FEASIBILITY STUDY ON DISTRIBUTION TRANSFORMER BASED URBAN GRID CONNECTED ENERGY ISLANDS WITH DISTRIBUTED GENERATION

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Degree of Master of Science in Electrical Engineering

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January 2018

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DECLARATION OF THE CANDIDATE & SUPERVISOR

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(Dr. P. S. N De Silva)

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

Abstract

Sri Lanka's distribution network has been facing drastic changes during recent past due to the continuous addition of distributed renewable generation into the network. Addition of rooftop solar PV into the low voltage distribution feeders has significantly increased during 2016-2017, due to the government initiative "Surya Bala Sangramaya" on promoting rooftop solar generation.

As a result, in highly populated urban areas, some distribution transformer service areas now have more than 50% of installed solar rooftop capacity, compared to the connected transformer capacity. These transformers export power to the medium voltage network from low voltage side during daytime due to high solar generation and low energy usage inside these service areas. An increasing number of transformers will experience such reverse power flow in near future with the acceleration of promoting rooftop solar programs.

Operating with higher density of rooftop solar in distribution transformer service areas will result in numerous power quality issues and higher distribution losses in spite of the advantages of utilizing household rooftops for solar PV generation.

In this study, a futuristic solution is proposed to effectively utilize the daytime solar PV generation in a single distribution transformer service area itself with the formation of smart grid type operation.

Distribution transformer based smart grid, which operates with controlling mechanisms, loads, rooftop solar and battery storage systems is discussed in this report. This system can be developed and operated as a community-based smart grid that is formed inside the distribution transformer service area with the contribution of the electricity customers.

Other than operating as individual energy customers and energy producers, public can become procumers who operate and control their loads and PV generation together to optimize load flow, power quality and economics in this proposed smart grid.

This research is a preliminary study to identify the possibility of such distribution transformer based smart grid for Lanka Electricity Company Private Limited operation area. Extensive simulations were carried out using Matlab Simulink by modeling the three phase four wire LV network for a single transformer area to identify the present behavior of the LV Network. Then the model was upgraded to proposed future smart grid arrangement. Results on the customer behaviors, load flows and power quality on both normal and smart grid type scenarios are presented for several case studies including the present situation, future expected situation and for the proposed smart grid.

As the outcome of this research, simulated results were obtained for smart grid arrangement inside an actual transformer service area and technical compatibility of the concept is presented to the Sri Lankan urban distribution transformers.

Acknowledgement

It is my great pleasure to express gratitude to those who were behind me in completing my research project.

First, I would like to express my sincere gratitude to my supervisor Dr. Narendra De Silva for providing this visionary concept to study and for his continuous guidance throughout the period.

I extend my sincere gratitude to Dr. Upuli Jayatunga for the guidance, motivation and undoubtedly the best support and kindness from the beginning up until to the end of the research period.

My sincere thanks go to my immediate supervisor, LECO system development manager Mr. S.D.C Gunawardhana and all my colleagues at Lanka Electricity Company Private Limited who helped me in many ways during this period. Further I would like to thank LECO IT Department for providing the required network data related to the research.

Last but not least, I would express my heartiest gratitude and love to my wife, my father, my mother and my brother who took a lot of burden and patient, which helped me to complete this work in difficult circumstances.

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List of Abbreviations

Abbreviation	Description
IEEE	Institute of Electrical and Electronics Engineers
ICT	Information and communication Technology
PUCSL	Public Utilities Commission of Sri Lanka
LECO	Lanka Electricity Company Private Limited
CEB	Ceylon Electricity Board
LV	Low Voltage
MV	Medium Voltage
PV	Photovoltaic
XLPE	Cross-Linked Polyethylene
ABC	Arial Bundled Conductor
GIS	Geographic Information System