

THE IMPACTS OF FUEL PRICE VARIATION ON ELECTRICITY PRICING IN SRI LANKA

Malindu Sarin Sri Hapuarachchi

(09/8656)



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

April 2014

THE IMPACTS OF FUEL PRICE VARIATION ON ELECTRICITY PRICING IN SRI LANKA

Malindu Sarin Sri Hapuarachchi

(09/8656)

Dissertation Submitted in partial fulfillment of the requirements

 University of Moratuwa, Sri Lanka
for the degree Master of Science
www.lib.mrt.ac.lk

Department of Electrical Engineering

University of Moratuwa

Sri Lanka

April 2014

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).

Signature:



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

Date:

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

Signature of the supervisor:

Date:

Abstract

This thesis report presents the analysis of the fuel price variation in the global context and review its impact to the power generation cycle of the country. Due to the delay caused in implementation of proposed generation plan during the period of 1990 to 2000, country suffocated from a power crisis where scheduled power cuts were common in nature. And further the Ceylon Electricity Board (CEB); the state owned institution which owned the monopoly of power generation, transmission is operating under a huge loss where it cannot cover its operating expenditures by selling electricity. This further created a huge financial crisis in the country where treasury has to fund in order to maintain the operation.

In this analysis, impact of fuel prices on electricity pricing is analyzed for the period from 2013 to 2025. This analysis is carried out based on the Long Term Generation Plan developed by CEB in 2010.

According to the analysis, generation cost shows a negative trend in real terms where the Generation cost reduces from 16.54 LKR to 9.96 LKR. This mainly due to fact that, power generation sector will be governed by coal power generation. And further, when power generation prices are determined subjected to current inflation rate prevail in the country, it is only 60% increase over the period of study (12 years) where in the past, electricity prices has shown a rise of more than 120% over similar period of time even though the published fuel prices are subjected to influences emerged from the political arena, where those were not calculated solely based on the cost of production.

Further it is required to consider the fact that coal prices can be increased more than the forecasted values as Sri Lanka entered into the coal power business after 12 years where it is supposed to come into the operation by 1998. As per the sensitivity analysis carried out based on the fuel price variation, it is calculated that, even if the prices of both crude oil and coal are increased by 50% than the current predictions, generation cost will be less than the generation cost as at 2013 until the year 2025.

Acknowledgements

First of all I am highly indebted to University of Moratuwa, Faculty of Engineering, & department of Electrical Engineering providing this opportunity to excel our skills via carrying out postgraduate programs. And then special thank must go to my supervisor Dr. Asanka Rodrigo, for his great insights, guidance and constant supervision for successful completion of the research topic.

Next I would like to express my special gratitude and thanks to Mobitel and divisional head for granting permission to carry out this my academic studies and also the staff at Mobitel who have not been mentioned here personally in making this educational process a success

Last but not least, I thank my parents, wife and friends for their constant encouragement without which this assignment would not be possible

M.S.S. Hapuarachchi



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

Table of Contents

Declaration	i
Abstract	ii
Acknowledgements	iii
Table of Contents	iv
List of Tables	vi
List of Figures	viii
List of Appendices	x
1 INTRODUCTION	1
1.1 Background	1
1.2 Electricity Industry	1
1.3 Electricity Market Structure	5
1.3.1 Costs and Profits related to Monopoly market structure	5
1.4 Electricity Pricing	6
1.4.1 Electricity Cost Breakdown	7
1.5 Current Generation Methods used in Sri Lanka	9
1.5.1 Hydro Electricity	9
1.5.2 Diesel, Gas & Heavy Fuel Power Generation	10
1.5.3 Coal-fired power	11
1.5.4 Wind power	13
1.6 Electricity Pricing and National Economy	13
2 OBJECTIVES AND METHODOLOGY	16
2.1 Objective	16
2.2 Methodology	17
3 OBSERVATIONS AND DATA COLLECTION	19
3.1 Impact of thermal Generation on Electricity Price	19
3.2 Correlation between inflation and Electricity Price	20
3.3 Correlation between Electricity Prices and Fuel Prices	22
3.4 Hydrological Study	24
3.4.1 Hydro Generation and Rainfall	24
3.4.2 Rainfall trend in Sri Lanka	31

3.4.3	Impact of drought in Hydro Power production	31
3.5	Fuel Price Forecasts	34
3.5.1	Forecasted Coal Prices & Crude Oil Price	34
4	RESULTS, ANALYSIS AND ACTIONS	36
4.1	Forecasting Hydro Power Generation	36
4.1.1	Correlation of Hydro Power generation and Rain fall	36
4.1.2	Calculations: Hydro Power generation Forecast	38
4.2	Capacity Cost Forecast	42
4.2.1	Calculation of capacity cost of existing power plants	42
4.3	Fuel Price Forecast	45
4.3.1	Auto Diesel price Forecast	45
4.3.2	Forecasting Fuel Oil Prices	48
4.3.3	Forecasting Naphtha Prices	51
4.4	Determining Plant factors	52
4.4.1	Plant Factor: Definition	52
4.4.2	Electricity Price Forecast	53
4.5	Sensitivity Analysis	54
4.5.1	Fuel Prices Increased by 50% during the Planning Horizon	54
4.5.2	Analysis of Electricity Price Variation against the inflation	58
4.5.3	Electricity generation cost variation against plant factor variation of coal plants	62
4.5.4	Electricity price Variation against the variation of Hydro Power generation	64
5	DISCUSSION	66
6	CONCLUSIONS AND RECOMMENDATIONS	70
	References	78
	Annexure I: Annual Rainfall Pattern of the period from 1941-2002	82
	Annexure II: Calculation Methodology	83

List of Tables

Table 1.1: Electricity tariff structure comparison in the region	7
Table 1.2: Per Unit cost of Electricity Supply	8
Table 1.3: Rapid increment of thermal energy intervention	10
Table 3.1 : Quarterly rainfall data in catchment areas and Hydro generation	25
Table 3.2: Annual rainfall data in All 8 areas, selected areas Vs Hydro generation	28
Table 3.3: Annual Rainfall Pattern of the period from 1941-2002	31
Table 3.4: Rainfall pattern affected by drought	32
Table 4.1: Rainfall Trend in selected districts	38
Table 4.2: Forecasted Hydro generation for 2013-2025	39
Table 4.3: Net Rainfall forecast for 2013-2025	41
Table 4.4: capacity cost calculation sheet	44
Table 4.5: Electricity Price Forecast	53
Table 4.6: Electricity Price Variation when Crude Oil Prices increased by 50%	55
Table 4.7: Electricity Price Variation when Coal Prices increased by 50%	56
Table 4.8: Electricity Price Variation when Coal Prices increased by 50%	57
Table 4.9: Electricity Price Variation against inflation	59
Table 4.10: Electricity price variation against inflation subjected to variation in all cost components	60
Table 4.11: Electricity price variation against probable inflation subjected to variation in all cost components	61
Table 4.12: Power Generation cost against Plant factor of coal plants	63
Table 4.13: variation of electricity price against the reduction of hydro generation by 50%	64
Table 6.1: Electricity price variation over 12 year periods	72
Table 6.2: Generation Cost against Plant factor of Coal plants	73
Table 6.4: Upper Limit & Lower Limit variation of Generation Cost &	75

Electricity Price

Table 6.5: Electricity Generation Prices at 500% increase of Coal Prices

76

List of Figures

Figure 1.1: Hydro-Thermal mix in Electricity Generation	2
Figure 1.2: Intervention of Thermal Production	3
Figure 1.3: Crude Oil Price Variation and Net Oil Imports as a percentage of Exports	8
Figure 1.4: National Average Electricity Selling Price	9
Figure 15: Petroleum utilization by each sector	11
Figure 1.6: Global Coal Utilization	12
Figure 1.7: Regional Electricity prices	15
Figure 2.1: Action Plan	17
Figure 3.1: Variation of Electricity Price	19
Figure 3.2: Variation of electricity prices & inflation	21
Figure 3.3: Regression Analysis results – Variation of electricity prices & inflation	21
Figure 3.4: SPSS Regression Analysis output -Variation of electricity prices & Fuel prices	22
Figure 3.5: Crude Oil Price vs Electricity Price	23
Figure 3.6 : Petroleum imports vs Electricity Price	23
Figure 3.7: SPSS regression Analysis output – RF in catchment area and Hydro generation	27
Figure 3.8: SPSS Regression Analysis output -Hydro production vs rainfall in all 8 areas	29
Figure 3.9: SPSS Regression Analysis output - Hydro production vs rainfall in selected 4 areas	30
Figure 3.10: Forecasted crude oil and coal price	35
Figure 4.1: Hydro Generation vs Rainfall – linear correlation	37
Figure 4.2: Hydro Generation vs Rainfall – Selected Areas only	37
Figure 4.3: Annual Hydro Generation against annual rainfall	40

Figure 4.4: Annual Hydro Generation	41
Figure 4.5: Capacity Cost Vs Total Investment for Power Generation	45
Figure 4.6: Crude Oil Vs Auto Diesel Prices Local Prices	46
Figure 4.7: International diesel price variation against Crude Oil price	47
Figure 4.8: Diesel Prices vs Crude Oil price variation	48
Figure 4.9: Fuel Oil vs crude oil price variation	49
Figure 4.10: Correlation of FO380	50
Figure 4.11: Correlation of FO180	50
Figure 4.12: Price Variation of Naphtha vs Crude Oil	51
Figure 4.13: Correlation of Naphtha vs Crude Oil	51
Figure 4.14: Plant Factors	52
Figure 4.15: Variation of Electricity price over the 2013 -2025	54
Figure 4.16: Electricity Price Variation over increase of crude oil by 50% than forecasted	55
Figure 4.17: Electricity Price Variation over increase of coal by 50% than forecasted	57
Figure 4.18: Electricity Price Variation when coal price increased by 50%	58
Figure 4.19: Electricity price variation against inflation (Tx and Distribution cost at fixed)	59
Figure 4.20: Electricity price variation against inflation	61
Figure 4.21: Electricity price variation against probable different inflation rates	62
Figure 4.22: Power Generation cost variation against the plant Factor of coal plants	63
Figure 4.23: Electricity Price Variation against reduction of Hydro Power generation	65
Figure 5.1: Coal production forecast	68
Figure 6.1: Electricity price variation	70
Figure 6.2: Electricity price variation subjected to inflation	71
Figure 6.3: Upper Limit & Lower Limit Variation of Fuel Cost	74

List of Appendices

Appendix	Description	Page
Appendix 1	Annual Rainfall Pattern of the period from 1941-2002	82
Appendix 2	Calculation methodology	83

