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# The Effects of Distributed Generation Sources within Commercial Retail Reticulation Networks

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**Abstract**

Distributed Generation (DG) systems are becoming more common with increasing electricity prices and growing awareness of sustainable energy generation sources. Reticulation networks are typically planned, designed and operated to be purely passive networks that deliver electricity to consumers in a unidirectional manner (from source to load). The integration of DG into reticulation networks can alter conventional power flow within the network, as well as load parameters. The effects of DG on load and network parameters is investigated in this paper through the use of a developed hypothetical commercial reticulation network and load demand profiles. The introduction of a DG source at low levels of penetration was found to not significantly alter load parameters, although effects are noticeable. The largest variation in load parameters can be observed at high levels of DG penetration. Since load parameters (such as coincident demand) play an important role in the design of reticulation networks, the results obtained from this study indicate that current design procedures and standards for reticulation networks must be scrutinized when high levels of DG penetration are introduced.



*Keywords:* Distributed generation; load parameters; photovoltaic systems, reticulation network, wind power system.

## 1. Introduction

Renewable energy DG sources reduce carbon emissions as well as the dependence on fossil fuels to generate electricity. Another factor that has contributed to the increased utilization of renewable energy DG is the decreasing cost of electricity generation from renewable energy generation sources, such as wind and photovoltaic (PV) systems, as a result of the progression of technology [1]. Distribution networks in the past were traditionally planned, designed and operated to be purely passive networks that deliver electricity to consumers in a unidirectional manner with

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minimal, or no, monitoring and control capabilities [2]. In recent times the integration of DG into distribution networks has altered conventional power flow within the network resulting in bi-directional power flow which can impact load and network parameters [3].

It is important to understand the effects DG has on load and network parameters, and if existing reticulation network design procedures and standards are suitable for the design of reticulation networks that will contain varying levels of DG penetration. Although the body of knowledge related to the integration of DG into distribution networks is vast, there is little research related to the design of reticulation networks with specific attention paid to DG.

The key focus of this research is how DG effects load parameters when integrated into commercial retail reticulation networks. The load parameters that are investigated are load demand, coincident demand, demand factor, utilization factor, load factor, diversity factor, coincidence factor, load diversity, and loss factor. Factors that impact the technical performance of an electrical network are power losses, voltage regulation, equipment loading and utilisation, fault levels, stability limits, frequency and harmonics [4]. However, at a commercial retail reticulation network level, only certain network parameters are applicable and should be investigated. These parameters include the thermal rating of electrical equipment, reserve power flow capabilities of transformer tap-changes, steady-state voltage rise, and power losses. Supply voltage is regulated by electricity supply standards and national regulations; and is an important network parameter. It is for this reason that supply voltage was the only network parameter investigated in this paper. Load and network parameters for the reticulation network with no DG integrated are determined which forms the basis on which comparisons are made. DG, in the form of PV, was integrated into the reticulation network and penetration levels varied to investigate the effects of DG on load and network parameters.

## 2. Hypothetical Network Model

A hypothetical reticulation network is developed in this paper to investigate the effect of DG on load and network parameters. The load demand profiles are based on publically available load demand information [5]. Certain assumptions regarding network component capacities and sizes, as well as network topology, are made. The hypothetical reticulation network consists of five low-voltage loads that are supplied from a common step-down transformer. A load demand profile for each customer is developed. All profiles are assumed to be similar due to all customers being commercial retail electricity consumers. Maximum load demand and the length of the feeder cables to each of the customers are considered to be different in order to add variability to the network model. Commercial electricity consumers are modelled as voltage dependent loads [6]. A single line diagram (SLD) of the network outlining the topology and main components are shown in Fig. 1.

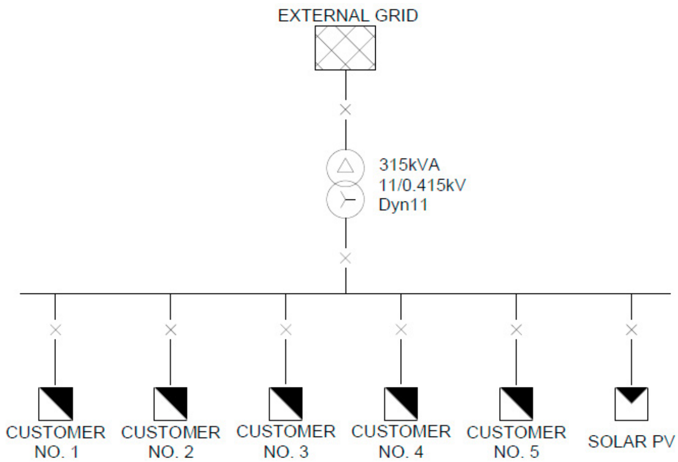


Fig. 1: Commercial retail reticulation network single line diagram