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A Novel Approach for Improving Voltage Profile in Low Voltage Networks with High Solar Panel Penetration Level by Using Flexible Loads

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***Abstract*—Nowadays, with the expansion of the use of renewable energy sources, there are many opportunities and challenges for researchers. One of these resources is PVs that have many advantages however the proper control is always a challenging issue in the power system. This article suggests the use of flexible loads in order to enable the consumers for injection of their extra power that leads to AC power quality's violation. The extra power may be effortlessly directed to flexible loads due to keeping an equivalency of generated power and loads. The suggested method in this paper is analyzed and compared with the common method of using energy storages, economically and technically. The proposed solution is simulated by using MATLAB/Simulink and economic analysis is performed by Homer software. The proposed method will be a leading solution for the future of power systems in existence of renewable energy sources.**

Keywords—flexible loads, PV, residential building, voltage rise.

I. INTRODUCTION

Photovoltaic units are the most available resources of small-scale power supplies in the world. Although they have many benefits to consumers and producers of the electric power, they can violate the power quality constraints in the main grid with a high penetration level of PVs [1-4]. The major problem is increasing voltage during the power generation by PVs [5,6]. Therefore, operations of electricity networks are needed to be updated by the means of new strategies in order to solve these concerns.

The best solution for solving the penetration rate of PVs is to establish a balance among the power generation and load demand, especially in the time of high generated power and low demand [7]. In order to establish a balance between these two in electricity network operation, the following strategies have been presented in previous studies.

Cutting PV active power to solve contravened power quality constraints [8-10]. The basic drawback of this approach is decrement of the revenue for consumers. Making use of reactive power control for PVs [11-13] which is not good because of high resistance level of LV networks. Presenting a solution based on DC links for LV networks [14]. A DC link can be applied in order to adjust injected extra power and increasing voltage issue by the residential areas. PV voltage rise can be consumed by other consumers in the same area, other areas or other feeders to increase the balance between load demand and generation. One of the basic problems in this solution is the high cost of DC links. Making use of batteries in presence of PVs to charge at the time of extra generation and discharge among high demand period [15-19]. This approach, which is usually used in hybrid networks in order to store surplus power, is not economically efficient because of the batteries' high initial cost and short lifetime [20].

To prevent the problems above, a new solution based on flexible loads in LV networks is presented in this article. Flexible loads are the ones that are not sensitive to voltage volatilities and have not a huge priority in demand response, therefore according to the generated power in different periods of day or night they can be utilized. Furthermore, by the economic analysis presented in this article the efficiency of this method will be proven. In a residential building, a flexible load can be used to solve the problem of injected surplus power and the increased voltage. The PV surplus power can be consumed for flexible loads by the same consumer which can maintain a better balance between load and generation.

In part 2 of this article, the method of using flexible loads for voltage control will be described. In order to show the efficiency of this method, a case study will be analyzed in part 3 and in the final part, the economic analysis of the proposed method will be compared to the method of using ESS[1] (in this case batteries).

II. PROPOSED METHOD, THE USE OF FLEXIBLE LOADS

In order to control nodes voltage in case of surplus power in the presence of the main load, use of flexible loads is suggested in this paper. Flexible or deferrable is referred to those kinds of loads which only need limited power hours in days in order to function, and in these limited hours they can store enough energy to provide their proposed duty until next day. For example, water pumps, electric water heaters, and compressors can be in such category. At first this paper studies the thermal loads of a 20 units building, containing oven and

[1] Energy Storage System

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