80.61	3.41	38.65	21.96
10.00	77.27	3.7	36.81	21.79
11.00	78.65	3.12	57.52	63.37
12.00	78.93	3.09	58.01	59.39
13.00	80.76	2.52	59.3	59.98
14.00	80.32	2.32	57.11	53.37
15.00	75.91	2.32	52.69	50.06
16.00	69.55	3.13	43.33	58.33
17.00	61.18	3.93	38.49	67.05

4. RESULT & DISCUSSION:

Values of temperature, humidity, and temperature and humidity gathered from the sensor and readings from the Thermometer and humidity meter are different, based on the observations made from the below results. Because the variations between readings are so obvious, a percentage for the variances between them had to be determined to assess the IoT system's sensitivity.

Table 5: Results for temperature using sensor and thermometers

Time In Hrs.	Dryer Collector outlet Temp.			Banana Drying Chamber Temp.		
	Reading from sensor	Reading from Thermometer	Percentage Difference (%)	Reading from sensor	Reading from Thermometer	Percentage Difference (%)
9.00	80.61	79.51	1.4	38.65	37.56	2.9
10.00	77.27	76.48	0.2	36.81	36.32	1.3
11.00	78.65	77.95	0.9	57.52	57.33	0.3
12.00	78.93	78.26	0.9	58.01	57.8	0.4
13.00	80.76	80.39	0.5	59.3	58.62	1.2
14.00	80.32	79.84	0.6	57.11	56.73	0.7
15.00	75.91	75.65	0.3	52.69	52.52	0.3
16.00	69.55	69.03	0.8	43.33	42.83	1.2
17.00	61.18	60.67	0.8	38.49	37.31	3.1

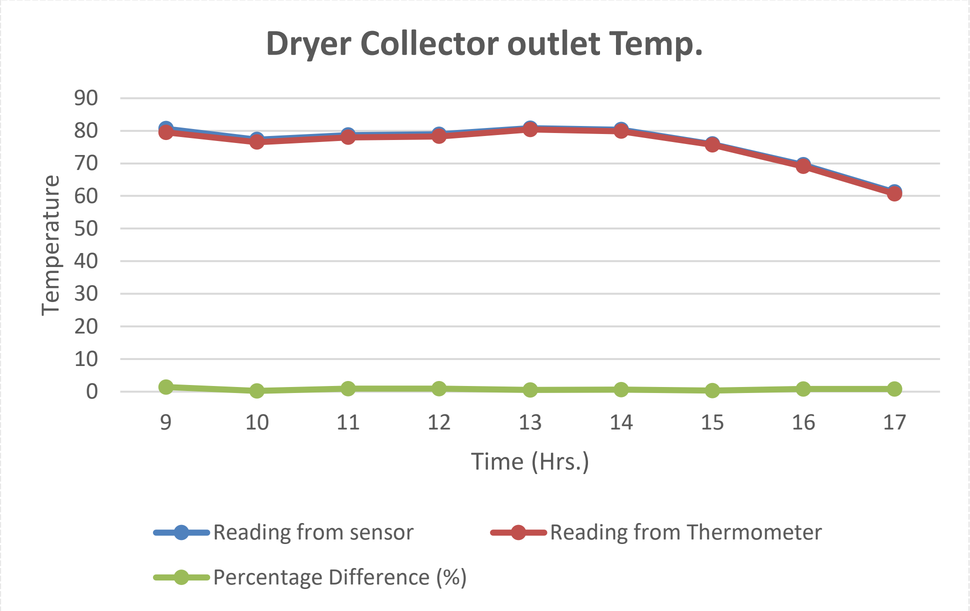

Figure 4 Comparison of dryer collector outlet temp. and error analysis

Table 6: Results for temperature using sensor and Humidity meter

Time In Hrs.	**% Relative Humidity at Dryer Collector Outlet**			**% Relative Humidity at Banana Drying Chamber**		
	Reading from sensor	**Reading from Humidity meter**	**Percentage Difference (%)**	**Reading from sensor**	**Reading from Humidity meter**	**Percentage Difference (%)**
9.00	3.41	3.35	1.8	21.96	21.36	2.8
10.00	3.7	3.36	3.9	21.79	21.52	1.2
11.00	3.12	2.98	4.6	63.37	63.03	0.5
12.00	3.09	2.86	3.3	59.39	59.11	0.5
13.00	2.52	2.44	3.2	59.98	59.36	1.0
14.00	2.32	2.26	2.6	53.37	52.62	1.4
15.00	2.32	2.17	4.4	50.06	49.86	0.4
16.00	3.13	3.11	0.6	58.33	57.88	0.8
17.00	3.93	3.69	1.8	67.05	66.79	0.4

The temperature and humidity for both the collector and the dryer are computed as 4 factors for the percentage difference shown in the table-3 above. The percentage difference for the readings of temperatures for solar collector shows that there the temperature varies from 0.19% to 1.37% that error may cause due to environmental condition as well as calibration of instruments. The variation in the percentage of reading for humidity in solar collector range from 0.64% to 4.59% which is much greater. The values of temperature for banana drying temperature 0.32% to 3.11% with ± 1-2°C. For the readings of Humidity in the banana drying chamber the percentage error is also little high since the humidity is calculated from the Humidity meter.

During the 14pm the humidity shows highest percentage with 1.41% in the reading variation between sensor and humidity meter. The data from the sensors appears quicker, and it updates every second. This circumstance will have an impact on sensor readings since there is a chance that ambient conditions may change, causing the measurement to be higher or lower than the humidity metered.

5. CONCLUSION

This research investigates an IoT-based control system for improving solar drying in the household and on the farm. The IoT-based solar banana dryer monitoring and control system has been successfully developed and tested. The usage of the Blynk application, which is suited for both household and farmer for drying, has made the monitoring process easier and smarter with the introduction of IoT. This banana drying and monitoring system will ultimately assist users in evaluating and forecasting the solar dryer's performance in real time.

6. SCOPE OF THE WORK:

There are various work recommendations that may be offered in order to get a better outcome in the future:

- ✓ Data may be exchanged with multiple drying systems at the same time.
- ✓ Smart drying will be accomplished via an IoT system, which will save time and energy compared to a typical solar drier.
- ✓ The drying process will be done in different way as the farmer and householders can have lot of data available with them for managing time and work.
- ✓ Because the Blynk application can only show data in real time and data can be saved for later use, it is suggested that you can build a webserver for data gathering.

Conflicts of interest

The authors declare that they have no conflict of interest.

References

[1] Y. Alvinika, D. B. Setyohadi, and M. Sulistyoningsih, “IoT-based monitoring and design of automatic fish drying equipment using fuzzy logic,” IOP Conf. Ser. Earth Environ. Sci., vol. 704, no. 1, 2021, doi: 10.1088/1755-1315/704/1/012042.

[2] S. M. Patil and R. T. M., Vijayalashmi, “IoT based solar energy monitoring system,” Mater. Today Proc., pp. 1574–1579, 2021, doi: 10.1016/j.matpr.2021.07.364.

[3] B. Karthik and M. P. Gandhi, “Solar powered based DC drives controlled by using IoT,” Mater. Today Proc., vol. 37, no. Part 2, pp. 2513–2516, 2020, doi: 10.1016/j.matpr.2020.08.317.

[4] S. R. Prathibha, A. Hongal, and M. P. Jyothi, “IOT Based Monitoring System in Smart Agriculture,” Proc. - 2017 Int. Conf. Recent Adv. Electron. Commun. Technol. ICRAECT 2017, pp. 81–84, 2017, doi: 10.1109/ICRAECT.2017.52.

[5] O. Elijah, T. A. Rahman, I. Orikumhi, C. Y. Leow, and M. N. Hindia, “An Overview of Internet of Things (IoT) and Data Analytics in Agriculture: Benefits and Challenges,” IEEE Internet Things J., vol. 5, no. 5, pp. 3758–3773, 2018, doi: 10.1109/JIOT.2018.2844296.

[6] P. de Arquer Fernández, M. Á. Fernández Fernández, J. L. Carús Candás, and P. Arboleya Arboleya, “An IoT open source platform for photovoltaic plants supervision,” Int. J. Electr. Power Energy Syst., vol. 125, no. October 2020, 2021, doi: 10.1016/j.ijepes.2020.106540.

[7] W. T. Li, W. Tushar, C. Yuen, B. K. K. Ng, S. Tai, and K. T. Chew, “Energy efficiency improvement of solar water heating systems – An IoT based commissioning methodology,” Energy Build., vol. 224, p. 110231, 2020, doi: 10.1016/j.enbuild.2020.110231.

[8] S. Ahmed, F. Le Mouel, and N. Stouls, “Resilient IoT-based monitoring system for crude oil pipelines,” 2020 7th Int. Conf. Internet Things Syst. Manag. Secur. IOTSMS 2020, 2020, doi: 10.1109/IOTSMS52051.2020.9340197.

[9] S. Balaji, K. Nathani, and R. Santhakumar, “IoT Technology, Applications and Challenges: A Contemporary Survey,” Wirel. Pers. Commun., vol. 108, no. 1, pp. 363–388, 2019, doi: 10.1007/s11277-019-06407-w.

[10] I. Lee and K. Lee, “The Internet of Things (IoT): Applications, investments, and challenges for enterprises,” Bus. Horiz., vol. 58, no. 4, pp. 431–440, 2015, doi: 10.1016/j.bushor.2015.03.008.

[11] K. R. Veena and G. Shyamala, “Solar Water Pumping System Using IOT Monitoring System,” vol. 2, no. 10, pp. 259–263, 2019.

[12] A. Reyes, F. Cubillos, A. Mahn, and J. Vasquez, “Control system in a hybrid solar dryer,” IREC 2014 - 5th Int. Renew. Energy Congr., pp. 5–9, 2014, doi: 10.1109/IREC.2014.6826936.

[13] K. Jiju, P. Ramesh, P. Brijesh, and B. Sreekumari, “Development of Android based on-line monitoring and control system for Renewable Energy Sources,” I4CT 2014 - 1st Int. Conf. Comput. Commun. Control Technol. Proc., no. I4ct, pp. 372–375, 2014, doi: 10.1109/I4CT.2014.6914208.

[14] M. A. Khan and K. Salah, “IoT security: Review, blockchain solutions, and open challenges,” Futur. Gener. Comput. Syst., vol. 82, pp. 395–411, 2018, doi: 10.1016/j.future.2017.11.022.

[15] V. G. Menon, S. Jacob, S. Joseph, P. Sehdev, M. R. Khosravi, and F. Al-Turjman, “An IoT-enabled intelligent automobile system for smart cities,” Internet of Things, p. 100213, 2020, doi: 10.1016/j.iot.2020.100213.

[16] S. Sen Gupta, M. Shad Khan, and T. Sethi, “Latest Trends in Security, Privacy and Trust in IOT,” Proc. 3rd Int. Conf. Electron. Commun. Aerosp. Technol. ICECA 2019, no. February 2020, pp. 382–385, 2019, doi: 10.1109/ICECA.2019.8822178.

[17] O. Vermesan et al., “Internet of Things strategic research and innovation Agenda,” Internet Things Appl. From Res. Innov. to Mark. Deploy., pp. 7–142, 2014.

[18] C. Wheelus and X. Zhu, “IoT Network Security: Threats, Risks, and a Data-Driven Defense Framework,” IoT, vol. 1, no. 2, pp. 259–285, 2020, doi: 10.3390/iot1020016.

[19] Y. Cui, W. Liu, P. Rani, and M. Alrasheedi, “Internet of Things (IoT) adoption barriers for the circular economy using Pythagorean fuzzy SWARA-CoCoSo decision-making approach in the manufacturing sector,” Technol. Forecast. Soc. Change, vol. 171, Oct. 2021.

[20] H. P. Breivold and K. Sandstrom, “Internet of Things for Industrial Automation-Challenges and Technical Solutions,” Proc. - 2015 IEEE Int. Conf. Data Sci. Data Intensive Syst. 8th IEEE Int. Conf. Cyber, Phys. Soc. Comput. 11th IEEE Int. Conf. Green Comput. Commun. 8th IEEE Inte, pp. 532–539, 2015, doi: 10.1109/DSDIS.2015.11.

[21] N. Ahmed, D. De, and I. Hussain, “Internet of Things (IoT) for Smart Precision Agriculture and Farming in Rural Areas,” IEEE Internet Things J., vol. 5, no. 6, pp. 4890–4899, 2018, doi: 10.1109/JIOT.2018.2879579.