Assessment of Clustered Renewable Energy Systems Interconnected with Low-Voltage Distribution Networks

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Abstract**—As assessment of clustered renewable energy systems (CRESs) interconnected with low-voltage distribution system have been discussed in this paper. A direct search method is proposed to evaluate the maximum allowable capacity of CRESs in the low-voltage distribution system in Taiwan. Simulation results have shown that the arbitrary installation for CRESs would damage the customer loads and significantly increase the costs on system operation and maintenance. The simulation results and analysis methods are of value to engineer for planning and designing the suitable CRESs in a low voltage distribution network.**

Index Terms**—Clustered renewable energy systems(CRESs); Low-voltage distribution system; Direct search method; Planning and designing.**

I. INTRODUCTION

In 1992, the first United Nation framework convention on climate change was adopted in New York. Following with the Kyoto protocol in Japan 1998 and the Durban conference in South African 2011, the problems such as energy crisis and greenhouse emission have caused a significant concerned worldwide. Many energy policies and research projects focused on the energy-saving and the clean energy have been presented in recent years. To reduce the electricity which is produced by burning the fossil fuels, the distributed generation resources (DGs) are gaining in significance in the last two decades. In the Spanish, by the end of 2010, there is around 33% of total electricity production are required to produce by those distributed generation [1]. The first zero-energy office building integrated grid-connected rooftop BIPV to meet its demand for energy was established in Singapore [2]. A demonstrative project on grid-interconnection of clustered photovoltaic power generation systems, which including more than 550 residential PV system, was built in Ota city in Japan [3]. Therefore, one development of renewable energy resources is toward clustered DGs installed in a specific small area, which is named as the clustered renewable energy systems (CRESs) in this paper.

As the CRESs have been widely installed in the power distribution network, some measurable problems on the system operation, power quality, and power regulation start to arise. To solve these problems, many research papers have been published to reduce the adverse effects. An assessment on voltage profiles in residential neighborhoods in the presence of PV systems is published in [4]. A study to assess the impact of fluctuating solar irradiance on the grid voltage is provided in [5]. The difference among local interconnection rules for DGs, local geographic characteristics, national grid code, etc. makes the provided simulation results misfit the case in Taiwan. Therefore, the paper is focus on the low-voltage distribution system in Taiwan to evaluate the effects of CRESs on the system performance and search for the maximum allowable capacity of CRESs. Some important indices such as line thermal limits and allowable maximum voltage deviation are all taken into account in the paper. This paper is organized as follows. The mathematical models of DGs and interconnection rules for DGs are introduced in Section 2. The definitions of simulation scenarios are presented in Section 3. Simulation and discussion are introduced in Section 4. Finally, a brief conclusion is drawn

II. MATHEMATICAL MODELS OF DGS AND INTERCONNECTION RULES FOR DGS

A. Mathematical models of DGs

There are three mathematical models are commonly used to represent the performance of DGs in the distribution system analysis. That is, the constant-power-factor model, the constant-voltage model, and the induction-machine model. In recent years, the DGs are ruled to control their output power and reactive component to reduce the adverse impact on the distribution system. Here, the constant-power-factor model is chosen to simulate the operating characteristic of DGs. The DGs injection current for the constant-power-factor model is given in (1).

$$I = (S/V)^{*} \angle \delta - \theta \tag{1}$$