# IoT-Based Data Logger for solar systems applications

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**Abstract.** A data logger is an electronic device that senses temperature, relative humidity, and other characteristics such as voltage and pulse by combining analog and digital measurements with programming methods. Thus, data acquisition systems (DAQSs) are frequently used in PV facilities to capture all system data to analyze and optimize plant performance. The major purpose of the project is to create a low-cost DAQS. The suggested monitoring system has been used to continuously gather and display the electrical output characteristics of a stand-alone PV system. PV produced voltage, current, and power are examples of such parameters. Furthermore, because the PV module short circuit current is directly proportional to the molar concentration, the global solar radiation may be determined by monitoring it. The proposed system is considered a good solution for collecting the system database to be ready for the analysis and optimization of the PV plant's performance. The configurations of software and hardware of the proposed system are presented, and the proposed system's performance is tested when integrated with a small size PV system.

## 1 Introduction

PV modules' energy conversion efficiency has significantly increased. By utilizing modern technology, it has already risen to 40%. Multi-junction solar cells are one example of such technology [1]. As a result, PV systems have become an important source of energy in the generation of electrical energy all over the world[2]. PV system installation costs are still expensive in developing countries. As a result, the optimal design, size, and performance analysis of PV systems are regarded critical issues [3-4].

Solar agricultural energy systems have exploded in popularity in recent decades. To fulfill people's needs, both on-grid and grid configurations have been devised [5-6]. Solar radiation is the system's energy source, which is transformed into electricity by solar panels and then either conserved in a battery for later use or instantly converted into AC by an inverter to power the load [7].

The efficiency of the entire system is generally determined by the efficiency of the solar panels. Many academics across the world are investigating its potential and dependability in converting solar energy into electricity. As a result, the power characteristic of solar panels is measured and assessed [8].

In recent years, most firms have claimed that their solar panels can last up to 25 years, based on a brief reliability test. However, a more thorough examination of its performance is required.

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To attain this purpose, extensive information on operational output system data as well as solar irradiance information must be collected over a lengthy period. As a result, a data acquisition system (DAQS) has been deemed necessary for monitoring and collecting PV system data to assess its performance. DAQSs help to diffuse PV systems, especially in developing countries. The expense of commercial DAQS remains a barrier to the wider use of PV systems in developing countries [9].

The data logger is a device that can automatically measure the power characteristics of solar panels [10].

Any higher-level system requires the capacity to acquire data on instantaneous power use over a lengthy period. Many solar panel systems designed nowadays may be classified as smart or intelligent systems, both in terms of plugging and unplugging. The data logger, it may be claimed, must be able to work in both systems. Real-time monitoring connected to a PC, according to [10], is power-hungry and hence unsuitable for remote areas. A unique stand-alone data recorder device for solar panel energy systems is presented in this study.

## 2 System Architecture

According to a study of the components of this system, the ACS712-30A sensor is in series between the MPPT and inverter to measure the DC, the ACS753-100A sensor is in series with the inverter and the 4 relay module to also measure the current flowing to supply loads, for the temperature, luminosity, humidity sensors are linked with the solar panel, to measure the

battery voltage a voltage sensor is connected in parallel as shown in fig 1.

To display the data captured by the sensors, two platforms are offered: one is used with a mobile phone or a computer or tablet to monitor the system remotely and to control the relays also remotely thanks to virtual buttons in the platform and the other is for LCD TFT touch screen assembled in a box, these two platforms are created using PHP, CSS, HTML, Javascript program, so in these two platforms can display temperature values, the voltage the currents the power, luminosity, humidity plus the curves too.

So after the Arduino processes the values captured by the sensors, it sends this data to the Raspberry card by sequential commands and precisely in MY SEQUAL (database) is in the servo of the Raspberry and that it communicated by the PHP language with the site, the operating scheme is illustrated in fig 2:

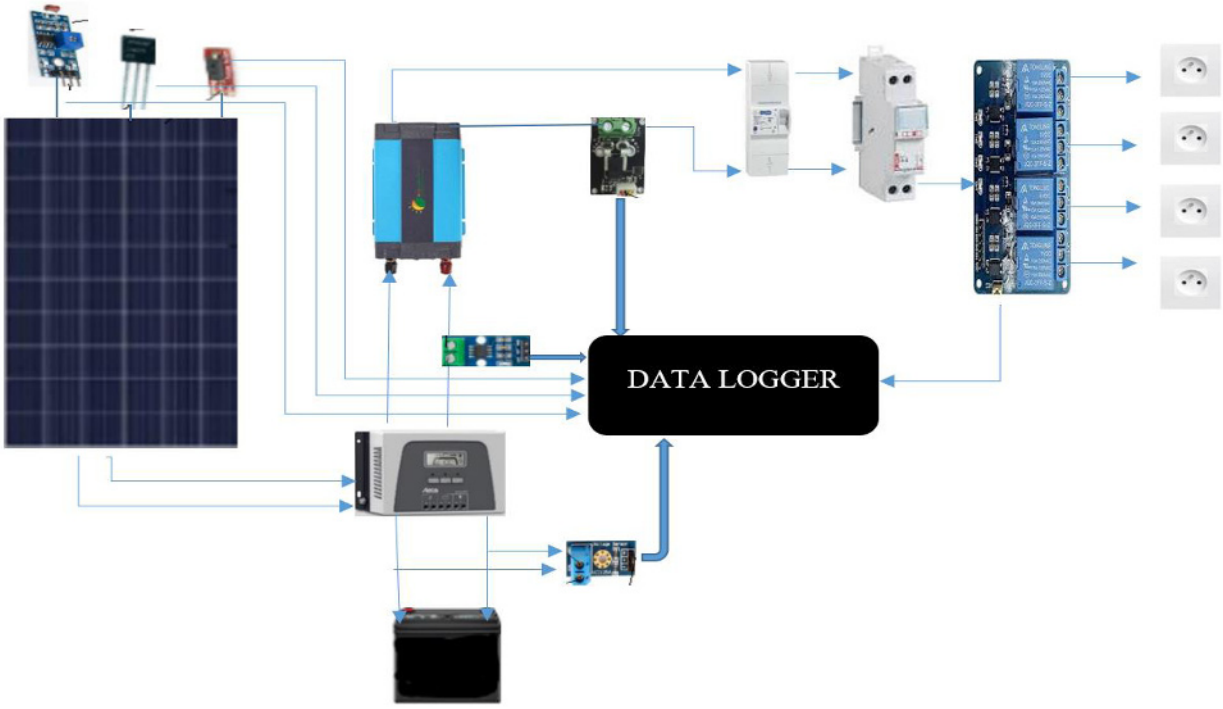



**Fig. 1** Solar system equipped with DATA LOGGER

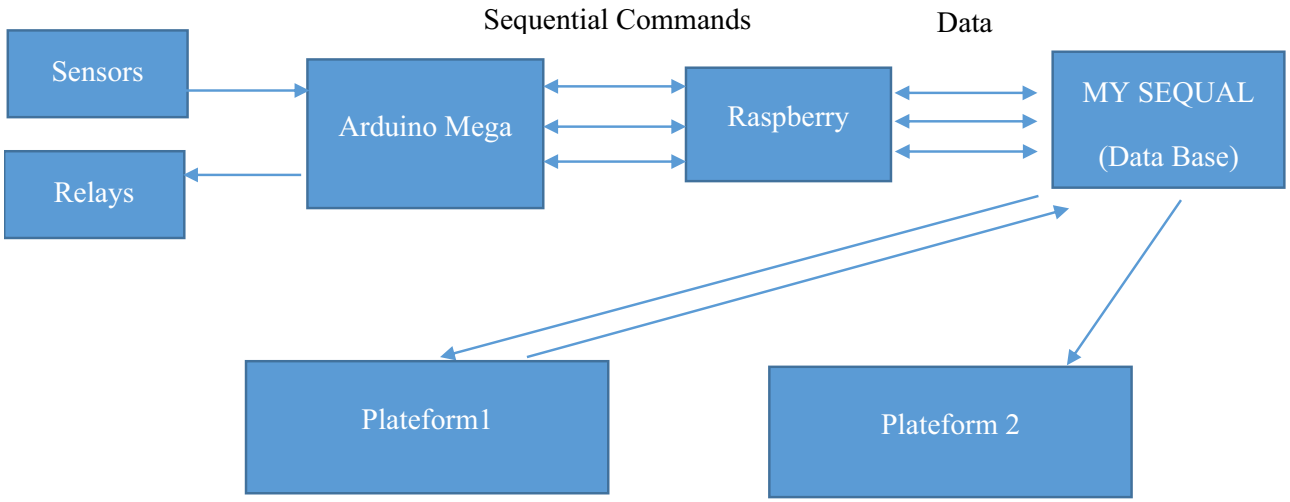



**Fig. 2** Data logging process

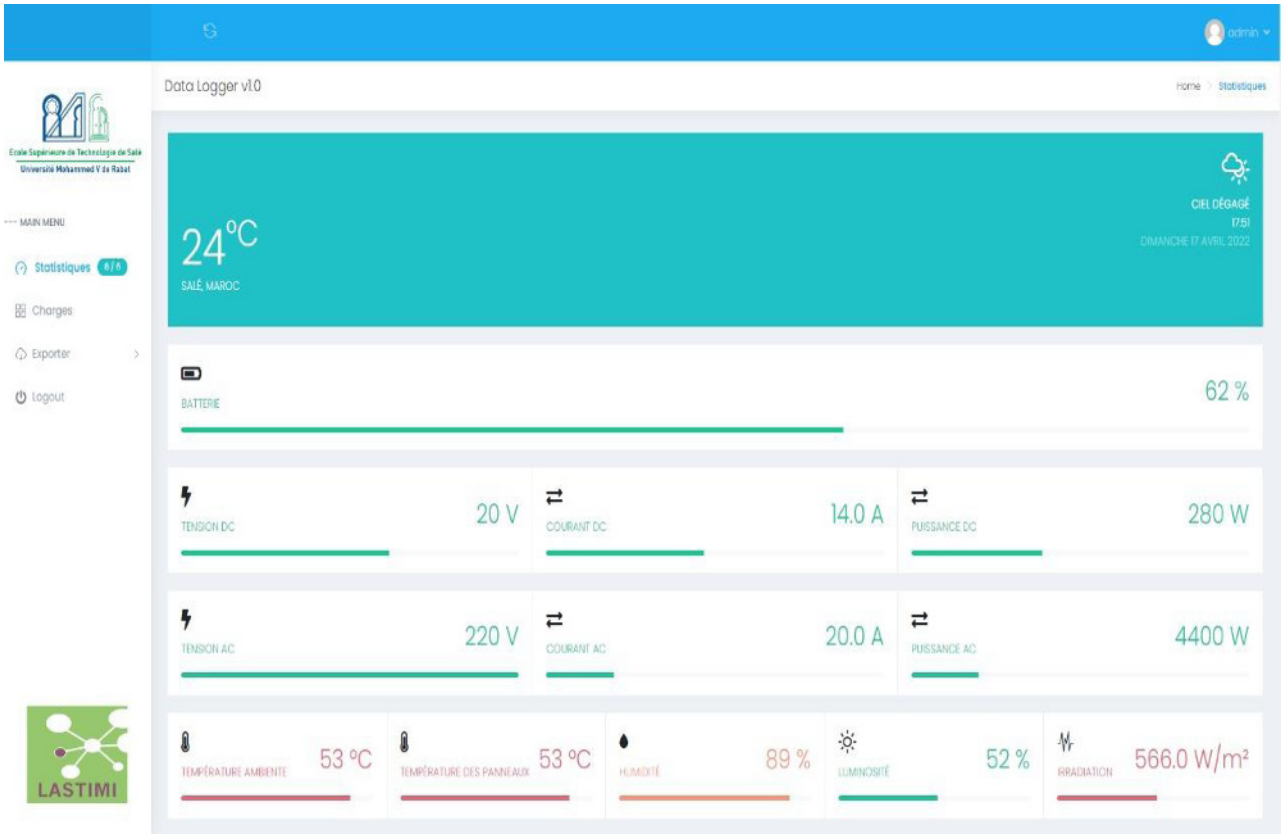



**Fig. 3** Graphical user interface

## 3 Results and discussion

In the proposed layout, It sets up a local HTTP server for you. PHP is a server-side programming language and a hypertext preprocessor. A server is required to host a website whenever one is built. When the request is produced, PHP assists in the interpretation of the pages and gives the page to the client. It can create dynamic web pages and interface with many database systems such as MySQL.

Data must be saved in a database format once it has been created. The suggested system design makes use of the MySQL database. The Apache web server is supported by the Raspberry Pi running the RASBIAN operating system. MySQL databases and PHP programming are also supported. This greatly facilitates data transport.

PCAN USB and USB for data storage are linked to the Raspberry Pi's USB hub. The USB hub is examined for attached devices when the Raspberry Pi boots. Data that the \sPCAN USB inputs are in serial format. This data is recorded as a \sCSV file for database administration, which is done using \sMySQL. This data is sent to the server using FileZilla and an external table.

So for the curves, we have the Javascript language used and precisely the chart.js library.

Js and Chart. Js are two JavaScript libraries that allow for graphical and interactive data visualization. These libraries bind data to an object and display it in a chart or table to make it easier to understand and analyze.

Fig 3 shows the DATA LOGGER GUI platform, While the first interface shown is the login interface shown in Fig 4, two admin users can change the status of loads in fig 5 remotely, however, the user does not have access to modify the state of the loads remotely.

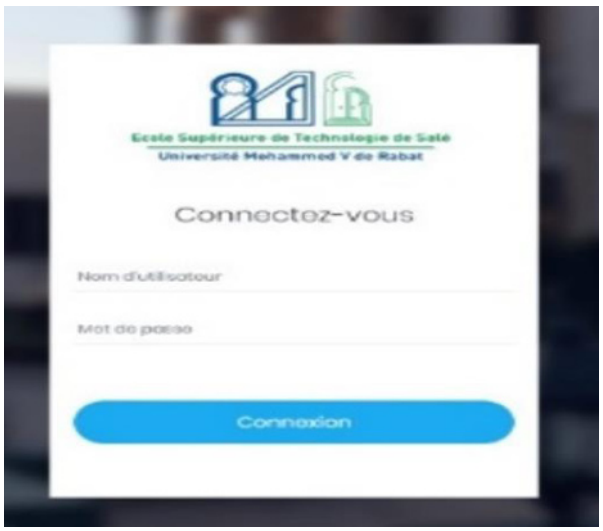



**Fig. 4** Login interface

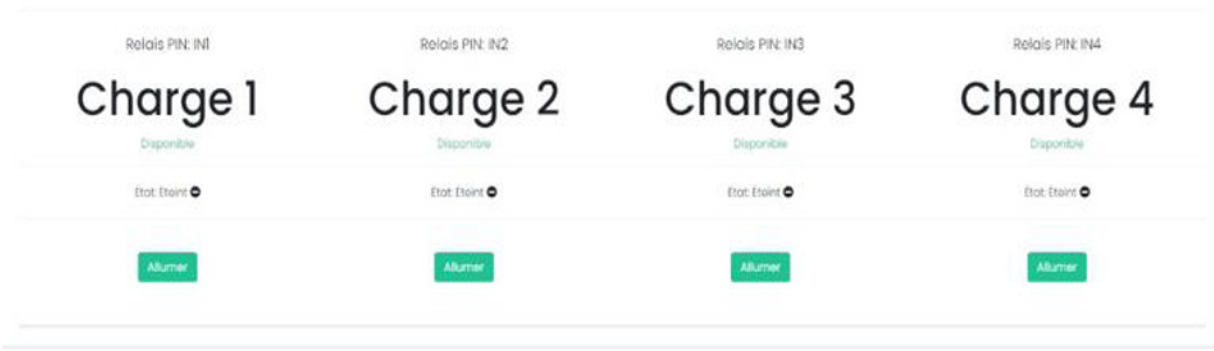



**Fig. 5 Loads interface**

**Fig. 6 Luminosité and Solar irradiance curves**

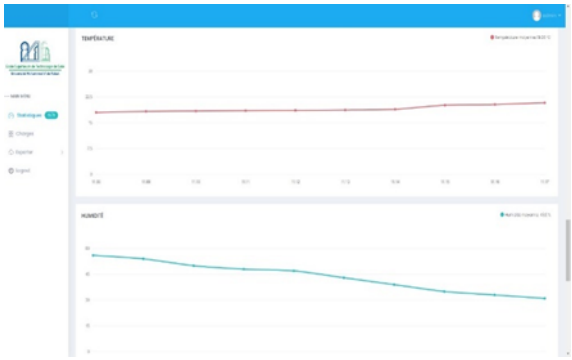


**Fig. 7: Temperature and humidity curves**

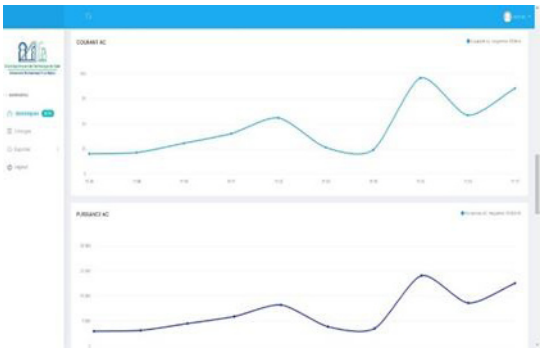
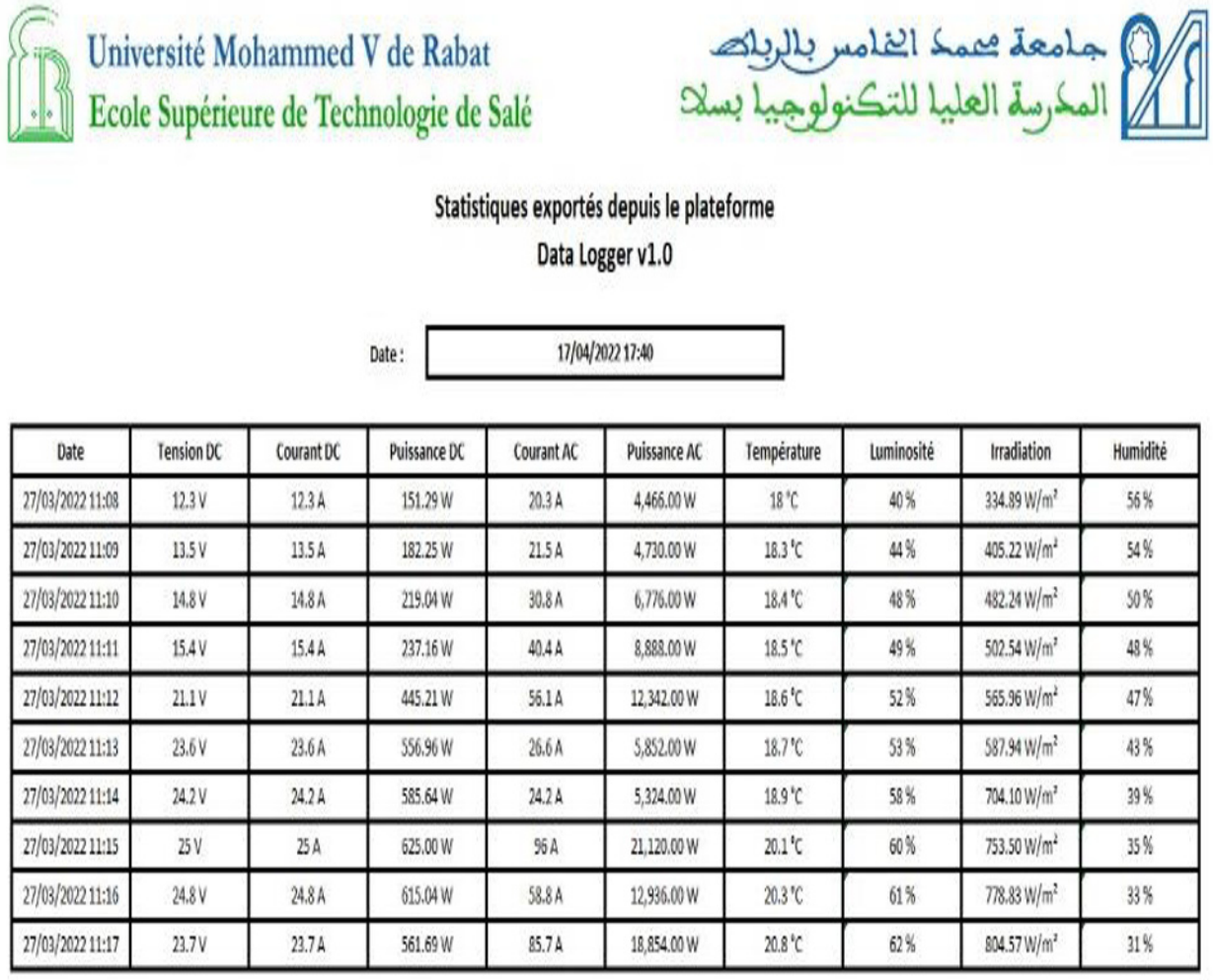


**Fig. 8: AC and DC Current**

**Fig. 9 DC and AC Power**

For data recording the PHP Excel library is used, it is a library that has been programmed in PHP and has a complete set of classes, which allows writing and reading in different spreadsheet file formats, such as Excel (BIFF). XLS, Excel 2007 (OFFICEOPENXML) .XLSX, CSV, LIBRE/OPENOFFICECALC .ODS, GNUMERIC, PDF and HTML.
Then the data can be exported from the last hour or the last month from the platform according to our needs.
Fig 10 shows the printed Excel file: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Statistiques exportés depuis le plateforme
Data Logger v1.0

Date : 17/04/2022 17:40

| Date | Tension DC | Courant DC | Puissance DC | Courant AC | Puissance AC | Température | Luminosité | Irradiation | Humidité |
|---|---|---|---|---|---|---|---|---|---|
| 27/03/2022 11:08 | 12.3 V | 12.3 A | 151.29 W | 20.3 A | 4,466.00 W | 18 °C | 40 % | 334.89 W/m² | 56 % |
| 27/03/2022 11:09 | 13.5 V | 13.5 A | 182.25 W | 21.5 A | 4,730.00 W | 18.3 °C | 44 % | 405.22 W/m² | 54 % |
| 27/03/2022 11:10 | 14.8 V | 14.8 A | 219.04 W | 30.8 A | 6,776.00 W | 18.4 °C | 48 % | 482.24 W/m² | 50 % |
| 27/03/2022 11:11 | 15.4 V | 15.4 A | 237.16 W | 40.4 A | 8,888.00 W | 18.5 °C | 49 % | 502.54 W/m² | 48 % |
| 27/03/2022 11:12 | 21.1 V | 21.1 A | 445.21 W | 56.1 A | 12,342.00 W | 18.6 °C | 52 % | 565.96 W/m² | 47 % |
| 27/03/2022 11:13 | 23.6 V | 23.6 A | 556.96 W | 26.6 A | 5,852.00 W | 18.7 °C | 53 % | 587.94 W/m² | 43 % |
| 27/03/2022 11:14 | 24.2 V | 24.2 A | 585.64 W | 24.2 A | 5,324.00 W | 18.9 °C | 58 % | 704.10 W/m² | 39 % |
| 27/03/2022 11:15 | 25 V | 25 A | 625.00 W | 96 A | 21,120.00 W | 20.1 °C | 60 % | 753.50 W/m² | 35 % |
| 27/03/2022 11:16 | 24.8 V | 24.8 A | 615.04 W | 58.8 A | 12,936.00 W | 20.3 °C | 61 % | 778.83 W/m² | 33 % |
| 27/03/2022 11:17 | 23.7 V | 23.7 A | 561.69 W | 85.7 A | 18,854.00 W | 20.8 °C | 62 % | 804.57 W/m² | 31 % |

**Fig. 10 exported file in excel format**

## Conclusion

The work presented in this paper concerns the theoretical study and the realization of a DATA LOGGER system adapted by an MPPT command which ensures the continuation of the maximum power supplied by the PV generator.
First, a detailed description is given on PV systems, and the importance of Data Acquisition to monitor the efficiency of the installation.
In a second time, a presentation of the software and the hardware used for the realization of this system.
Finally, the creation of the two platforms plus the display and export of data.

## References

1. T. K. Todorov, D. M. Bishop, et Y. S. Lee, « Materials perspectives for next-generation low-cost tandem solar cells », *Sol. Energy Mater. Sol. Cells*, vol. 180, p. 350-357, juin 2018, doi: 10.1016/j.solmat.2017.07.033.
2. A. Awan, M. Zubair, P. P., et A. Abokhalil, « Solar Energy Resource Analysis and Evaluation of Photovoltaic System Performance in Various Regions of Saudi Arabia », *Sustainability*, vol. 10, n° 4, p. 1129, avr. 2018, doi: 10.3390/su10041129.
3. M. Benghanem, K. O. Daffallah, et A. Almohammedi, « Estimation of daily flow rate of photovoltaic water pumping systems using solar radiation data », *Results Phys.*, vol. 8, p. 949-954, mars 2018, doi: 10.1016/j.rinp.2018.01.022.
4. F. J. Gimeno-Sales *et al.*, « PV Monitoring System for a Water Pumping Scheme with a Lithium-Ion Battery Using Free Open-Source Software and IoT Technologies », *Sustainability*, vol. 12, n° 24, p. 10651, déc. 2020, doi: 10.3390/su122410651.
5. X. Lü *et al.*, « Energy management of hybrid electric vehicles: A review of energy optimization of fuel cell hybrid power system based on genetic

algorithm », *Energy Convers. Manag.*, vol. 205, p. 112474, févr. 2020, doi: 10.1016/j.enconman.2020.112474.

6. S. M. Alirahmi, S. Rahmani Dabbagh, P. Ahmadi, et S. Wongwises, « Multi-objective design optimization of a multi-generation energy system based on geothermal and solar energy », *Energy Convers. Manag.*, vol. 205, p. 112426, févr. 2020, doi: 10.1016/j.enconman.2019.112426.
7. S. Fanourakis, K. Wang, P. McCarthy, et L. Jiao, « Low-cost data acquisition systems for photovoltaic system monitoring and usage statistics », *IOP Conf. Ser. Earth Environ. Sci.*, vol. 93, p. 012048, nov. 2017, doi: 10.1088/1755-1315/93/1/012048.
8. R. Zafar, A. Mahmood, S. Razzaq, W. Ali, U. Naeem, et K. Shehzad, « Prosumer based energy management and sharing in smart grid », *Renew. Sustain. Energy Rev.*, vol. 82, p. 1675-1684, févr. 2018, doi: 10.1016/j.rser.2017.07.018.
9. Mokh. S. Hadi, A. N. Afandi, A. P. Wibawa, A. S. Ahmar, et K. H. Saputra, « Stand-Alone Data Logger for Solar Panel Energy System with RTC and SD Card », *J. Phys. Conf. Ser.*, vol. 1028, p. 012065, juin 2018, doi: 10.1088/1742-6596/1028/1/012065.
10. K. Ronay, D. Bică, et C. Dumitru, « ENERGY MONITORING AND LOAD CONTROL. APPLICATION FOR AN OFF-GRID PV SYSTEM. », p. 4.