**Response to Editors and Reviewers**

Dear Editors and Dear Reviewers,

we really appreciated your advice and recommendations and, according to these, the entire manuscript has been revised and improved. All comments have been taken into account and the new version of the paper is more comprehensive and clearer. Your comments enabled a significant enhancement of the paper.

In the revised manuscript (highlighted version), the main corrections/enhancements deriving from the comments are highlighted in yellow. In the following lines, the main revisions are explained and clarified. Other minor corrections carried out by the authors in order to furtherly improve the manuscript quality are not highlighted.

Thank you for your kind attention,

Yours faithfully,

*Fabrizio Ascione*

*Nicola Bianco*

*Gerardo Maria Mauro (corresponding author)*

*Davide Ferdinando Napolitano*

**Legend:**

- Comment **-** Authors’ Response

**General Opinion**

The paper Energy analysis of a real industrial building: model development, calibration via genetic algorithm and monitored data, optimization of photovoltaic integration reports the usage of a genetic-algorithm calibration process to define the optimal amount of PV panels for an industrial building site near Naples, Italy. The topic is interesting and in line with several researches on the topic. Before publication, I suggest to consider the following comments.

**Reply:** Thank you for your comments. We deeply appreciate your opinion. The **corrections/ enhancements** in the revised version of the manuscript are highlighted in yellow.

**Comments**

1. Please try to detail the first two lines of the introduction with additional data.

**Reply:** Thank you for your comment. The first lines of the manuscript have been enriched with additional data. Please, see page 1:

“Buildings are responsible for about 36% of total world energy consumption and for about 40% of CO2-equivalent emissions [1]. At EU level, the scenario is similar [2]. For this reason, one of the main routes to follow to preserve the world we live in is the sustainable development of the building sector, aiming at reducing both the polluting emissions and the energy consumption.”

1. Building energy models are part of the research topic since decades (more than only the last one).

**Reply:** Thank you for your comment. The summentioned sentence has been modified. Please, see page 1:

“For the same reason, during last decades several studies focused on building energy modeling, calibration and optimization [7,8]…”

1. Can you please enlarge a bit the number of quoted paper? Several of them seem to be produced by the same research group, while on this topic several other groups are working. This will allow to better define where the paper is localized at international level. Furthermore, can you please include more papers on PV production forecast or analysis? Thank

**Reply:** Thank you for your precious comment, which has been addressed. 12 other papers have been quoted, to better define the state of the art where the paper is introduced. More in detail, three of these newly-added paper are focused on PV production forecast and analysis. Please, see pages 1-3. The new papers that have been quoted are here reported:

1. Yu, W., Li, B., Jia, H., Zhang, M., & Wang, D. (2015). Application of multi-objective genetic algorithm to optimize energy efficiency and thermal comfort in building design. Energy and Buildings, 88, 135-143.
2. Ruiz, G. R., Bandera, C. F., Temes, T. G. A., & Gutierrez, A. S. O. (2016). Genetic algorithm for building envelope calibration. Applied Energy, 168, 691-705.
3. Xuemei, L., Ming, S., Lixing, D., Gang, X., & Jibin, L. (2010). Particle swarm optimization-based LS-SVM for building cooling load prediction. Journal of Computers, 5(4), 614-621.
4. Delgarm, N., Sajadi, B., Kowsary, F., & Delgarm, S. (2016). Multi-objective optimization of the building energy performance: A simulation-based approach by means of particle swarm optimization (PSO). Applied energy, 170, 293-303.
5. Bamdad, K., Cholette, M. E., Guan, L., & Bell, J. (2017). Building Energy Optimisation Using Artificial Neural Network and Ant Colony Optimisation. In AIRAH and IBPSA’s Australasian Building Simulation 2017 Conference, Melbourne.
6. Bamdad, K., Cholette, M. E., Guan, L., & Bell, J. (2017). Ant colony algorithm for building energy optimisation problems and comparison with benchmark algorithms. Energy and Buildings, 154, 404-414.

[16] De Boeck, L., Verbeke, S., Audenaert, A., & De Mesmaeker, L. (2015). Improving the energy performance of residential buildings: A literature review. Renewable and Sustainable Energy Reviews, 52, 960-975.

[17] Asadi, S., Mostavi, E., Boussaa, D., & Indaganti, M. (2019). Building Energy Model Calibration Using Automated Optimization-Based Algorithm. Energy and Buildings.

[18] Ahmad, M., & Culp, C. H. (2006). Uncalibrated building energy simulation modeling results. HVAC&R Research, 12(4), 1141-1155.

1. El-Baz, W., Tzscheutschler, P., & Wagner, U. (2018). Day-ahead probabilistic PV generation forecast for buildings energy management systems. Solar Energy, 171, 478-490.
2. van der Meer, D. W., Shepero, M., Svensson, A., Widén, J., & Munkhammar, J. (2018). Probabilistic forecasting of electricity consumption, photovoltaic power generation and net demand of an individual building using Gaussian Processes. Applied energy, 213, 195-207.
3. Camilo, F. M., Castro, R., Almeida, M. E., & Pires, V. F. (2017). Economic assessment of residential PV systems with self-consumption and storage in Portugal. Solar Energy, 150, 353-362.
4. Was the climate database (\*epw) used for Validating the model the real one (monitored), or were the bill consumptions normalized? If not, in which way can you calibrate a model using real data of consumptions, but typical weather data? This point has to be strongly discussed and justified.

**Reply:** Thank you very much for giving us the opportunity to better clarify this point. As explained in the revised manuscript, the leak of data related to local weather conditions has obliged the authors to use a typical weather data file for the calibration. Being one of the main purposes of this paper the energy consumption calibration of a model in presence of a lack of data making use of a genetic algorithm, the results obtained could be reputee satisfying. In fact, even if using a real climate database file would have been more precise, the assumption made by the authors has permitted to attain reliable and robust results, which have been verified by the comparison with the real data concerning the energy consumption of the building available on the bills for the year 2018, after having calibrated the model considering the same bills, but for the previous year 2017. This approach was adopted also for the calibration of the productivity of the existing PV system. The model was calibrated considering the monitored data – in this case, they were available – referring to the year 2017, and subsequently the robustness of the calibration was verified with the monitored data relating to the next year 2018. Please, see page 17:

“Despite the effectiveness of the calibration method, and thus the robustness of the results, which was confirmed by the comparison with the measured data related to the year 2018 too, the study here proposed presents a limit.

The leak of data related to on-site measurements concerning the energy consumption of each device and to the local weather conditions has obliged the authors to make some simplifications, in order to calibrate the energy model and investigate the cost-effectiveness of the PV integration for the firm. In usual conditions, the normalization of the bill consumptions would have been required as well as the use of on-site monitored weather data. However, these latter were unavailble, exspecially the productivity of each device, due to the fact that the company works on commission. For this reason, the only way to proceed was to calibrate the energy model basing on typical weather conditions and considering the energy consumptions reported on the bills. This operation was performed referring to the energy bills of the year 2017. As verification, the monthly energy consumption values assessed by the model were compared with the ones monitored the following year 2018. Being the main calibration indexes limit values – evaluated on the yearly global energy performance – respected also for this different year, the model was considered “calibrated”. This approach was adopted also for modelling and calibrating the existing PV system.”

1. Can you please enlarge point 4.2? Being the scope of the specific paper, it has to be enriched, e.g. by analysing more in details the four proposed scenarios.

**Reply:** Thank you for the comment. Point 4.2 has been enriched and the four proposed scenarios have been discussed more in detail. Please, see pages 14-16:

“The electricity production of existing PV system is reported in each of the following summentioned tables, in order to make any comparison clearer for the readers.

***Table 4.*** *Production of PV panels covering the 25% of the non-occupied roof area*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Month** | **Electricity production of existing PV [kWh]** | **Electricity production of PV integration [kWh]** | **Total Electricity production of PV [kWh]** | **Electricity sold to the grid [kWh]** |
| January | 10’865 | 1’613 | 12’478 | 0 |
| February | 14’498 | 2’133 | 16’631 | 106 |
| March | 23’076 | 3’342 | 26’418 | 164 |
| April | 28’663 | 4’048 | 32’711 | 780 |
| May | 38’582 | 4’891 | 43’743 | 2'137 |
| June | 38’057 | 5’083 | 43’140 | 3’199 |
| July | 40’578 | 5’271 | 45’849 | 1'120 |
| August | 36’084 | 4’680 | 40’764 | 1'477 |
| September | 26’307 | 3’562 | 29’869 | 293 |
| October | 19’409 | 2’697 | 22’106 | 64 |
| November | 11’888 | 1’731 | 13’619 | 0 |
| December | 9’640 | 1’431 | 11’071 | 0 |
| Total | 294’920 | 40’482 | 335’402 | 9'340 |

***Table 5.*** *Production of PV panels covering the 50% of the non-occupied roof area*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Month** | **Electricity production of existing PV [kWh]** | **Electricity production of PV integration [kWh]** | **Total Electricity production of PV [kWh]** | **Electricity sold to the grid [kWh]** |
| January | 10’865 | 3’072 | 13’937 | 0 |
| February | 14’498 | 4’062 | 18’560 | 240 |
| March | 23’076 | 6’365 | 29’441 | 445 |
| April | 28’663 | 7’710 | 36’373 | 1’386 |
| May | 35’852 | 6’586 | 45’168 | 3'388 |
| June | 38’057 | 9’681 | 47’738 | 4'479 |
| July | 40’578 | 10’039 | 50’617 | 2'128 |
| August | 36’084 | 8’915 | 44’999 | 2'475 |
| September | 26’307 | 6’785 | 33’092 | 752 |
| October | 19’409 | 5’137 | 24’546 | 239 |
| November | 11’888 | 3’297 | 15’185 | 0 |
| December | 9’639 | 2’724 | 12’364 | 0 |
| Total | 294’916 | 74’373 | 369’293 | 15’633 |

***Table 6.*** *Production of PV panels covering the 75% of the non-occupied roof area*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Month** | **Electricity production of existing PV [kWh]** | **Electricity production of PV integration [kWh]** | **Total Electricity production of PV [kWh]** | **Electricity sold to the grid [kWh]** |
| January | 10’865 | 4’608 | 15’473 | 0 |
| February | 14’498 | 6’092 | 20’590 | 563 |
| March | 23’076 | 9’548 | 32’624 | 1'041 |
| April | 28’663 | 11’565 | 40’228 | 2'319 |
| May | 38’582 | 11’244 | 49’826 | 5'136 |
| June | 38’057 | 14’521 | 52’578 | 6'379 |
| July | 40’578 | 15’059 | 55’637 | 3'236 |
| August | 36’084 | 13’372 | 49’456 | 3'548 |
| September | 26’307 | 10’178 | 36’485 | 1'377 |
| October | 19’409 | 7’705 | 27’114 | 559 |
| November | 11’888 | 4’946 | 16’834 | 4.1 |
| December | 9’640 | 4’086 | 13’726 | 0 |
| Total | 294’920 | 112’924 | 407’844 | 24’162 |

***Table 7.*** *Production of PV panels covering the 100% of the non-occupied roof area*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Month** | **Electricity production of existing PV [kWh]** | **Electricity production of PV integration [kWh]** | **Total Electricity production of PV [kWh]** | **Electricity sold to the grid [kWh]** |
| January | 10’865 | 6’335 | 17’200 | 5 |
| February | 14’498 | 8’377 | 22’875 | 1'139 |
| March | 23’076 | 13’129 | 36’205 | 2'017 |
| April | 28’663 | 15’903 | 44’566 | 3'728 |
| May | 38’582 | 16’485 | 55’067 | 7'456 |
| June | 38’057 | 19’967 | 58’024 | 8'819 |
| July | 40’578 | 20’706 | 61’284 | 4'539 |
| August | 36’084 | 18’387 | 54’471 | 4'796 |
| September | 26’307 | 13’995 | 40’302 | 2'296 |
| October | 19’409 | 10’594 | 30’003 | 1'111 |
| November | 11’888 | 6’801 | 18’689 | 39 |
| December | 9’640 | 5’618 | 15’258 | 0 |
| Total | 294’920 | 160’297 | 455’217 | 35’944 |

Concerning the 25% PV coverage, the electricity production increases of around 40 MWh per year and the sold electricity is around 9 MWh per year. Considering also the existing PV system, the production capacity complexively rises to 335 MWh per year. During warm months, the integration system guarantees an electricity production between 4-5 MWh per month, while during the rest of the year its production is included between 0 and around 3 MWh per month. Finally, the sold energy is equal to 2-3 MWh per month in warm periods, while it assumes values included between 0 and 1 MWh per month for the rest of the year.

When the PV integration covers the 50% of roof area, the electricity production increases of around 74 MWh per year and the sold electricity is around 16 MWh per year. Overall, a production of 369 MWh per year is achieved. Considering exclusively the PV integration system, this latter produces around 9-10 MWh per month during the warmer period, while its production is included between 3 and 7 MWh per month for the rest of the year, with the exception of April, when the electricity production has a peak equal to around 8 MWh. Concerning the sold energy, it is possible to observe that it reaches about 3-4 MWh per month in the warm months and values ​​between 0 and 2 MWh per month in the other months.

Concerning the 75% PV coverage, the electricity production increases of around 113 MWh per year and the sold electricity is around 24 MWh per year. Considering also the existing PV system, the production capacity complexively rises to 408 MWh per year. During warm months, the integration system permits to produce around 15 MWh per month. Finally, the sold energy is equal to 5-6 MWh per month in the warm period, while it assumes values included between 0 and 3 MWh per month for the rest of the year.

In conclusion, when the PV integration covers the 100% of roof area, the electricity production increases of around 160 MWh per year and the sold electricity is around 36 MWh per year. In this case, a total production capacity of 455 MWh per year is achieved, reaching with the second plant about 20 MWh per month in the warm months and 6-16 MWh per month during the rest of the year. The sold energy is equal to 7-8 MWh per month during the warmer period, while it is included between 0 and 4 MWh per month for the rest of the year. Finally, such PV integration can reduce (close to zero) the electricity taken from the grid by supporting the facility self-sustainability.”

1. Please add a section concerning limitation of the proposed studies and a devoted part to introduce further developments.

**Reply:** Thank you for your indication and for giving us the opportunity of enhancing the manuscript. A section concerning the limitation of the proposed studies and the further developments has been added. Please, see pages 17-18:

**“ 5. LIMITATIONS AND FURTHER DEVELOPMENTS**

Despite the effectiveness of the calibration method, and thus the robustness of the results, which was confirmed by the comparison with the measured data related to the year 2018 too, the study here proposed presents a limit.

The leak of data related to on-site measurements concerning the energy consumption of each device and to the local weather conditions has obliged the authors to make some simplifications, in order to calibrate the energy model and investigate the cost-effectiveness of the PV integration for the firm. In usual conditions, the normalization of the bill consumptions would have been required as well as the use of on-site monitored weather data. However, these latter were unavailble, exspecially the productivity of each device, due to the fact that the company works on commission. For this reason, the only way to proceed was to calibrate the energy model basing on typical weather conditions and considering the energy consumptions reported on the bills. This operation was performed referring to the energy bills of the year 2017. As verification, the monthly energy consumption values assessed by the model were compared with the ones monitored the following year 2018. Being the main calibration indexes limit values – evaluated on the yearly global energy performance – respected also for this different year, the model was considered “calibrated”. This approach was adopted also for modelling and calibrating the existing PV system.

The unavailability of data concerning the pieces production of each device, and so their individual electricity consumption, has obliged the authors to use the genetic algorithm, in order to existimate the load factors of each device. However, the assessed load factors could be different from the real one – if measured –, even if the global electricity consumption of the production site resulting from the energy simulations is approximately the same of the measured one. As further development, it would be interesting to measure on site the load factors of the devices, if possible, and, consequently, re-calibrate the energy model. In fact, with the re-calibrated model, it would be possible to investigate also the thermal comfort of the workers, because it would be known the exactly disposition of the internal gain sources, and so it would be also possible to optimize the operation of the HVAC (heating, ventilation and air conditioning) system, considering the thermal comfort and the running costs as objective functions.

In addition, another interesting improvement that could be done to the energy model is the calibration of the CO2 emissions and, more in general, of the environmental impact – from the energy point of view. Once done, a genetic algorithm could be performed, in order to evaluate the optimal energy retrofit strategy for the firm, considering the cost-effectiveness and the environmental sustainability as main targets.”

1. Finally can you please enrich the discussion or the description of your outcomes in order to support the conclusion proposition “it is outlined that the accurate model calibration was fundamental to achieve robust
optimization results”, which is logical, but if the results are that the more PV the better it is, this can be a result that can be potentially reached even without genetic optimization approaches.

**Reply:** Thank you for your comment. The discussion of the outcomes has been enhanced, as better clarified in previous response 5), and the conclusion section has been enriched by modifying and commenting the summentioned statement. Pleaase, see pages 14-16 for the discussion of the outcomes and page 18 for the conclusion:

“Generally speaking, even if the results could appear quite obvious, it is important to remark that an accurate model calibration is always fundamental to achieve robust optimization results. In fact, having a well-calibrated energy model, even other energy retrofit measures concerning the power system could have been easily taken into account, in order to reduce the environmental impact of the building. This could be another interesting point to investigate furtherly.”