



BOOK OF ABSTRACTS

The 8th International Conference on
Energy and Environment Research

*“ Developing the World in 2021
with Clean and Safe Energy ”*

Co-organizers



Sponsors



Media Partners



September 13-16, 2021

VIRTUAL CONFERENCE



ICEER 2021

2021 The 8th International Conference on Energy and Environment Research –
“Developing the World in 2021 with Clean and Safe Energy”

Publisher

Instituto Superior de Engenharia do Porto

Editors

Nídia de Sá Caetano, Coriolano Salvini,
Ambra Giovannelli, Carlos Felgueiras

ISBN

978-989-54758-9-6

Printing

e-Book

Number of copies

130

Increasing Energy Efficiency with a Smart Farm - an Economic Evaluation

Filipe Pereira¹, Nidia S. Caetano^{1,2}, Carlos Felgueiras¹

¹ CIETI, Department of Chemical Engineering, School of Engineering (ISEP), Polytechnic of Porto (P.Porto), R. Dr. Antonio Bernardino de Almeida 431, 4249-015 Porto, Portugal

² LEPABE-Laboratory for Process Engineering, Environment, Biotechnology and Energy, Faculty of Engineering, University of Porto (FEUP), R. Dr. Roberto Frias S/N, 4200-465 Porto, Portugal

ABSTRACT

Rural farms are typically energy-intensive facilities with relatively low energy efficiency. In this sector, the introduction of renewable energies and integrated resource management technologies has been slower than in the domestic and industrial sector. The introduction of renewable energy sources was an important step in the past, but they are currently insufficient, as they do not allow for adequate energy management. The development of new solutions with integrated energy control is especially attractive for these installations as they present the least limitations in terms of space and adaptation to new technologies.

This work describes a solution that was developed and implemented in a farm located in central Portugal. The results show that 83.2% reduction in energy from the grid can be achieved, with 5527 kg CO₂ savings, and the return on investment (of €32,434) is about 8 years. However, this period can be shortened if evolutionary options are taken, such as upgrading to electric driven agricultural equipment.

Keywords: Photovoltaic, Renewable Energy, Sustainable Communities, Sustainable farms.

1. INTRODUCTION

The SDGs [1] set specific targets for the next 15 years, ensuring a balance between the three dimensions of sustainable development - economic, social and environmental, while focusing on a healthy planet. In this context, the main objectives of the present work were both to develop a system able to reduce energy consumption in a rural farm, using a photovoltaic (PV) system, and to develop a specific automation oriented to manage a set of existing devices within the infrastructure and equipment applied in agricultural use. This paper will also analyze environmental impacts, both positive and negative, and perform an economic analysis of the project's viability. This work brings an original contribution, as it presents a developed system for a rural farm that responds to some specific SDGs: SDG 6 – Clean water and sanitation; SDG 7 – Affordable and clean energy; SDG 9 – Industry, innovation, and infrastructure; SDG 11 – Sustainable cities and communities. In fact, solutions that have been exploited and implemented for *smart farms* are frequently based in infrastructures that were developed for industry and therefore more expensive than the ones that certainly will take place when verifying the massification of its use [2].

2. MATERIALS AND METHODS

The dimensioned photovoltaic system consists of 6 solar trackers with 18 photovoltaic modules each and has 24 OPzS 2V batteries each. It should be noted that the system has a Multicluster MC-Box6.3 control box to interface and control the loads, and there is also control and monitoring through a PLC with a supervision application.

3. RESULTS AND DISCUSSION

The implemented photovoltaic system will always be in service and only in exceptional cases, for example in the absence of battery charge, does the DC/AC converter switch and allow the electricity to come from the national electricity grid. The costs associated with supplying electricity from the grid were quite significant. One of the invoices is shown for a non-significant month of electricity consumption from the network, in this case in March. Annually, the user had costs of about €5,000, which is quite high. The contracted power is 20.7 kVA.

The expected benefit of installing the photovoltaic system was to reduce the costs of purchasing electricity from the National electricity grid. The calculation of the gross revenue is made through the product of the electric energy produced and the value of the remuneration for the purchase, considering the value of 0.1258 €/kWh for the first year. However, this value is not the same every year, as the cost of purchasing power from the grid will have a predictable average increase of 5.8% per year, as a result of inflation, over the lifetime of the project. The Operation and Maintenance (O&M) cost of all components remains fixed at a defined value for all years. It was considered that all equipment used in the photovoltaic system has a lifetime equal to the operating time of the system. It should be noted that the possible negotiation of insurance for the installation of the photovoltaic system was not considered.

The project's net revenue was calculated by the difference between the gross revenue and the facility's O&M costs. In order to allow for a comparative analysis, it was decided to consider the value of the initial investment without VAT and a discount rate of 7%. In short, the considered values were as follows:

Photovoltaic System cost	€32,434.00 (VAT excluded)
Estimated annual production	27.000 kWh
Operation and Maintenance cost	€324.34/year (VAT excluded)
Electricity price growth	5.8%
Percentage of energy produced	83.24%

With the data obtained, it was concluded that the investment capital is recovered, which is why the project is economically viable. It could also be concluded that, with the application of a rate of 7%, a positive NPV (VAL=49,960 €) is obtained with an Internal Rate of Return (IRR) of 6% and a Payback Time of 8 years. In short, it is a viable project and there is no doubt that this will be the future in self-consumption with energy storage in smart farms.

A technical comparison was made between the developed solution against some solutions available in the literature [3,4,5], concluding that our solution is more expensive but allows the incorporation, later on, of other energy sources such as the one resulting from a mini hydro generator.

Additionally, the electric energy produced by the present solution from the photovoltaic system avoids an annual emission of 5527 kg of CO₂.

4. CONCLUSION

As the implemented System A is framed in the so-called energy efficiency, it has in fact contributed to a significant improvement in the rural farm owner's monthly energy bill, thus making housing more efficient, ecological and automated. With an investment cost of 32,434.00 €, energy savings in CO₂ of 5527 kg CO₂ and 83.24% reduction in the energy consumption from the grid, the system has a payback time of 8 years. The development of technologies based on electronics is consistently low in prices at the same time that it has high potentialities. So, in the future, the use of technologies oriented for the smart farms will be more affordable and, therefore, with much more attractive payback. In addition, the completion of the following phases of the project, i.e., inclusion of a mini-hydro generator and change to electric agricultural machines it is expected that will lead to an increase in the competitiveness of smart farm products.

REFERENCES

- [1] United Nations, 2017. Resolution adopted by the General Assembly on 6 July 2017, Work of the Statistical Commission pertaining to the 2030 Agenda for Sustainable Development.
- [2] Felgueiras, M.C., Martins, F.F., Caetano, N.S., 2017. Sustainability in Buildings – A Teaching Approach. *Energy Procedia* 107, 15–22. <https://doi.org/10.1016/J.EGYPRO.2016.12.124>
- [3] Soufi, A., Chermitti, A., Mostafa, B.M., Zehor, A., 2014. Investigating the Performance of Chosen Models for the Estimation of Global Solar Radiation on Horizontal Surface - A Case Study in Terny Hdiel , Tlemcen of Algeria. *J. Eng. Sci. Technol. Rev.* 7. <https://doi.org/10.25103/jestr.073.07>
- [4] Salihu, T.Y., Akorede, M.F., Abdulkarim, A., Abdullateef, A.I., 2020. Off-grid photovoltaic microgrid development for rural electrification in Nigeria. *Electr. J.* 33, 106765. <https://doi.org/10.1016/J.TEJ.2020.106765>
- [5] Ibrik, I., 2020. Micro-Grid Solar Photovoltaic Systems for Rural Development and Sustainable Agriculture in Palestine. *Agron.* 2020, Vol. 10, Page 1474 10, 1474. <https://doi.org/10.3390/AGRONOMY10101474>