

**IMPACTS OF DISTRIBUTED GENERATION ON
TRANSMISSION AND DISTRIBUTION LOSSES IN SRI
LANKAN POWER SYSTEM**

A.A.C. PRIYANGIKA

(109244X)



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

Degree of Master of Science

Department of Electrical Engineering

University of Moratuwa

Sri Lanka

September 2015

**IMPACTS OF DISTRIBUTED GENERATION ON
TRANSMISSION AND DISTRIBUTION LOSSES IN SRI
LANKAN POWER SYSTEM**

Abeysingha Arachchilage Chathuri Priyangika

(109244X)



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

Dissertation submitted in partial fulfillment of the requirements for the degree Master
of Science

Department of Electrical Engineering

University of Moratuwa
Sri Lanka

September 2015

DECLARATION

I declare that this is my own work and this dissertation does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Also, I hereby grant to University of Moratuwa the non-exclusive right to reproduce and distribute my thesis/dissertation, in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as articles or books).

.....

A.A.C. Priyangika

Date:



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations

The above candidate has carried out research for the Masters under my supervision.

.....

Eng. W.D.A.S. Wijayapala

Date:

.....

Dr. H.M. Wijekoon Banda

Date:

ABSTRACT

According to the National Energy Policy and Strategies of Sri Lanka [1], the Government will endeavour to reach a minimum level of 10% of electrical energy supplied to the grid to be from Non- Conventional Renewable Energy sources by year 2015. Further, Government of Sri Lanka has revised the target to reach 20% of electricity supply is expected to be generated by renewable energy by year 2020.

Main Non Conventional Renewable Energy Sources available in Sri Lanka are Wind, Small hydro, Solar and Biomass. They are also called as Distributed Generation (DG) units which are located especially close to load centers of the distribution network.

When driven for such a national target as a utility, impacts of these technologies should be evaluated to maintain power quality and the stability of the power system. There are considerable impacts of DG units to utility as well as to consumers.

While improving power quality and stability, DG is a financial benefit to the utility and to the country. One of the main impacts of the DG for the utility is reduction of losses. The objective of this study is to estimate the impact of distributed generation on transmission and distribution losses in Sri Lanka power system. Transmission network and the part of the distribution network were separately studied and used to calculate the losses by using PSSE software and SynerGEE software. Badulla, Kiribathkumbura, Rathnapura and Ukuwela, grid substations with the feeders which are connected to considerable amount of DGs are selected for analysis.

According to the results, transmission network always gives a loss reduction by introducing DGs. But in distribution network, only some feeders give a positive value for the loss reduction when DGs are present.

The study shows that, when total network is considered, always there is a loss reduction and a financial benefit from DGs added to the system.

ACKNOWLEDGEMENT

My first sincere gratitude goes to my supervisors, Eng. W.D.A.S. Wijayapala and Dr. H.M. Wijekoon Banda for their great and kind guidance, insights, attention extended towards me for successful flow of the dissertation.

Next thanking is due to, course coordinator, all senior lectures, visiting lectures in the graduation programme, for their valuable teaching, guidance, assistance and co-operation delivered throughout the course.

In addition I would like to thank the officers in Post Graduate Office of Faculty of Engineering of University of Moratuwa for helping in various ways to clarify the things related to my academic works in time with excellent co-operation and guidance.

Especially I must be thankful very much to my colleagues in the Transmission Planning Branch, Distribution Region 2 and 3 of Ceylon Electricity Board for providing assistance in numerous ways to carry out the studies of the project.



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

I express my thanks and appreciation to my family for their understanding, motivation and patience. Lastly, but in no sense the least, I am thankful to all colleagues and friends for giving their fullest co-operation throughout the time of research and writing of the thesis.

TABLE OF CONTENTS

DECLARATION	i
ABSTRACT.....	ii
ACKNOWLEDGEMENT	iii
TABLE OF CONTENTS.....	iv
LIST OF FIGURES	vi
LIST OF TABLES	vii
LIST OF ANNEXES	viii
1. INTRODUCTION	1
1.1 Distributed Generation.....	1
1.2 Objective of the project.....	2
1.3 Methodology.....	2
1.4 Sri Lanka Power System with DG.....	3
1.4.1 Small Hydro Power Plants	3
1.4.2 Wind Power Plants	3
1.4.3 Solar Power Plants.....	4
1.4.4 Biomass Power Plants	4
2. TRANSMISSION LOSS CALCULATION.....	6
2.1 Calculation Scenarios	6
2.1.1 Time Basis	6
2.1.2 Load Basis	7
2.2 Data Analysis for Transmission Loss calculation.....	8
2.3 Comparison of Transmission Energy Loss Reduction	10
2.3.1 Energy Loss reduction with 40% loading of DG	10
2.3.2 Energy Loss reduction with full DG	11
3. DISTRIBUTION LOSS CALCULATION	12
3.1 Calculation Scenarios	13
3.2 Loss Calculation – Ukuwela Grid Substation.....	13



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

3.3	Loss Calculation – Badulla Grid Substation.....	18
3.4	Loss Calculation – Kiribathkumbura Grid Substation.....	22
3.5	Loss Calculation – Rathnapura Grid Substation.....	26
4.	ECONOMIC ANALYSIS OF LOSS REDUCTION.....	31
4.1	Cost Saving due to Transmission Loss Reduction.....	31
4.1.1	Energy Cost Saving due to reduction of Transmission Loss.....	31
4.1.2	Capacity Cost Saving due to reduction of Transmission Loss	32
4.2	Cost saving due to Distribution Loss Reduction	33
4.2.1	Energy Cost Saving due to reduction of Distribution Loss.....	34
4.2.2	Capacity Cost Saving due to reduction of Distribution Loss	35
5.	CONCLUTIONS	36
	REFERENCE LIST	38
	ANNEXES	39



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

LIST OF FIGURES

Figure 1.1 : Dynamic Diagram of how DG connected to the Power System.	2
Figure 2.1: Load curve of 9 th April 2013	6
Figure 3.1: Overview of Ukuwela Grid Substation Feeders in SynerGEE software. 14	14
Figure 3.2: Power Loss (kW) Vs DG% added to the system.....	16
Figure 3.3: Annual Energy Loss (GWh) Vs DG% added to the System for Ukuwela Grid Substation.	18
Figure 3.4: Overview of Badulla Grid Substation feeders in SynerGEE software. ...	19
Figure 3.5: Power Loss (kW) Vs DG% added to the system.....	20
Figure 3.6: Annual Energy Loss (GWh) Vs DG% added to the System for Badulla Grid Substation.	22
Figure 3.7: Overview of Kiribathkumbura Grid Substation feeders in SynerGEE software.....	23
Figure 3.8: Loss (kW) Vs DG% added to the system	24
Figure 3.9: Annual Energy Loss (GWh) Vs DG% added to the System for Kiribathkumbura Grid Substation.	26
Figure 3.10: Overview of Rathnapura Grid Substation feeders in SynerGEE software.	27
Figure 3.11: Loss (kW) Vs DG% added to the system	28
Figure 3.12: Annual Energy Loss (GWh) Vs DG% added to the System for Rathnapura Grid Substation.	30



LIST OF TABLES

Table 1.1: Summary of DGs connected to Sri Lanka power system(January 2015)	5
Table 2.1: Transmission loss figures calculated by using PSSSE software.	8
Table 2.2: Transmission Loss	8
Table 2.3 : Annual Transmission Energy Loss and Percentage Loss	10
Table 2.4 : Summary of Energy Loss Reduction in Transmission Network.	11
Table 3.1: Selected Grid Substations for the Distribution Loss Calculation	13
Table 3.2: Power Loss Figures of Ukuwela Grid Substation.....	15
Table 3.3: Annual Energy Loss at Ukuwela Grid Substation.	17
Table 3.4: Power Loss at Badulla Grid Substation	19
Table 3.5: Annual Energy Loss at Badulla Grid Substation.	21
Table 3.6: Power Loss at Kiribathkumbura Grid Substation	23
Table 3.7: Annual Energy Loss at Kiribathkumbura Grid Substation.	25
Table 3.8: Power Loss at Rathnapura Grid Substation	27
Table 3.9: Daily Power Loss Figures of Rathnapura Grid Substation.	29
Table 4.1: Marginal Generation Costs in year 2013.	31
Table 4.2: Energy Cost Saving of transmission network due to DGs.....	32
Table 4.3: Capacity Cost saving of Transmission network due to DGs.	33
Table 4.4: Energy Cost saving in Distribution network.....	34
Table 4.5 : Capacity Cost Saving due to reduction of Distribution Losses.	35
Table 5.1: Summary of Transmission and Distribution Loss Reduction.	36

LIST OF ANNEXES

Annex A-1: The map of Sri Lanka Transmission System in Year2013.....	40
Annex B-1: Schemetic Diagram of the 2013 Transmission System.....	41
Abbex C-1: The network Diagram while running the PSSE Software.....	42



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk