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# Energy planning tools applied into urban photovoltaic: the importance of compatibilizing with the constructions

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## 1. INTRODUCTION

The great interest for renewable sources for electricity generation and the considerable growth in their use has gained prominence in the world scenario. In this aspect, photovoltaic (PV) power stands out for its great expansion, especially in urban environments, where distributed generation (DG) predominates. According to the International Renewable Energy Agency (IRENA), in 2010 the world's installed capacity was 40,28 GW and in 2019 was 578,55 GW. In Brasil, in 2010, 30 kW of installed PV power was registered, according to the *Agência Nacional de Energia Elétrica* (ANEEL); in February 2021 there was 4,67 GW installed in DG, according to the *Associação Brasileira de Energia Solar* (ABSOLAR).

## 2. OBJECTIVES

the present study we evaluated 20 computational tools to analyze its functionalities considering five criteria, being the ability to simulation, scenario projection, bottom-up, payment need and urban PV application. Additionally of classifying the tools according to the criteria, we analyze Building Applied Photovoltaics (BAPV) and Building Integrated Photovoltaics (BIPV) in the tools, according to the articles used as the basis of the research, aiming to provide a critique of integration capacity BAPV and BIPV of urban PV planning tools.

The tools are: Balmorel, CEA, Dieter, District ECA, EnergyPlan, EnergyPro, Grid LAB–D, Homer PRO, HUES, iHOGA, Insel, Oemof, OSeMOSYS, RETScreen, SIREN, Solarius PV, SOLergo, Synergi Electric, Urbs and WebOpt.

## 3. METHODOLOGY

The applied classification was based on 04 features defined to facilitate the distinction between energy planning programs and in addition, the availability of each tool was considered: free access, educational/commercial version or paid.

- The first functionality refers to the ability of the simulation tool;
- The second functionality concerns scenario generation;
- The third functionality is bottom-up;
- The fourth functionality refers to the capacity of urban PV energy planning.

The Fig. 01 shows the diagram of tools evaluation methodology.

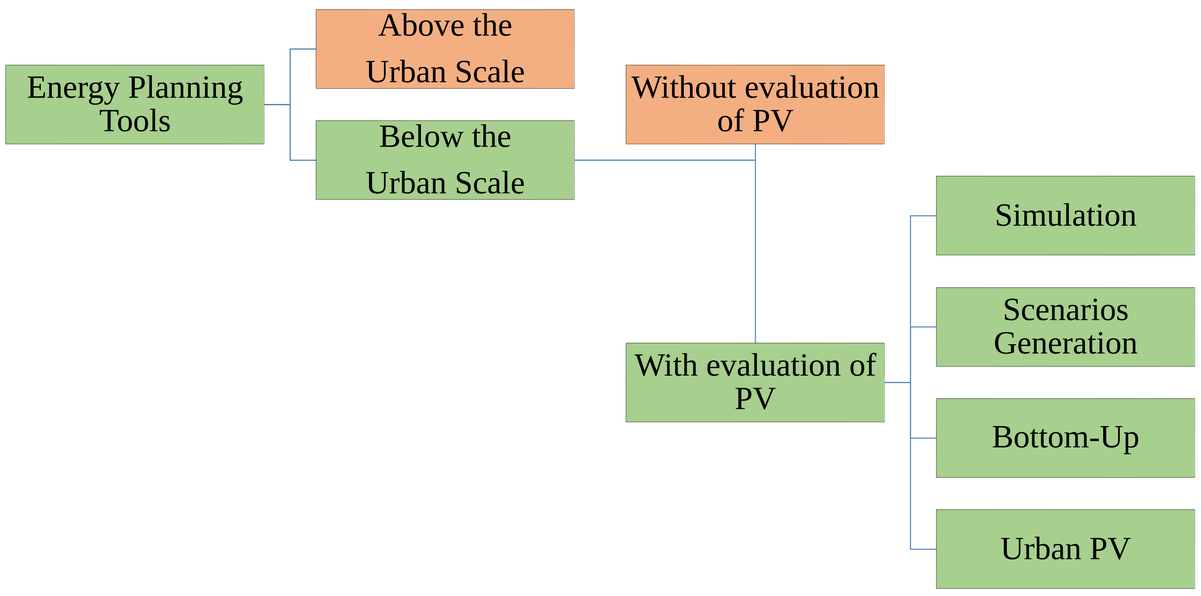


Fig. 01 – Tools evaluation methodology diagram

## 4. RESULTS AND DISCUSSIONS

### 4.1. Evaluation Tools

For the evaluation developed, less than half of the tools have all the features. Fig. 02 shows the number of functionalities each program has in green and in blue the criteria of availability, being assigned value 1 for free access and educational/commercial version and 0 for paid.

### 4.2. Evaluation Energetic

According to the literature review, the applications of BAPV and BIPV were identified in the selected articles, meaning the need to understand the level of integration of the tools in scaling the PV system in isolation and to allow the addition of structural information to make the system integrated to the construction.

With the exception of Dieter, District ECA and OSeMOSYS, all evaluated tools have sizing and energy planning capacity when the installation already exists and the system is designed later, that is, for the BAPV case. However none has complete integration in the BIPV, since a project with BIPV requires a structural analysis, adapting the materials to the construction of the system still in the elaboration phase.

Currently, structural projects are developed in programs such as AutoCAD, AutoCAD Civil 3D and SketchUp, but these do not have the capacity to develop BIPV. Differently, programs such as Revit and ArchCAD, which use BIM methodology, refer to the modeling of construction information deal exactly with this type of integrated project, since one of the bases of BIM is the energy modeling of the construction.

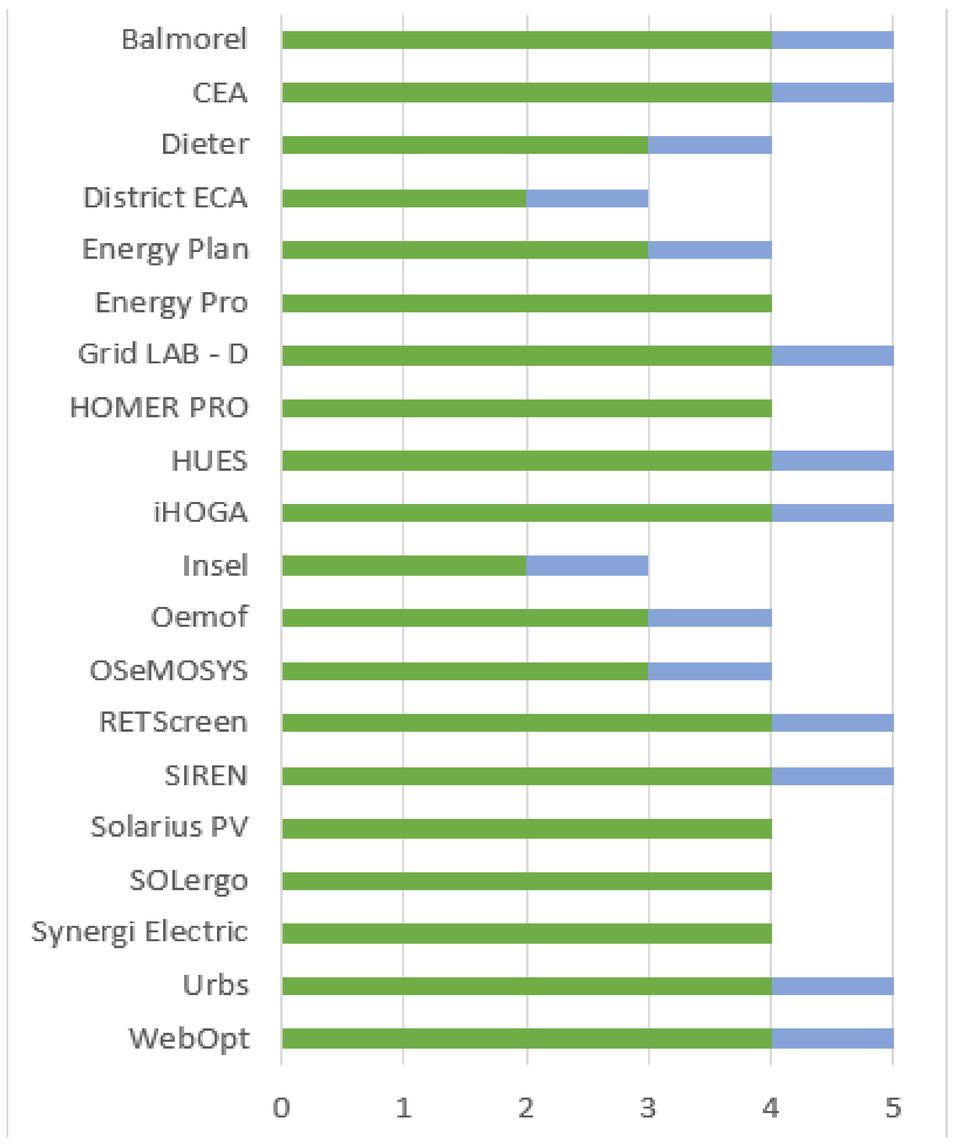


Fig. 02 – Quantitative of funcionalities

## 5. CONCLUSION

In this sense, only the simulation feature was identified in all programs evaluated, and 16 of the 20 presented ability to evaluate urban PV. Thus, Balmorel, CEA, Grid LAB-D, HUES, iHOGA, RETScreen, SIREN, Urbs and WebOpt are highlighted by having all the features and being available free of charge to the community.

In addition, for a fully integrated urban PV planning project, BIPV applications are an alternative to be considered and, consequently, the integration with the BIM methodology, which already exists as a trend to integrated projects between all building and energy elements.

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