IMPACT OF THE LOAD MODELING ON THE OPTIMAL SELECTION OF ROOFTOP SURFACES FOR PV INSTALLATION

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Summary

Integration of the distributed generation units into the electric distribution networks (DNs) is proliferated by the technological development as well as the current political and environmental directives. Slovenia is considered to be a country with an underutilized solar potential [1]. Therefore, the rooftop surfaces of its urban areas offer a possible solution to a larger scale integration of the photovoltaic (PV) systems into the low voltage parts of its DNs. However, in order to select the rooftop surfaces, which are the most suitable for the PV installation, a wholesome approach should be taken, and both time-dependent network operation as well as the behavior of the loads should be considered simultaneously with the actual data regarding the availability of the solar energy on a considered area.

The previous work of the authors presented a methodology for determining rooftop surfaces suitable for the installation of PV systems, based on the simultaneous consideration of a high-resolution PV potential assessment as well as the time-dependent consideration of the DN operation [2]. LiDAR (Light Detection And Ranging) data and long-term direct and diffuse irradiance measurements by a pyranometer were used for performing a high resolution, spatio-temporal assessment of the solar and PV potential [3]. However, the rooftop surfaces rated as highly suitable for PV installation are not necessarily the most suitable from the network operation standpoint. Therefore, a model of a DN supplying the network, equipped with the time-dependent measurements of the power loading were utilized to assess the impact that the additional PV generation might have on network operation. Evaluation of the network operation and calculation of the network losses is performed through a load flow analysis, namely a "backward-forward sweep" [4] load flow method. The proposed methodology is a two-step procedure. Firstly, a Differential Evolution [5] based optimization algorithm finds such additional PV generation that yields minimum annual energy losses in the network, while ensuring the proper voltage profiles and prevents the thermal overloading of the power lines. The PV generation profiles used are obtained from the PV assessment data. The second step includes a selection procedure that considers the both aspects, i.e. the actual PV potential and network operation, in order to select such rooftop surfaces, capable of generating the power determined in the optimization step. Figure 1 shows how all the above-mentioned aspects, presented as layers, overlap in order to create a wholesome approach to solving the problem of optimal selection of rooftop surfaces for PV installation.

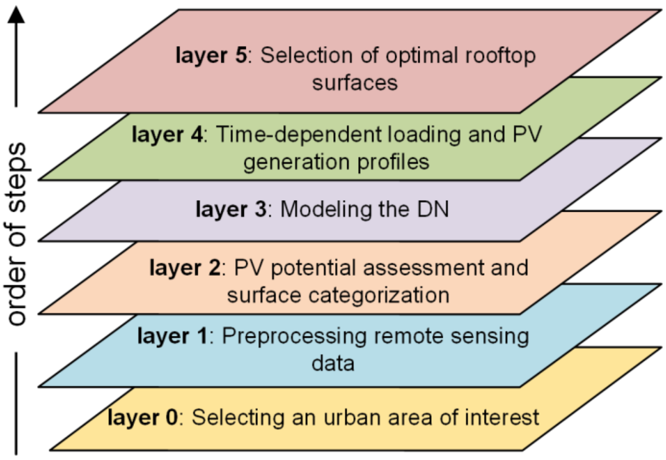

Figure 1: Overlapping layers for optimal selection of rooftop surfaces for PV installation.

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The initial methodology considered that the power consumed by the loads is independent from the system voltage, i.e. all loads were presented using a constant power loading model. However, if the loads in the network behave differently and their consumption changes with the supply voltage, the impact of the additional PV generation on power losses changes as well. This paper, therefore, presents the analysis of the impact that the different loading models have on optimal selection of rooftop surfaces for PV installation. In order to adequately describe the dependence of the power consumed from the supply voltage a polynomial model of the active and reactive power consumed in a node is utilized [6].

The analysis is performed on a real, urban low voltage part of the network supplying the city of Maribor, presented in Figure 2. Polygons of different colors represent rooftop surfaces with the PV assessment performed, considered for possible PV installation. The polygons are colored, based on their suitability for PV installation from the PV potential standpoint. The results will show how two extreme cases of the consideration of the loads – constant power and constant impedance loading models, have on optimal accommodation of the PV systems and how this installation affects the network operation.

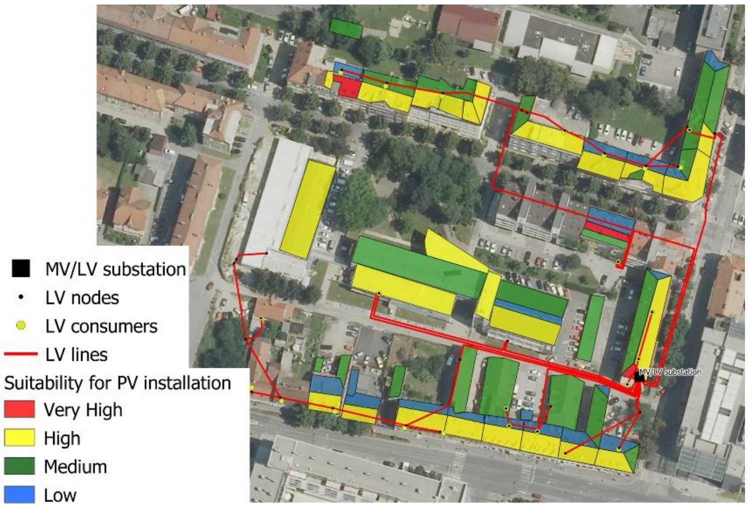

Figure 2: Low voltage test site.

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