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PV Potential Assessment Platform

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***Abstract*—Collective self-consumption and renewable energy communities (RECs) have gained global attention due to increasing integration of distributed energy resources (DERs) into the power system and rising concerns of consumers in the electricity market. The determination of the renewable generation potential in a zone becomes a relevant input for planning purposes. This paper presents the platform being developed by the research team to automatically assess the solar power and yearly energy that can be produced in any given area. The platform combines manual selection with geographic information system (GIS) based methods and incorporates satellite solar radiation data. A case study applied at Las Palmas Port in Gran Canaria (Canary Islands, Spain) resulted on the definition of 342,020 m^2 of suitable surfaces for PV panels that could be used to generate 70.81 MWp, capable of producing 113.351 GWh per year.**

Keywords—solar energy, PV potential assessment, geographic information system

I. INTRODUCTION

The adoption of the “Clean energy for all Europeans package” [1] aims to decarbonise the energy system in EU. A key part is making the electricity market fit for the clean energy transition with the consumer at the core. By empowering the active participation of individuals and groups of consumers more flexibility is allowed to accommodate an increasing share of renewable energy into the grid. This is producing a growing interest for collective self-consumption and renewable energy communities (RECs).

RECs bring local communities together with the integration of distributed energy resources (DERs) reshaping the energy system [2]. The backbone of a REC consists of coordinated DERs to meet the demand locally ensuring cost-effectiveness and reliability [3]. However, this transformation from passive to active distribution grids require planning and operating actions [4]. For both electricity utilities and councils, determining the renewable generation potential in a neighbourhood, district or city becomes a relevant input for their planning purposes.

A. Radiation Map

Many studies have been carried out to determine the photovoltaic (PV) generation potential in a zone [5] often with results limited to radiation maps though. Only few works combine the radiation with available surface areas to produce figures of potential PV power.

B. Rooftop Suitability

In [6] the literature on rooftop-area estimation is reviewed. It identified three major methods, i.e. constant-value, manual selection, and geographic information systems (GIS) based methods.

Constant-value methods consider typical rooftop configurations and estimate a multiplier that can be applied to an entire region. These methods are easy to use and are neither time- nor resource- intensive. However, the results do not consider localized rooftop characteristics and validation is difficult. Manual selection methods to identify suitable rooftops make use of aerial imagery where the footprints for buildings are digitized and the rooftop areas calculated. These methods are detail specific but time consuming and hard to replicate across regions. GIS-based methods are used in the majority of rooftop analyses. The main difference with the previous methods is that ideal values for rooftop characteristics are inputs to computer models and the GIS software determines suitable areas. These methods can be automated and are replicable across regions. The drawbacks are excessive time consumption and the high computer burden involved.

This work presents the platform being developed by the research team to automatically assess the potential PV power in a region, district or neighbourhood. It combines manual selection and GIS based methods to obtain the rooftop suitability, and incorporates satellite solar radiation data. Built upon Quantum GIS (QGIS, GIS platform) [7], makes use of high-resolution territorial orthoimages, the Mapflow plugin (based on artificial intelligence models, extracts real-world objects from satellite imagery including buildings, roads, construction sites, agricultural fields and forests) [8], the QGIS Python console (PyQGIS) [9] and the Photovoltaic Geographical (PVGIS) [10].

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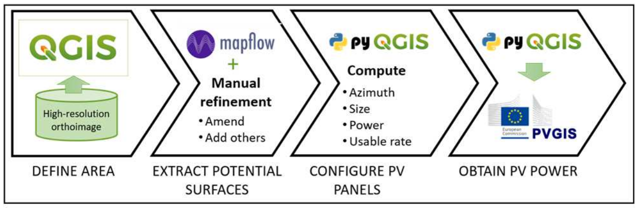


Fig. 1. Process carried out by the platform.

The rest of this paper is organised as follows. Section II describes the methodology. Section III presents the use case carried out in the port of Las Palmas de Gran Canaria premises. The potentiality of the platform is discussed in Section IV. Finally, Section V reports the concluding remarks.

II. METHODOLOGY

The process carried out by the platform towards the PV potential assessment is depicted in Fig. 1.

The first step consists in defining the zone under study on the GIS platform provided with a high-resolution orthoimage layer. Then, the Mapflow plugin is applied to automatically extract potential rooftops for PV panels. This step requires some manual refinement of the areas obtained. On the one hand to amend building footprints improperly identified and to include additional potential areas on the other.

At the next stage, PyQGIS takes the main role. By means of the python console the objects extracted previously are classified attending to the azimuth angle of their main axis. This will serve as the basis for the configuration of the PV panel strings. The inclination of non-flat rooftops, the size and power characteristics of each PV panel and the rate of usable surface on the rooftops are fields manually introduced into the console.

Finally, PyQGIS accesses the solar radiation data for the location from the PVGIS server and processes all together yielding to the potential PV power that can be produced on that area and the daily, monthly and yearly estimated energy that could be generated.

III. PLATFORM DEMONSTRATION - CASE STUDY

A case study is performed to assess the PV power potential at the facilities of Las Palmas (La Luz) Port in Gran Canaria. Located in the north-east of Gran Canaria, Canary Islands (Spain), the complex includes 14 km of docks and moles, 2,000 hectares of floating surface, 40,000 m^2 and 300,000 m^2 of covered and uncovered storage respectively and a petrol storage capacity over 328,000 m^3. As for activity indicators, in 2018 there were 1,034,063 containers movements.

The web map service for the high-resolution imagery is provided by IDE Canarias, dependent on the Canary Islands Government, and based on ortho-pictures taken during flights in 2022 improved to produce 16 cm/pixel resolution images.

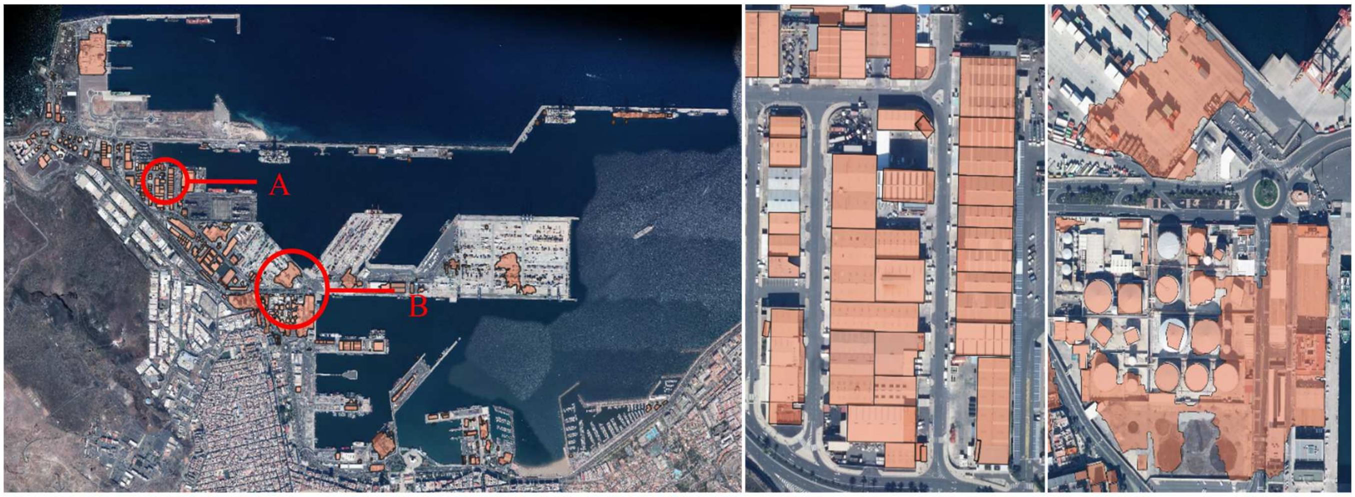
Once the QGIS layers are loaded and the area defined, the Mapflow plugin is applied and the footprints from buildings and other shapes in the zone are extracted onto a new layer. Fig. 2 shows the resulting layer, with some good extractions (zone A) but with others requiring manual refinement (zone B).

For this case study, fuel tanks and parking lots are identified as suitable surfaces for PV panels as well and therefore manually rendered into the platform.

Fig. 3 displays the improved objects extraction categorized into flat or sloping rooftops, fuel tanks, parking lots and others (in this application it was found that there were hillsides worth making use of), coloured into yellow, pink, blue, orange and green respectively.

All the categorized shapes are then processed by the PyQGIS scripts, resulting in the areas presented in Table I. The application of different rates of usable surface yields to a total suitable area of 342,020 m^2.

The PV installation is based on regular panels made of monocrystalline/N-type cells, rating 450 Wp and extending over



(a) (b) (c)

Fig. 2. Layer with the automatic extraction of building footprints. (a) General view. (b) Zoom-in of zone A, a well resolved extraction. (c) Zoom-in of zone B, extraction requiring further refinement.

Fig. 3. Objects extraction categorized into flat rooftops (yellow), sloping rooftops (pink), fuel tanks (blue), parking lots (orange) and others (green).

207 W/m^2. The installation angle is set to 25º for rooftops and hillsides and 0º for fuel tanks and parking lots. A separation distance of 70 cm is kept between strings to facilitate installation and maintenance operations.

TABLE I. RESULTING SUITABLE SURFACE AREAS

Category	*Area (m^2)*	*Rate of use (%)*	*Usable area (m^2)*
Flat rooftops	93,336	75	70,002
Sloping roofs	234,157	75	175.618
Fuel tanks	31,765	70	22,236
Parking lots	73,940	50	36,970
Others	92,986	40	37,194
Total	**526,184**		**342,020**

These assumptions result in 70.81 MWp of potential solar power that can be produced at Las Palmas Port.

For the next stage, in which the solar radiation over the zone is computed, PyQGIS asks the PVGIS server for the PV system performance at this location.

Table II presents the resulting average daily (E_d) and monthly (E_m) energy production and global irradiation (H_d , H_m) per square meter received by the modules. These data are also plotted into bars diagrams in Fig. 4. The estimated yearly solar energy production reaches 113.351 GWh.

IV. DISCUSSION

The platform is still being debugged and some amendments are still required. These include taking into account the heights of the building and the shadows that could affect the generation.

The granularity of the satellite solar radiation data provides four by four square kilometres (16 km^2) resolution. This is another thing worth addressing.

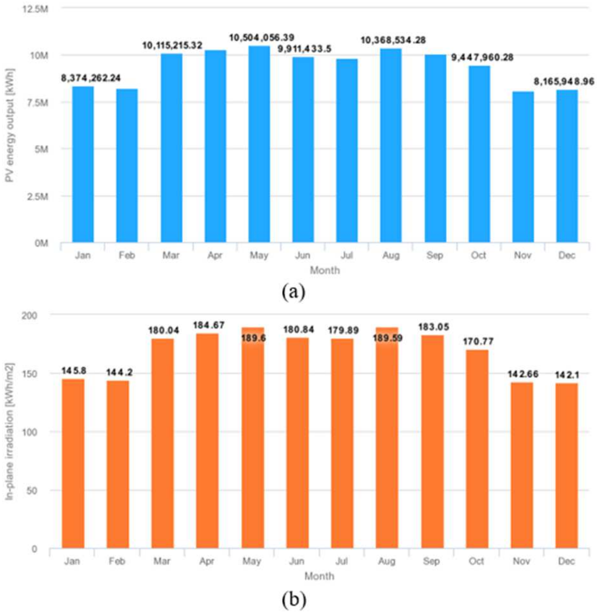
Future work will also include the analysis of the best possible management of the power that can be produced to fulfil Las Palmas Port energy demand considering on-shore power supply for vessels, electric mobility in the port, battery energy storage strategies or even production of green hydrogen.

V. CONCLUSION

This paper presents the platform being developed by the research team to automatically assess the solar power and yearly energy that can be produced in a zone. Although the accuracy provided could be improved, the resulting "big number" is found

TABLE II. RESULTING ENERGY PRODUCTION AND RADIATION AND AVERAGES

Month	*E_d (MWh)*	*E_m (MWh)*	*H_d (kWh/m^2)*	*H_m (kWh/m^2)*
1	270.14	8,374.26	4.70	145.80
2	293.20	8,209.69	5.15	144.20
3	326.30	10,115.22	5.81	180.04
4	342.57	10,277.20	6.16	184.67
5	338.84	10,504.06	6.12	189.60
6	330.38	9,911.43	6.03	180.84
7	317.66	9,847.38	5.80	179.89
8	334.47	10,368.53	6.12	189.59
9	335.10	10,053.10	6.10	183.05
10	304.77	9,447.96	5.51	170.77
11	269.22	8,076.72	4.76	142.66
12	263.42	8,165.95	4.58	142.10
Year	**310.55**	**9,445.96**	**5.57**	**169.43**



(a)

(b)

Fig. 4. PVGIS estimations. (a) Monthly energy production average. (b) Monthly radiation average.

to be a relevant input for both electricity utilities and councils for their planning purposes, in particular with the global momentum towards RECs.

The platform combines manual selection with GIS based methods and incorporates satellite solar radiation data. Compared with other PV potential assessment methods in literature, the platform provides the PV power that can be effectively installed and the yearly energy production, instead of just rooftop suitable areas.

A case study is carried out to assess the performance of the platform at the facilities of Las Palmas Port. It is found that there are 342,020 m^2 of suitable surfaces for PV panels that could be used to produce 70.81 MWp, resulting in 113.351 GWh per year.

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