CONSIDERATION OF LOSSES IN DETERMINING SOLAR PV PENETRATION LEVEL IN DISTRIBUTION NETWORKS

R. M. M. P. Nishshanka

(168623G)

Degree of Master of Science in Electrical Installations

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DECLARATION OF THE CANDIDATE & SUPERVISOR

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Signature of the supervisor: Date:

(Dr. J.V.U.P Jayatunga)

Signature of the supervisor: Date:

(Dr. P. S. N De Silva)

Abstract

When it was realized that the conventional energy sources which powered up the industrial revolution are on depletion, a sudden awakening occurred in the field of renewable energy, during the latter part of the last century. As a result, a salient technological development is progressive in the solar PV industry. There are certain benefits including zero emissions, free availability of solar power and economic benefits, turning rooftop solar into an attractive method of investment for domestic electricity consumers. The same global trend has moved towards Sri Lanka during the last five years, due to the government initiative "Surya Bala Sangramaya" on promoting rooftop solar generation. Along with that, loan schemes were introduced to encourage customers to install rooftop solar PV systems. As a result, in urban highly populated areas, distribution transformers are now available with the addition of more than 75% of installed solar rooftop capacities compared to the connected transformer capacity.

Rooftop solar PV systems add clean energy to the network, while enabling the customers to get financial benefits from their investment. However, continues addition of distributed renewable generation into the network creates several issues in the system, such as power quality issues, issues associated with reverse power flow etc.

Under this situation, now is the high time for utilities to identify the impact to the network with solar PV addition and take remedial action to mitigate the issues immediately. As a preliminary action, introducing maximum solar penetration level is recommended.

This research addresses the aforementioned issue and provides a methodology on identifying the maximum allowable solar penetration level, focusing on the power loss. It was observed that the power loss of the network decreases with solar PV addition but after some level, it increases. Though many researches are available for the common issues associated with rooftop solar systems, this is an aspect which has less attention. Thus, it is believed that this research would lay the foundation for certain practical implementations and many novel studies in this discipline.

In this study, a practical network was modeled and analyzed to identify the behavior of power loss of a distribution transformer with the increment of solar penetration level. Initial case study confirms that power losses increase with high solar penetration level. Therefore, to identify common behavior, generalized model was developed, which could provide platform to define limits for solar penetration.

Monte Carlo study was carried out for different cases, and as a result, maximum allowable solar penetration level for a transformer, which can be defined without any conditions was identified. Further, maximum allowable limit which can be defined with conditions also was identified with the applicable constraints. As the ultimate finding of the research, solar PV approval criteria were developed, which can be easily adopted by distribution utilities to add rooftop solar power to the network, in a mutual beneficial mode for both the customer and the utility.

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List of Abbreviations

Abbreviation	Description
PUCSL	Public Utilities Commission of Sri Lanka
LECO	Lanka Electricity Company Private Limited
CEB	Ceylon Electricity Board
LV	Low Voltage
MV	Medium Voltage
GIS	Geographic Information System
PV	Photovoltaic