Estimation of photovoltaic potential for electricity self-sufficiency: A study case of military facilities in northwest Spain

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Renewable energies, including photovoltaic energy, are attracting widespread international attention, in reaction to worsening environmental problems and the diminishing long-term sustainability of fossil fuel energies. In this work, the potential benefits of installing photovoltaic panels on several buildings at the Spanish Naval Military School (Escuela Naval Militar, ENM) of Marín are considered. The two salient advantages are: significant economic savings from the production and the sale of electricity to the Spanish Electricity Network, and by achieving self-sufficiency in electricity requirements. Consequently, the main objective of this work is to estimate the energy potential of photovoltaic installations on the roofs of the ENM buildings. This is the first time that a project of this nature and size is presented to the Spanish Navy. To that end, a three-dimensional geographic analysis of the buildings is performed using three freeware software: Trimble SketchUp, Skelion and Photovoltaic Geographical Information System (PVGIS). An economic study is also conducted to determine the feasibility of the installations, by estimating the Net Present Value (NPV) of the photovoltaic installation and the Internal Rate of Return (IRR) associated with the project. Subsequently, a sensitivity analysis that considers the most important parameters for the calculation of the amortization period is reported. The results show that the installation could fulfill the ENM electrical demands and could, in addition, generate significant economic benefits. The conclusions end with a recommendation to consider the merits of the proposed solution.

Keywords: renewable energy, photovoltaic installation, sensitivity analysis, electrical autonomy, economic analysis

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I. INTRODUCTION

Renewable energies are playing an increasingly important role in comparison to traditional fuels in the current global energy scenario. The international community, increasingly committed to sustainable development and environmental conservation, is active in promoting the development and use of technologies that harness sources of sustainable energy in different countries, aware that they will, in the future, completely replace the current processes of energy generation[1–3]. At the forefront of renewable energies are photovoltaic technologies that are capable of converting solar power into electric power. Having matured since the second half of the 20th century, these technologies have achieved increasingly efficient levels of production[4–6].

Given this energy panorama and the incessant growth of the photovoltaic sector, it is of immense interest to evaluate the feasibility and utility of using a photovoltaic system to supply electricity to the Spanish Naval Military School (Escuela Naval Militar, ENM). The installation of its own electricity supply off the national grid could contribute to energy independence, bringing tactical and strategic advantages from a military point of view[7,8]. The current electricity network of the ENM is connected to the Spanish Electricity Grid (Red Eléctrica Española, REE), which adds the option of selling the photovoltaic energy. Therefore, there is the possibility of achieving considerable economic savings; a fundamental factor in the current scenario of economic difficulty.

It is the first time that the electric self-supply of the ENM using renewables energy is analyzed. One of the major challenges was accessing to the necessary data, considering the military nature of the place, and filling the gaps where there was insufficient. In order to come up with a feasible solution, the renewable sources must not alter the transit space of the military base by its personnel in their daily tasks. Because of this, the thin-film photovoltaic panels integrated in the rooftops of the ENM buildings was chosen as the energy sources. Besides, the architectonic impact would be minimal, following the original architectural lines.

The Spanish government has implemented a series of measures to reduce energy consumption based on Horizon 2020[9]. Since the approval, in 2010, of the new energy saving and efficiency action[10], the Spanish Ministry of Defence has encouraged the development of new energy efficient technologies applied to military facilities[11]. Likewise, other governments such as Taiwan and US announced innovative energy planning for their armed forces[12–14]. Military energy policy plans list three paths to achieve energy efficiency: (1) reduce consumption, (2) develop new technologies and (3) improve the efficient use of energy. This study focuses on path (3): improving the efficient use of energy through the installation of renewable technology at a military facility.

In the present work, an estimation of the photovoltaic potential of solar panels on the roofs of the ENM buildings is proposed, taking into account present-day Spanish legislation. To do so, the following objectives are established:

i To estimate the photovoltaic electricity generation produced by thin-film panels installed on the roofs of the ENM buildings.

ii To compare estimated energy production with the ENM electric demand and to analyze the degree of energy independence that the proposed photovoltaic installation could provide.

iii To produce an economic and technical study of the installation, in order to estimate the costs of the proposal, as well as the associated amortization period with a detailed analysis of how it may be minimized.

This paper is organized as follows. In Section II, the methods employed in this work are described. In Section III, the results of applying those methods are described. Finally, in Section IV, the conclusions that may be derived from the results are presented.

II. METHODOLOGY

The present study follows a sequential workflow (Fig. 1). First, the rooftop surface areas of the buildings are modeled and the Sun Equivalent Hours (SEH) are approximated to arrive at an estimation of the electric photovoltaic production. Second, the economic feasibility of the photovoltaic installation was estimated in terms of the Net Present Value (NPV) and the Internal Rate of Return (IRR). Finally, the most important economic parameters were estimated through a sensitivity analysis of the IRR.

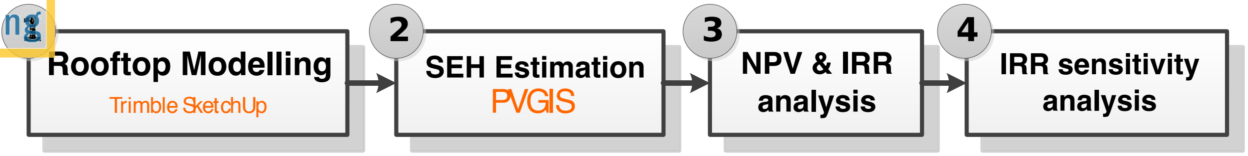

FIG. 1: Workflow diagram

A. Estimation of Photovoltaic Production

The estimation of photovoltaic potential is centered on the ENM buildings (Fig. 2), the coordinates of which are as follows: N42°2.3′ W8°42.3′. It is located in the small town of Marín, in the province of Pontevedra, in northwestern Spain. The main objective of the present work was to present to Spanish Armed Forces the photovoltaic energy as a viable option to fulfill the requirements of a military base. There are other locations where the Spanish army has basements. The main reason for choosing the ENM basement ahead of other options was the ease of obtaining the necessary data for the work. In addition, the northern Spain has the least amount of solar irradiation of all the country. It could be defined as one of the Spanish military bases with the most difficult conditions for the photovoltaic energy. Therefore, if a photovoltaic installation could supply the ENM electrical demand, it would be quite plausible to follow the same path in other military bases with higher solar irradiation.

The annual electrical energy, E_{yr} (kW h), generated by the photovoltaic panels was estimated (1), where PR is the performance ratio or operating efficiency of a photovoltaic installation, covering all types of energy loss that can occur (e.g. shadows, lack of alignment, wiring, etc.); P_i^* (kW$_\mathrm{p}$) is the peak power of the installation of the i-th building; and, SEH$_i$ (h) are the Sun Equivalents Hours of the i-th installation. This equation contains the electrical energy produced by the installation and the peak power of the photovoltaic panels in that installation. Each of the above-mentioned parameters are discussed in further detail below.

$$E_{yr} = \mathrm{PR} \sum_{26}^{i=1} P_i^* \, \mathrm{SEH}_i \tag{1}$$

Overall performance is a variable with a highly complex theoretical estimation that has to take several factors into account. These include losses from electrical wiring, the reduction

FIG. 2: Aerial photography of ENM ground facilities

of electrical energy produced due to panel overheating, the performance of the electrical installation components, and their deviations from the data specified by the manufacturer, amongst others. So as not to enter into such complex estimations, the values of PR were taken from the experimental values obtained from the monitoring of hundreds of photovoltaic installations over several years[15,16]. The values of these monthly records range from 0.75 to 0.85. This oscillation could almost be explained by temperature variations throughout the year. In summer, the panels are overheated, and the overall performance decreases. In contrast, in winter, the temperatures are cooler and the maximum PR values of the whole year are obtained. Actually, there are studies proclaiming a PR above the 0.85[17–19]. However, these experiences are based on single photovoltaic installations. Taking into account the PR experimental data of hundreds of photovoltaic installations, a conservative value of 0.8 was considered.

The peak power is defined as the maximum electrical power that a photovoltaic installation can generate under Standard Test Conditions (STC), which correspond to a solar irradiation of 1000 $\mathrm{W\,m^{-1}}$, a spectral distribution AM 1.5 and a photovoltaic cell temperature of 25 °C[20,21]. The peak power of the entire installation P_i^*, is calculated using (2), where P_p^* ($\mathrm{kW_p}$) is the peak power of the panel used in the installation; S_i ($\mathrm{m^2}$) is the roof surface of the roof building; and, S_{ele} ($\mathrm{m^2}$) is the surface of the selected photovoltaic panel for the simulations.

$$P_i^* = P_p^* \frac{S_i}{S_{ele}} \tag{2}$$

The values of P_p^* and S_{ele} will mainly depend on the technology of the photovoltaic panel. After evaluating the existing technologies and their main advantages and disadvantages, it was decided to use a thin-layer panel of CdTe (Cadmium Telluride). Actually, there are other thin-film technologies such as CIGS (Copper Indium Gallium Selenide) and amorphous silicon. The first one has similar efficieny to CdTe, whereas the second one is several percentage points below. Apart from the mentioned ones, there is a new promising thin-film material: the perovskite. However, it is an emerging technology not stabilized for industrial manufacturing yet. The main reasons for selecting the CdTe tech are its low cost, high efficiency with indirect or diffuse light and, finally, the versatility of the modules, suitable for architectural integration. The latest advances in this technology have permitted efficiencies of 22.1 % or 221 $\mathrm{W_p/m^2}$ in the transformation of solar radiation into electrical energy under STC[22]. Thus, in order to adopt a conservative approach, in the present study, an efficiency of 15 % or 150 $\mathrm{W_p/m^2}$ was assumed. For the sake of simplicity, a hypothetical photovoltaic panel of 150 $\mathrm{W_p/m^2}$ and 1 $\mathrm{m^2}$ was used in all the simulated installations.

The factors that affect the efficiency of a solar photovoltaic system are very numerous and very diverse, but the two most important are probably the azimuthal orientation and tilt. For a facility located in the Northern Hemisphere, as in this case, the optimal azimuthal orientation would be the geographical South. With regard to the inclination of the panel, depending on the season, three possible elevations would be considered[23]: (i) the geographical latitude for constant annual demands, the present case, (ii) the geographical latitude minus 10° for higher electrical demand in winter, or (iii) the geographical latitude plus 10° for higher demand in summer.

One of the advantages of the thin-film installation is its architectural integration. The minimization of visual and aesthetic impacts is a project requisite, so the panels cannot be placed in their optimum position. This under-optimized siting will mean the surfaces are

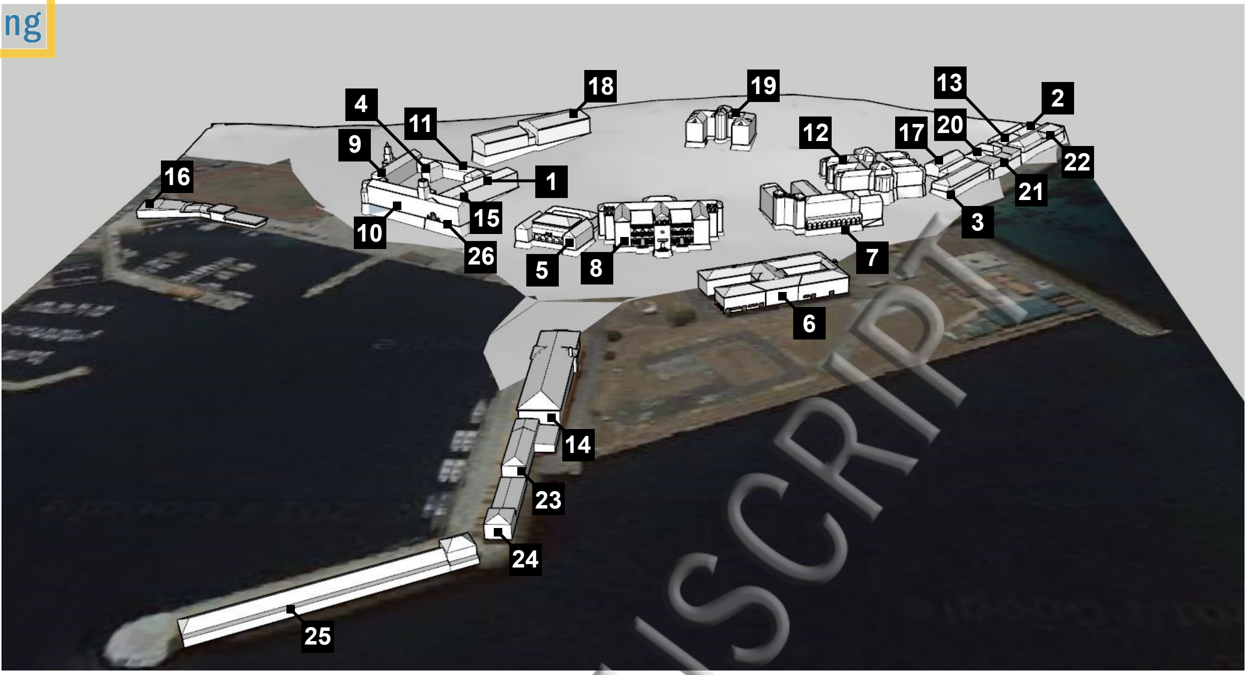

FIG. 3: Trimble Sketchup model of the ENM buildings

unable to capture as much radiation as the optimal orientation would otherwise allow. In the case of the building-integrated photovoltaic, it would imply losses up to 40 %[24].

A three-dimensional model of the rooftops has been devolped using the freeware Trimble Sketchup[25]. Over other commercial options, it was used because its freeware license and ease of use. Hence, it can use plugins developed by third parties, increasing its functionalities (e. g. Skelion). This software allows buildings to be easily modeled from their planes and heights. In addition, it permits a virtual geographic location of the constructions, helping to take the surrounding landscape into account (Fig. 3). As will be seen later on, it is a very important functionality in the calculation of the SEH_i. The architectural plans of the buildings were provided by the Navy institutions. In the buildings for which only the floor plans were available, it was used the BOSCH GLM 100C Professional laser rangefinder. Its technical characteristics (1.5 mm measurement error and 100 m range) were sufficient to obtain the heights of the buildings accurately enough for the estimation of the rooftops surface and its orientations. In this way, sufficient information was obtained to model the dimensions and the orientations of the roofs accurately.

The equivalent solar hour or peak solar hour is defined as the time in hours of a constant hypothetical solar irradiation of $1\,\mathrm{kW_p/m^2}$ to obtain a specific level of insolation. It helps to quantify the insolation in terms of the peak power. The concepts of solar irradiance and insolation are fundamental for the study of the photovoltaic potential. Solar irradiance is defined as the incident power per unit area on a given plane ($\mathrm{W\,m^{-2}}$), while insolation, H_i, is defined as the incident power per unit area during a given interval ($\mathrm{W\,h\,m^{-2}}$) or incident energy per unit area. Annual insolation was used for the estimation, because it is almost constant over time.

$$\mathrm{SEH}_i = \frac{H_i}{1\mathrm{kW_p/m^2}} \tag{3}$$

The estimate of the insolation of each installation, H_i, was performed by weighting the insolation of the roof surfaces, H_c, using their surface areas (4); where, S_c is the surface of each roof face; and, S_i is the total area of the roof. The calculation of H_c was done using a plugin of Trimble Sketchup called Skelion, chosen because its frewaare license and integration with the surface modelling software. This software provides a estimation of insolation levels using the previous surface modeled, taking into account its geographical location and the shadows projected by the surrounding buildings and terrain. In addition, Skelion takes the insolation data from the Photovoltaic Geographical Information System (PVGIS) database, a software tool for the promotion of renewable energy in the European Union. This piece of software is part of the vast freeware ecosystem surrounding the Trimble Sketchup software done by volunteers or startup companies.

$$\mathrm{H}_i = \sum H_c \, \frac{S_c}{S_i} \tag{4}$$

Soft computing techniques could be used for estimating the solar insolation of roofs. One option would be the use of neural networks that predict solar energy from photovoltaic installations with similar orientation to the ENM roofs[26–28]. This would require prior work on searching and obtaining multi-year data history for training the neural networks. Another option for dealing with uncertainty due to data scarcity would be the use of fuzzy sets[29–31]. However, it would require a more complex calculation. The present study is a first approach to the proposed problem. The result obtained, although been carried out using simpler techniques, will be a good indication of its suitability.

B. ENM Electric Consumption

From a military point of view, energetic self-sufficiency is one of the most advantageous aspects of a photovoltaic installation. Military staff were formally requested to provide as much information data as possible on the electrical consumption of the ENM in recent years. They were asked for as much information as possible. Nevertheless, only monthly electrical consumption was provided for the years 2011 to 2015 (Fig. 4). The maximum consumption is in the last and first months of each year when the number of residents is maximum and air-conditioning systems are the most widely used to reduce cold weather effects. On the other hand, the minimum demand is in the summer. Along these months, the officer aspirants and the ENM employees are taking their holidays, being the place almost empty.

Potential photovoltaic production was compared with the electrical demand of the ENM over these years (Fig. 5), in order to assess the self-sufficiency of the installation. The representation of the data shows no clear trend as it can be concluded from the poor value of the determination coefficient R^2 of the trend line. However, supposing a scenario of constantly increasing energy consumption, an approximate increase of 15 MW h or 0.5 % was considered per year (slope of the trend line Fig. 5). This scenario, more likely and adverse than one of constant electrical consumption, was used to estimate the degree of energy independence contributed by the facility over its useful life, usually guaranteed at 25 years[32–35]. At the end of this period, using the aforementioned trend, ENM electrical consumption would be approximately 13 % higher than the current one, i.e. 3963 MW h would be consumed.

C. Economic Analysis

The cost assessment and the feasibility of any project are two decisive factors in decision-making. In the Spanish Armed Forces, these factors could be essential in deciding whether a project will be approved. Net Present Value (NPV) was used in the evaluation; a procedure that allows us to calculate the present value of a certain number of future cash flows originated by an investment. If the NPV is greater than zero, the project is profitable. The NPV calculation is described in equation (5); where I_0 is the initial investment; F_t represents the cash flow for period t; and, k is the interest rate. In the analysis that was performed,

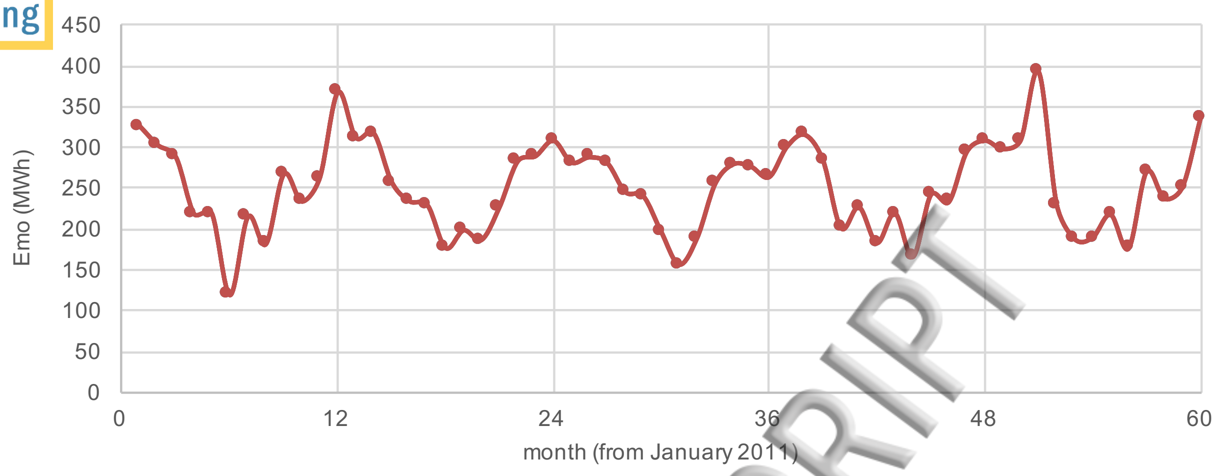

FIG. 4: ENM monthly electric consumption

FIG. 5: ENM yearly electric consumption

the NPV was studied over the life of the 25-year facility. When the NPV reaches a value equal to zero, the number of elapsed periods is called the Internal Rate of Return (IRR), defining the time needed for the investment to become profitable[36–38]. These parameters will be described in more detail below.

$$\mathrm{NPV} = -I_0 + \sum_{25}^{t=1} \frac{F_t}{(1+k)^t} \tag{5}$$

The initial investment, I_0, depends on the peak power, P^*, and the turnkey price, C_{key} (6). The last variable indicates the price of the elements of a photovoltaic facility and everything needed to work initially except taxes or post maintenance costs. The installation costs depend on its nature (residential, commercial, industrial or facility)[39]. The proposed installation was categorized as industrial, because it is a large installation and the electrical demand would be higher than a residential or commercial one. In 2015, the average C_{key} of an industrial facility was estimated at 1.74 €/$\mathrm{W_p}$[40,41] considering the Value Added Tax (VAT) rate of 21 %.

$$I_0 = C_{key}\, P^* \tag{6}$$

Incoming and outgoing cash flows, F_t, were defined for a given period[42] (7). The incoming cash flows represent the electric energy sold to the REE at an average price, S_{ele}, of 0.21 € $\mathrm{kW^{-1}\,h^{-1}}$[43]. It is assumed that all of the non-consumed photovoltaic energy will be sold through the grid, being the purchase price of electricity equal to the selling price. Based on Royal Decree 900/2015 (RD 29/2015), in draft form at the time of this work, the type of facility studied is a type 2 of self-consumption. That is, there is no limit on installed power. The outgoing cash flows represent the maintenance cost, C_{mnt}, and the tax burdens, C_{tax}. The values considered were a maintenance cost of 0.042 €/$\mathrm{kW_p}$, corresponding to the production and maintenance costs of a rooftop photovoltaic system estimated in 2015[44], and 0.029 399 €/(kWh) of taxes based on RD 900/2015.

$$F_t = S_{ele}\, E_{yr} - (C_{mnt}\, P^* - C_{tax}\, E_{yr}) \tag{7}$$

The discount rate, k, adjusts the cash flow due to changes in interest payments on the initial investment loan and depreciation due to inflation. The calculation of this rate is described in equation (8); where, i_n is the interest rate of the loan; and, i_f is the average national inflation rate. The interest rate of the loan was set at zero, because the project would be financed by the Spanish Ministry of Defence. The average national inflation rate in Spain over the last five years has been 1.18[43]. These two variables combined together result in a value of k of 0.988.

$$k = \frac{1 + i_n}{1 + i_f} - 1 \tag{8}$$

In addition, a sensitivity analysis was performed on the IRR. It consisted of determining the behavior of the IRR value compared with the variations of the different parameters that define it. In the initial estimation, those parameters were assumed to be constant over time. It was considered a pessimistic scenario, keeping constant the price of electricity. If the current price increasing trend had been considered, the profits of the facility would be higher. Even though they could vary, the sensitivity analysis is useful to assess the different scenarios such variations might cause. The variables selected for the sensitivity analysis were S_{ele}, C_{key}, C_{mnt}, C_{tax}, i_f and P^*. In essence, all relevant parameters susceptible to temporal change were selected. The purpose of the sensitivity analysis was, on the one hand, to estimate the effect on the IRR of the variability of the selected parameters over time; and, on the other hand, to highlight those with a more critical quantification, because they have most effect on the IRR calculation.

III. RESULTS AND DISCUSSION

The study has been carried out in the area with the lowest insolation of the Iberian Peninsula and the results demonstrate the viability of the self-sufficiency using photovoltaics energy for singular facilities. The results can be extrapolated to other buildings with similar levels of occupancy, such as schools, residences or private homes and undoubtedly, will be very improved in places with higher insolation levels. The results of the simulation have been contrasted with real data of the operation of similar installations, which shows the validity of the methodology used in the study. As an additional advantage, the use of free software for the development of all the work allows the realization of these feasibility studies at virtually no cost to the designer. Although the energy viability of the facility is obvious, the uncertainty regarding the evolution of electricity prices in Spain and the legislation on energy self-sufficiency imply great difficulties in analysing the economic viability of the installation.

In Fig. 6, the SEH is shown alongside the estimated annual electrical energy produced by the hypothetical photovoltaic installation on the roofs of different buildings of the ENM. Also, in Fig. 7, the ENM buildings are shown coloured according to SEH. There is a difference of 14 % between the roof with the highest ($1615\,\mathrm{kW\,h^{-1}}$) and the lowest ($1319\,\mathrm{kW\,h^{-1}}$) estimated SEH. This variation is mainly explained by the different azimuthal orientations of the buildings, where roofs facing South have the highest photovoltaic potential. Nonetheless, buildings with the highest SEH are different from those with the highest energy potential. The explanation lies in the different surface areas of the roofs. Among all the buildings in

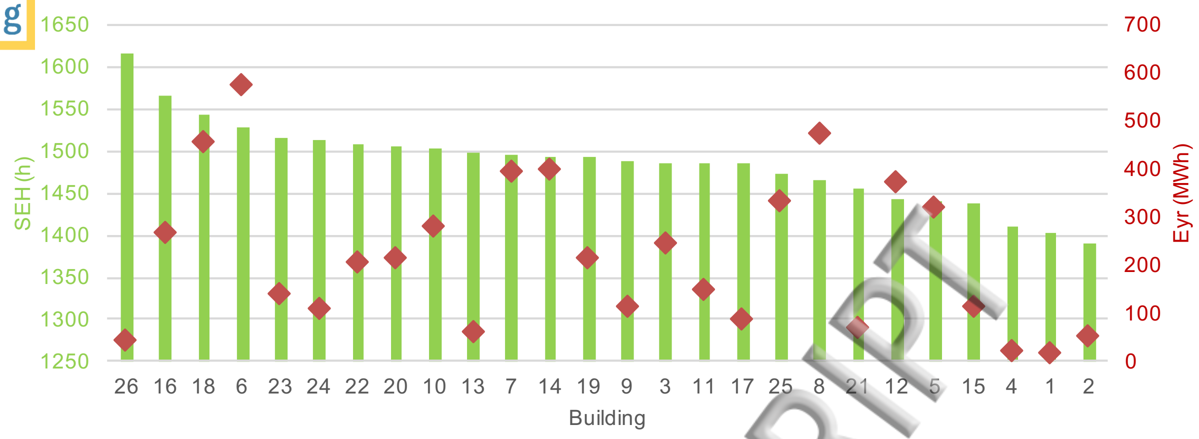

FIG. 6: Photovoltaic yearly production and SEH on the rooftops of the ENM buildings

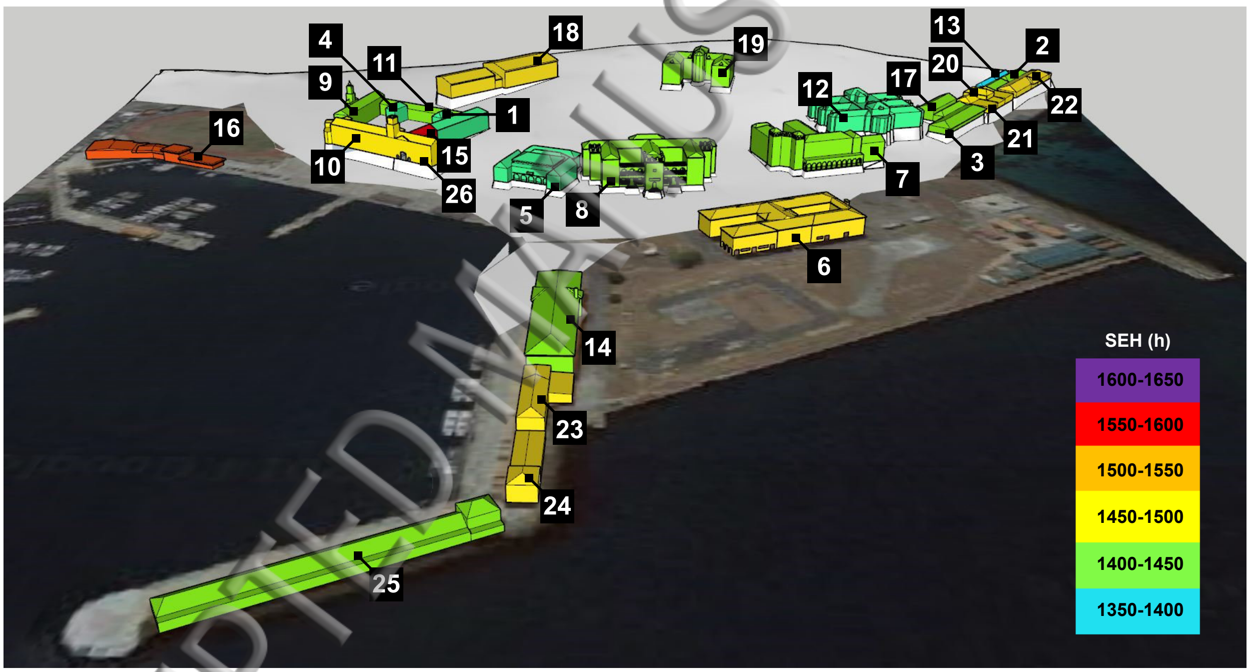

FIG. 7: SEH of the ENM buildings

the analysis, those with higher SEH and E_a would be buildings 6 and 8. It is estimated that the total power installed in the ENM would be in the region of $4.84\,\mathrm{MW_p}$ and its annual production of electricity would be $5780\,\mathrm{MW\,h}$; a level that is twice as high as the electricity consumption of the ENM in 2015 and $45\,\%$ higher than the projected consumption in twenty-five years from the present.

The results obtained from the PVGIS website reflect the importance of good orientation of the building to maximize solar energy collected per square meter. The roof surface of building

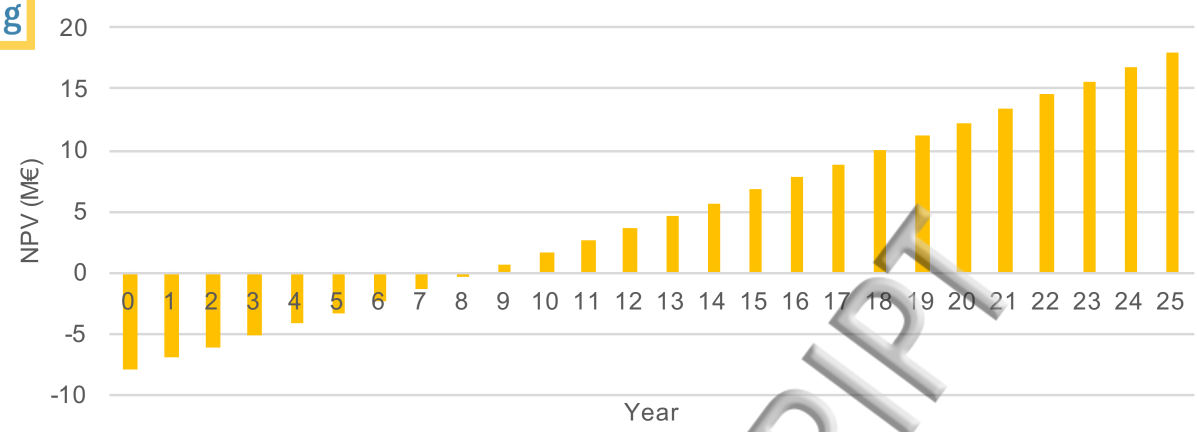

FIG. 8: IRR estimation of the photovoltaic installation

5 has a total of $1800\,\mathrm{m}^2$, while building 6 has a total of $3100\,\mathrm{m}^2$ on its roof. This contrasts with the total solar energy incident on the roofs of the buildings, being $5700\,\mathrm{kW\,yr^{-1}}$ in building 6 and $5800\,\mathrm{kW\,yr^{-1}}$ in building 7. Henceforth, a worse orientation and/or a greater number of projected shadows in building 7 are the cause that its roof collects the same annual energy as the building 6, in spite of having three times more area.

The NPV calculated on the basis of a 25-year period was 18 M€ with an IRR calculated at 9 years (Fig. 8), a period that almost doubled the estimated 5 years for a photovoltaic plant today. The initial investment was estimated at 7.85 M€. 25-year is usually the covered warranty period of the photovoltaic panels. To show the economic viability of the photovoltaic installation, the IRR value must be minimized: it was assumed that all photovoltaic energy was sold. In other words, if initially the economic aspect took precedence over energy self-sufficiency, it would take a decade to amortize the installation.

In the calculation of the NPV, the profits from the sale of electricity and savings produced by self-consumption were added to the incoming cash flows. The latter is money that has not been paid for buying energy from the electricity grid. Of the 18 million euros, taking into account the annual electricity consumption of 3000 MW h of ENM with an annual increase of 15 MW h, 17 million euros correspond to the savings of self-consumption. The remaining amount, 1 M€, would be produced by the sale of unconsumed electrical energy to the grid.

In Fig. 9, IRR variability is shown form the most influencing parameters (i.e. S_{ele} and C_{key}). It can be seen that S_{ele} is the parameter with the highest potential influence on variability, which when decreased by 50 % increases variability by 178 %. Also, an increase

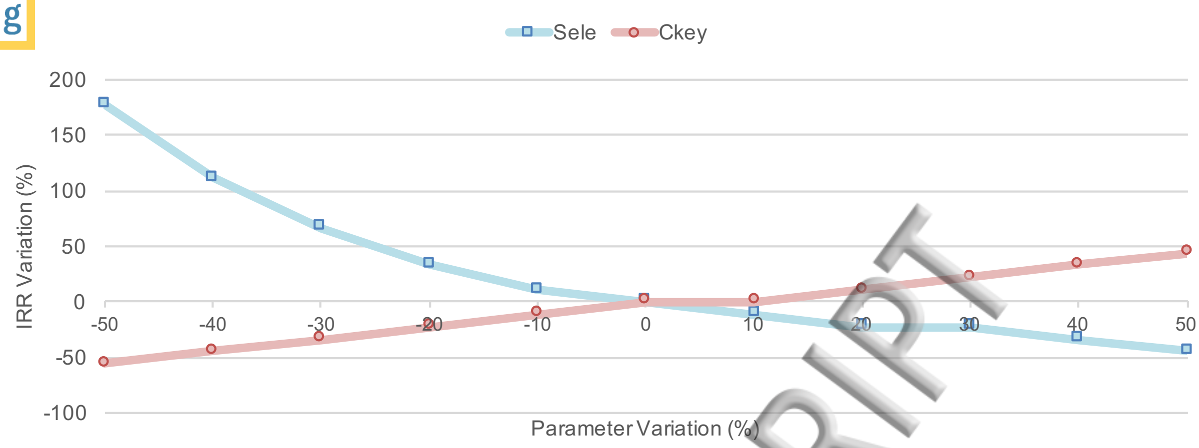

FIG. 9: IRR sensitivity analysis of most influencing parameters

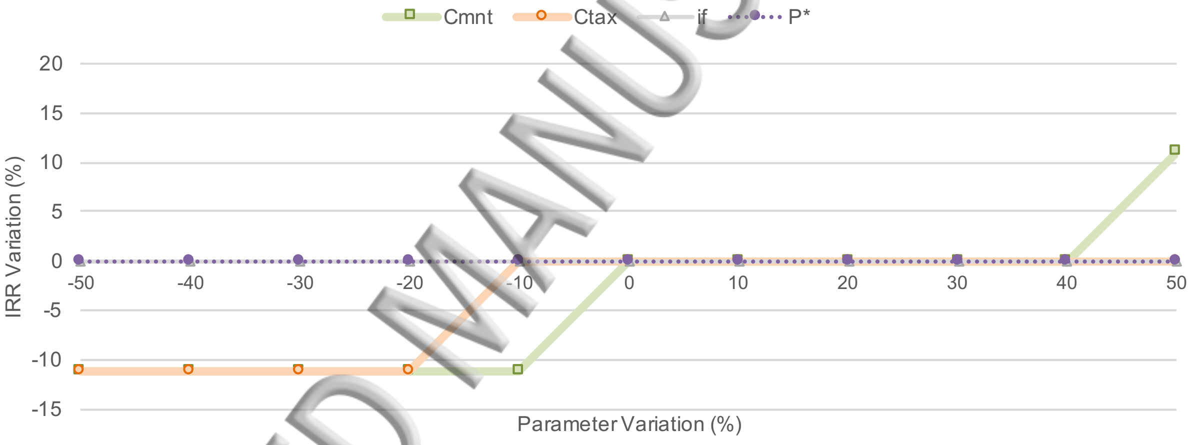

FIG. 10: IRR sensitivity analysis of least influencing parameters

in C_{key} of 50 % could increase the IRR by 49 %. However, both scenarios are unlikely, since over their last decade temporal progression. In other words, assuming the immutability of the parameters, their expected evolution would produce an IRR of less than the estimated period of 9 years.

In Fig. 10, it is shown the IRR variability for the least influencing parameters (C_{mnt}, C_{tax}, i_f and P^*). C_{mnt} and C_{tax} vary the IRR less than 10 %. Meanwhile, i_f and P^* have no appreciable effect on the IRR. It can be concluded that it is worthless to keep them into account. However, their null influence it was only checked in parameter variation below the 50 %, having to check again the conclusion if their variation was higher.

Another major beneficiary of this approach would be the environment. Once the phovoltaic installation has been completed in its entirety, it would produce 5780 MW h yr^{-1}. Taking into account that in the life cycle of a thin-film CdTe photovoltaic installation it produces the equivalent 20 g_eCO_2/kWh[45], the ENM photovoltaic installation would produce about 115 t_eCO_2/yr. To produce the same amount of electrical energy, assuming a 100 % efficiency, it would take 7727 barrels of oil. When producing electricity from oil, 0.24 kg_eCO_2/kWh is emitted[45]. If electricity production were based on fossil fuels, at best, 1387 t_eCO_2 would be released to the atmosphere. Overall, greenhouse gas emissions would be reduced by one tenth by using the photovoltaic installation.

IV. CONCLUSIONS

An analysis of the energy autonomy and the economic benefit that a photovoltaic installation could bring to the Spanish Military Navy School has been presented. The panels would be integrated into the roofs and, therefore, the impact on the architectonic style would be minimized. The estimated electric photovoltaic energy could fully meet the electrical needs of the school. In addition, in the case of selling surplus energy to the local energy network, the time needed to payback from the investment would be in the region of 9 years. In the mentioned period, also there are the savings of the energetic self-suffcicency.

Observing the results of the IRR sensitivity analysis, special attention should be given to the C_{key} and S_{ele} estimations. In the worst case, an error in their quantification of the 50 % could involve a 44 % underestimation of the IRR in the case of the C_{key} and 178 % for the S_{ele}. Different scenarios should also be considered with the possible evolution of the parameters that influence the IRR, to see their combined effect.That is, the variables selected for the sensitivity analysis were those that directly affect the results and may change over the service life of the facility. Furthermore, the construction of pilot plants is recommended before carrying out the entire photovoltaic systems installations. To that end, the use of buildings with the highest SEH and E_{yr} is recommended, i.e. buildings number 18 (GGM Barrutia) and 6 (Admiral Francisco Moreno). The data on these facilities would introduce adjustments in the predictions.

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