

Our decision is: Revisions Required

'In addition to reviewers request and in order to grow the magazine, I would recommend that you to include some citation from ACTA IMEKO in your bibliography.

First of all we would like to thank all the Reviewers that helped us to improve the overall quality of the manuscript with their precious comments. We also added some references to papers found previous issues of Acta Imeko that were strictly related with the topic of our work. All the integrations in the manuscript are marked in yellow colour.

Reviewer B:

Dear Colleagues,

the paper deals with a topic absolutely hot as the design and realization of WSN not powered by mains but an alternative energy source as solar one. Even if the paper does not show great innovation, it paper is technically interesting and, anyway, it represents a new ring in a long chain which aims to find the better design for these kind of network. For this reason the paper should be rewarded, but something could be improved:

1) (Remark) The word "Optimization" in the title is wrong because the paper shows a design solution but does not realize specific comparisons or test that could justify the word "optimization". In my opinion, this word prevent to the title to reflect the content of the paper. I suggest to change the title deleting the word "optimization".

We thank the Reviewer for the suggestion. We corrected the title removing the word "Optimization".

2) (Mandatory) Please write the measurement units in a way compliant with the International Standard so, where you haven't already done, introduce a space between the number and the measurement unit, e.g.: 10 micrometer, must be written 10 um and not 10um. Please check all and correct.

We apologize for the errors. We modified the wrong notation.

3) (Remark) In the paragraph "5.2. Solar cell characterization results" you show Fig. 8 the power production of a cell in a day, let me say that the holes (0 production) in the graph leave me perplexed: how is it possible that the cell no longer produces power during the day? Typically the efficiency lower in case of cloudy day but it is strange that is zero. Please justify or change the graph.

We substituted Figure 8 with a more reliable acquisition. The wells are due to the presence of trees in the place where we deployed the solar cell characterization instrument, blocking the sun rays at some times during the day. This is not a problem for the actual system operation, but simulates a more realistic condition of use.

4) (Suggestion) I suggest the reading of the following that surely can help you for this and future work:

4.a) the first talks of the realization of Optical WSN powered by solar cells used in a very stressed environment:

Leccese, F., Cagnetti, M., Sciuto, S., Scorza, A., Torokhtii, K., Silva, E. Analysis, design, realization and test of a sensor network for aerospace applications (2017) I2MTC 2017 - 2017 IEEE International Instrumentation and Measurement Technology Conference, Proceedings, art. no. 7969946, . DOI: 10.1109/I2MTC.2017.7969946.

4.b) The second faces the problem from a routing protocol point of view:

Leccese, F., Cagnetti, M., Tuti, S., Gabriele, P., De Francesco, E., Đurovic-Pejcev, R., Pecora, A. Modified leach for Necropolis scenario (2019) IMEKO International Conference on Metrology for Archaeology and Cultural Heritage, MetroArchaeo 2017, pp. 442-447. DOCUMENT TYPE: Conference Paper

4.c) The third is an application for Archeological site in which there is not the mains and the system is powered by a solar panel.

Leccese, F., Cagnetti, M., Calogero, A., Trinca, D., di Pasquale, S., Giarnetti, S., Cozzella, L. A new acquisition and imaging system for environmental measurements: An experience on the Italian cultural heritage (2014) Sensors (Switzerland), 14 (5), pp. 9290-9312. DOI: 10.3390/s140509290

We sincerely thank the Reviewer for his/her suggestion. We carefully read the suggested papers and we included them as references in our work.

Reviewer E:

Title of the paper refers to "optimization" while in the text all that is given is "characterization". No optimization is made nor explained in the paper.

We agree with the Reviewer comment that is in line with comment 1 of Reviewer B. We changed the title accordingly, removing the word "optimization"-

What is the motivation to use LoRa in this particular case? In the busy city area that is assumed for this project to be implemented, there are plenty of other more practical and available options. In remote, isolated, hard to reach area, ok, but in this case, why? It is not a bad idea, but no reasoning is given.

We apologize for not having underlined this aspect in the paper. We chose to adopt LoRa as a transmission technology since we believe that within the Smart City domain it is able to provide possibly the best compromise between performances and costs. Indeed, the long transmission ranges allow to cover a large area with a relatively small number of Gateways: regarding the performances in terms of transmission ranges in urban areas, a large number of papers can be found in literature. Moreover, thanks to the LoRaWAN protocol, a large number of end devices can be simultaneously managed thanks to multi-channel and Gateway redundancies. At the same time, costs are kept very low since no fee is required for the transmitting devices: such aspect may be crucial when the number of devices to be deployed is expected to grow. At the same time, the same LoRaWAN network may be exploited also for other purposes, thus further reducing the costs.

If compared with competing technologies, the benefits coming from the adoption of LoRaWAN can be better underlined. Starting from Local Area technologies like ZigBee, Bluetooth or WiFi, their short transmission range obviously prevents for using them for monitoring at a city scale since too many Gateways may be required. Of course, in some areas a WiFi network may be present, but this is not a rule of thumb.

Moving to Wide Area technologies, cellular ones are of course more reliable than LoRa. However, they require a subscription for each device and this cost may be unsustainable with a growing number of devices: conversely, LoRaWAN may easily scale since no cost is required for connection, and the price of LoRa modules is in the order of few euros, notably lower than its concurrent cellular technology, i.e., NB-IoT. The same limitation is applied to the other well-known sub-GHz technology. SigFox: indeed. Such technology too requires the payment of a subscription for each device.

At the same time, the limitations that may come from the usage of LoRaWAN are not crucial for the proposed application scenario. Indeed, the 1% duty-cycle limitation is not influent on the acquisition of PM values that can be performed every 10-15 minutes, while the limited reliability of the connection may lead to the loss of some packets that is not relevant too for the purpose of the proposed system.

While the previous observations are shaped to our system, they apply too to other applications within the Smart City domain, as witnessed by the large number of works in literature.

We added this explanation in the Introduction.

The main problem with motivation is the notion by the authors that this setup is presumed to be configured and used on public transportation vehicles. The paper presents a fixed position prototype. No practical problems associated with moveable sensor is given nor discussed.

We agree with the Reviewer that movement may cause some problems regarding the functioning of the PM sensor. However, the expected working principle in the real scenario foresees the acquisition of the PM values only when the vehicle is still. The LoRaWAN transmission will be performed in the same instant avoiding possible additional issues due to a radio transmission in non-stationary environment, even if at the speeds usually travelled by public transportation vehicles (i.e., less than 70 km/h) no significant packet loss is expected to be experienced. The vehicle movement will be monitored using an accelerometer. We added this explanation in the section 6.

The other problematic point is the idea itself, and it is presented by the authors as the very important one, is why would solar powered sensor be needed on a commuting bus? There is readily available power source in every vehicle, a battery. Solar power could be used as a backup, but when the bus is not moving for a long time, it is in the garage in some fixed place. As the idea of placing this setup on a public transportation is repeated again at the text conclusion, it looks like an afterthought.

The idea is to design a flexible sensor node that can be easily installed and removed from the roof of a public transportation vehicle (for example using a magnetic support). Obviously, the vehicle is equipped with at least a 24 V DC power line but, to connect the node with this power supply source, some modifications on the onboard electrical system need to be performed. These modifications need to be performed on each different vehicle and this issue strongly limits the flexibility of the application. For this reason, a battery operation has been chosen and since the power consumption of PM sensors is not negligible an energy harvesting system has been added. Moreover, when the vehicle is in the garage there is no reason to measure the concentration of PM and therefore the energy harvesting is not necessary, and it can start at the vehicle departure.

We clarified this point both in the Introduction and in the Conclusions.

Fig 6 and 7 are "typical" as in typical for this prototype or as in typical for this kind of sensor? It is not clear whether these figures are taken from the literature or a results of measurements by the authors? If the latter is the case, it is poorly explained with insufficient data. What was "optimized" and how in there, as stated by the paper title?

We obtained the curves reported in Figures 6-7 testing the solar cell and the characterization circuit in laboratory under a white power LED. The purpose is only to illustrate qualitatively the functioning and the response of the characterization tool.

We added in the text this brief explanation. The word “typical” was probably used improperly in Figure 6 caption, we removed it.

The paper presents as plenty of known information and readily available commercial modules, with a student level type of a project. The scientific importance of this paper is lacking and while it is interesting, it needs major revision, expansion and decision what the focus of the paper is: optimization, characterization, fixed or moveable independent sensor, etc.

Reviewer G:

The paper is well written. References are appropriate. The scientific content is good, and presented results are rather convincing.

We sincerely thank the Reviewer for her/his appreciation.