An IOT Based Control System for a Solar Membrane Distillation Plant Used for Greenhouse Irrigation

H. HAJITHA BANU1, S.S. RUTHRAN2, S. SHANMUGAPRABU[3], MOHAMED YUSUFSHA[4]
1 ASSISTANT PROFESSOR 2,3,4 UG STUDENT
ELECTRONICS AND COMMUNICATION ENGINEERING
PERIYA MANIAMMAI INSTITUTE OF SCIENCE & TECHNOLOGY, TAMILNADU, INDIA

ABSTRACT

This project presents a control strategy that uses the Internet of Things (IoT) technology to manage a smart-grid framework including a solar desalination facility and a group of greenhouses that demand water for irrigation. In addition, the water public utility network has also been considered an agent of this smart-grid framework. The controller is based on a Model Predictive Control (MPC) strategy which uses information, by means of an IoT platform, coming from each one of the facilities included in the smart-grid to calculate the optimal control actions in the Cloud. Simulation results are shown to demonstrate the efficiency of the proposed method.

KEYWORDS: Distillation, IoT, Solar Irrigation and smart-grid.

1.INTRODUCTION

Agriculture plays a major role in the economy of most cities of the Mediterranean area. This is the case of Almer´ıa (Southeast of Spain), which is located in a semi-desertic region with a serious problem of water shortage. However, despite this problem, the agriculture system in Almer´ıa increases steadily, and nowadays, it is composed by more than 31034 greenhouse hectares [6]. The development of such an intensive agriculture system in this dry zone demands solutions for its sustainability. In this sense, as pointed by [3], the combination of desalination processes with crops could become one of the main tools to alleviate the water problem. Nevertheless, some drawbacks must be faced before, among which, the associated economics costs stand out. One way to decrease the costs of the freshwater produced by means of desalination processes is to combine them with renewable energies. In this way, Membrane Distillation (MD) technology is a thermal separation process with potential in comparison to other desalination technologies, since it requires a low operational temperature, what makes that it can be easily coupled with solar thermal energy [10]. Although this technology is currently more expensive than other desalination processes, i.e. reverse osmosis, it is adequate to develop small medium desalination applications to be implanted in places with good solar irradiance conditions and access to sea water, as happens in Almer ´ıa. Towards sustainable irrigated crops, the connection of greenhouses and Solar Membrane Distillation (SMD) facilities should be performed by using adequate control systems, in which the Internet of Things (IoT) framework is becoming an enabling technology. On the one hand, bearing in mind a thermal desalination plant powered with solar thermal energy, the main objectives of a control system consist on: i) maximizing the use of the available renewable energy source, thus minimizing the costs associated to the use of non-renewable sources, and ii) adapting the production to the demand, thus minimizing the operating costs of the electricity consuming devices as pumps. Regarding the first point, several control approaches have been presented in the literature as the ones presented in [7], whereas only deals with the second one. Although these works were not developed under an IoT framework, they can be easily extrapolated to be used in combination with the IoT technology, using approaches as the one presented.

On the other hand, from greenhouses position, the control efforts are focused in the development of accurate irrigation control systems [10]. Besides, some IoT based methods have been already proposed, as the one presented in [9], in which a smart water management method for precision irrigation was developed. These kinds of works are in the line of the Precision Agriculture (PA) and smart farming, which are two relevant terms in the agriculture field. The first one is related to the use of Information and Communication. Technology (ICT) tools that allow the optimization of resource management, through a network of sensors, actuators and other devices. The second term integrates the use of new technologies such as IoT, Big Data, cloud computing, artificial intelligence and deep learning in agricultural systems, which is known as the third green revolution.

The idea presented in this work consists on combining the IoT technology and advanced control strategies, in particular MPC controllers, to develop efficient methods to manage the combination of SMD plants and greenhouses. It should be taken into account that, in a real implementation of these kind of smart-grids, the normal situation is to have one or more SMD plants feeding a large number of greenhouses, which are usually geographically separated (tens of kilometers or more). To operate these smart-grids efficiently, a centralized control system is required, which must receive information from all the facilities and calculates the optimal operating points based on this information, following a determine criterion such as minimizing the operating costs. Thereby, the IoT technology is especially suitable for this application since it allows us to obtain interoperability between the different facilities regardless of their geographical location, as it is able to read from all the subsystems, to analyze all the data in the Cloud, and to send the corresponding control actions to the actuators of the facilities. In addition, one of the main advantages of the IoT technology is that it establishes interconnection between the devices through open standards to Cloud platform, unlike the typical architectures used nowadays in the industry as the Machine to Machine one, which permits remote connections between devices in a circuit or closed system.

Thus, in order to show the benefits that can be achieved, a case of study is proposed which ombines several greenhouses connected to a SMD plant by means of a storage system. Moreover, the water public network is also considered for those cases in which the freshwater production of the SMD facility is not enough to fulfil the greenhouse requirements. Unlike the approaches presented until now in the literature, the MPC control system developed in this work has as main aim to minimize the operational costs, taking into account the associated electrical costs of the feed water SMD pumping system, and the costs of the water coming from the public utility network. The manipulated variables of the control system are: i) the number of MD modules in operation in the SMD facility, ii) the water coming from the SMD facility to the greenhouses, and iii) the water coming from the public network to the greenhouses. To make the decisions, the control system uses information coming from an IoT platform that unifies the information of the sensors and actuators of each of the agents (i.e. SMD plant, greenhouses and storage device) involved in the proposed smart-grid framework. Simulation results are presented to illustrate the benefits of the proposed approach.

2. LITERATURE REVIEW

Connected photovoltaic system was used as a photovoltaic power generation system and NI USB-6221 data acquisition (DAQ) card and developed electrical measurement circuits were used for monitoring the photovoltaic system. Parameters and parameter changes at current, voltage and generated power in photovoltaic system acquired from the system and these parameters were monitored in real time thanks to a Labview DAQ card. Output voltage, output current and power generated from the photovoltaic system were also monitored with developing Labview software

One of the systems is developed on an online monitoring and control system for distributed. Android-based Renewable Energy Sources (RES). This method basically uses the Bluetooth interface of the android tablet mobile phone as a communication link for data exchange with digital hardware of Power Conditioning Unit (PCU). The Low-Cost android tablet is suitable to replace the graphical LCD displays and RES Power Conditioning Unit (PCU) Internet modem with improved graphical representation and touch screen interface.

A professional O&M service package ensures that the solar photovoltaic system will assure to maintain high levels of technical and resultantly economic performance over its lifetime. Now, it is well acknowledged by all the stakeholders that high quality of O&M services aggravates the potential risks, improving the levelized cost of electricity (LCOE) and Power Purchase Agreement (PPA) prices and positively impacts upon the return on investment (ROI).

A substance in which an electron is raised to a higher energy level upon light absorption, and secondly, the transfer of this more energetic electron from the solar cell to an outside circuit. After losing its energy in the external circuit, the electron returns to the solar cell The requirements for photovoltaic energy conversion could theoretically be met by a range of materials and techniques.

IoT built distant monitoring will help to raise energy efficiency of the system by making use of low power consuming advanced wireless modules thereby reducing the carbon footprint. A delivery of advance to remotely manage the Solar PV plants of various operations like remote shutdown, remote management is to be incorporated with this system later. McLoughlin et al. (2004) conducted an experiment for the wastewater treatment process with E. build a 3 m2 reactor with a 1 m2 lighted surface made up of non-tracking compound parabolic collectors for the E. coli K-12 species. Titanium dioxide (TiO_2) suspensions with levels ranging from 0 to 9 mg/L were also used in the tests. The outcome includes that E.

Manariotis and Chrysikopoulos (2012) worked on the performance of anaerobic bioreactor with the help of designed solar system for heating the packed bed reactor to enhance the feasibility of the system. This study was to fill the reactor with solar-heated warm water and increase the temperature to close to 35 °C, which is beneficial for anaerobic processes year- round. According to the model, the heat demand of the reactor may be effectively balanced by varying the number of flat plate solar collectors that continuously feed warm water that is over
20°C. As a result, the suggested approach may present an effective substitute for improving anaerobic treatment in water treatment facilities.

The solar still was divided into two categories by Chandrashekara and Yadav (2017): (1) direct solar radiation collection and (2) indirect solar radiation collection. Rufuss et al. (2016) called it a passive and active solar still, and Kumar et al. (2015) divided it into single-effect type and multi-effect type solar stills. Several sorts of solar stills are categorised based on how heat from the sun or any other source (indirectly) that can be produced by various solar collectors causes the water to evaporate (Kumar et al., 2015). For the large-scale treatment of water, the economical and effective technology has not yet been fully realised (Arjunan et al., 2014).

Dual passage solar air absorber was used in the study carried out by Kabeel et al., 2016, together with his colleagues. Moreover, PCM has been used to store thermal energy. Between June and July, the suggested system was tested in the climate of Egypt. The results showed that the traditional still only generated 4.5 L/m2 per day. The same meteorological conditions were used to compare the two systems. Also, it has been claimed that the improved technique is 108% more effective than a standard still.

3. METHODOLOGY

The four specific goals for the current investigation are described in this proposed

Overview of the design

Sewage water collection

Process efficiency

Contaminant extraction efficiency

The proposed design is the combination of hardware and software. So, the working procedure of the proposed design is not the same for both software and hardware. For solving any problem or for any system development the whole work should be handled in these segments so that accuracy can be provided. The workflow feature is flexible and designer can return back to the previous step and correct the system at any time according to the requirement. In this workflow, before completing the next stage, each stage must be executed completely. Such a workflow is basically short and there are no uncertain requirements for the proposed design. At each stage the design is analyzed to determine whether the proposed design is going on in the right direction and whether to continue or cancel the stage

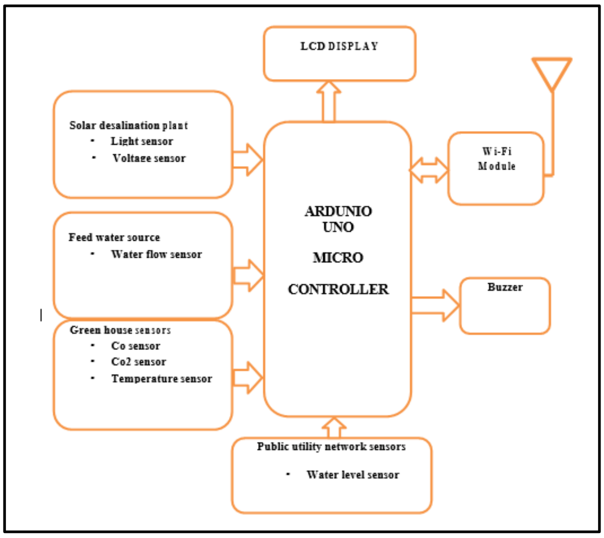

Fig: 1 Block Diagram

The Current and Voltage produced by solar panel will be measured by current and voltage sensors respectively and will be provided to the user. The Temperature sensor will sense the current temperature of the surrounding which will be provided to the user giving user a basic idea about system's surrounding. The Dust sensor will calculate the amount of dust accumulated on solar panel which slows down the generation of solar energy.

4. WORKING METHOD

Looking into the problems in the field of solar energy-based applications, the project aims to make the solar system more flexible and easier for users. The user is unknown about many of the parameters related to the solar panel. This project aims to provide users with detailed energy produced analysis. The proposed system works to monitor the state of a photovoltaic system through an IoT based network to control it remotely and used for maintenance of the system. The information from the sensors is transmitted via Wi-Fi module. A Wi-Fi module is ESP32 to transmit the data to the remote server and then be made visible to the user. Thus, the objective of the system is to improve efficiency of the solar panels and provide the system analysis to the user. The system block diagram shown, of a hardware unit comprising of Arduino, sensors, battery and amplifiers. The other unit in this project is the web portal which will help the user to get the reports of energy production.

The system uses Light sensor, CO2 and voltage sensors to measure current and voltage respectively produced by solar panels. Since the value of current and voltage produced is very small amplifiers are used to amplify the current and voltage in the measuring range. Temperature and Dust sensors provide the real time data regarding heat and soiling effect respectively. Since the output generated by all sensors is in analog, analog to digital converter is used.

5. COMPONENTS

5.1 HARDWARE REQUIREMENTS

Lcd display
Arduino unio microcontroller
Buzzer
IOT (wi-fi module)
Temperature sensor
Light sensor
Voltage sensor
Water flow sensor
Co sensor
Co2 sensor
Water level sensor

5.2 SOFTWARE REQUIREMENTS

Arduino IDE
ThingSpeak IoT Data base

6. RESULT & CONCLUSION

This work has addressed the development of a model predictive control strategy to be used in combination with an IoT platform for the optimal management of a smart grid framework. The smart-grid is composed by a Solar Membrane Distillation Facility and some greenhouses connected through a storage tank, in addition, the use of the water public utility network is also contemplated. Simulation results have been presented showing the high performance of the controller. Future works will be focused in the proper development of the IoT solution.

7.REFERENCES

[1] V. I. Adamchuk, J. Hummel, M. Morgan, and S. Upadhyaya, “On-thego soil sensors for precision agriculture,” Computers and electronics in agriculture, vol. 44, no. 1, pp. 71–91, 2004.

[2] A. Bemporad and M. Morari, “Control of systems integrating logic,dynamics, and constraints,” Automatica, vol. 35, no. 3, pp. 407–427,1999.

[3] S. Burn, M. Hoang, D. Zarzo, F. Olewniak, E. Campos, B. Bolto, and O. Barron, “Desalination techniques-A review of the opportunities for desalination in agriculture,” Desalination, vol. 364, pp. 2–16, 2015.

[4] E. Camacho and C. Bordons, Model Predictive Control. London: Springer-Verlag Ltd,2004.

[5] M. Fazio, A. Celesti, F. G. Marquez, A. Glikson, and M. Villari, “Exploiting the FIWARE cloud platform to develop a remote patient monitoring system,” in 2015 IEEE Symposium on Computers and Communication (ISCC). IEEE, 2015, pp. 264–270.

[6] P. Garcia-Caparros, J. I. Contreras, R. Baeza, M. L. Segura, and M. T. Lao, “Integral management of irrigation water in intensive horticultural systems of Almer´ıa,” Sustainability, vol. 9, no. 12, p. 2271, 2017.

[7] J. D. Gil, L. Roca, A. Ruiz-Aguirre, G. Zaragoza, and M. Berenguel, “Optimal operation of a solar membrane distillation pilot plant via nonlinear model predictive control,” Computers & Chemical Engineering, vol. 109, pp. 151–165, 2018.

[8] G. Gomes and A. P´erez Garc´ıa, “El proceso de modernizaci´on de la agricultura latinoamericana,” 2000.

[9] C. Kamienski, J.-P. Soininen, M. Taumberger, S. Fernandes, A. Toscano, T. S. Cinotti, R. F. Maia, and A. T. Neto, “Swamp: an iot-based smart water management platform for precision irrigation in agriculture,” in 2018 Global Internet of Things Summit (GIoTS). IEEE, 2018, pp. 1–6.

[10] C. Lozoya, C. Mendoza, A. Aguilar, A. Rom´an, and R. Castell´o, “Sensor-based model driven control strategy for precision irrigation,” Journal of Sensors, vol. 2016, 2016.