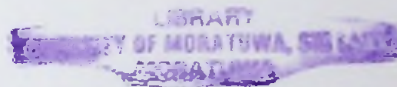


LB/DON/57/06

DEE 05/08

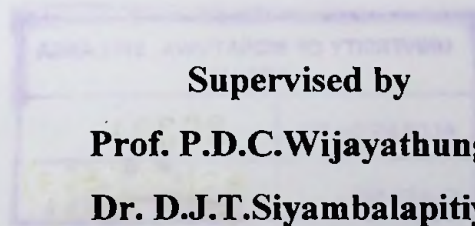
SHORT TERM DISPATCH MODEL FOR SRI LANKA HYDROTHERMAL POWER SYSTEM

A Thesis submitted to the
Department of Electrical Engineering, University of Moratuwa
in partial fulfillment of the requirement for the
Degree of Master of Science in Electrical Engineering
2003/2005



By

**HETTIARACHCHIGE DON SARATHCHANDRA
THIMOTHIES**



Supervised by

Prof. P.D.C. Wijayathunga

Dr. D.J.T. Siyambalapitiya

621.3 "06"
621.3(043)

Department of Electrical Engineering,
University of Moratuwa, Sri Lanka

January 2006

University of Moratuwa



86331

86331



86331

DECLARATION

The work submitted in this thesis is the result of my own investigations.

This subject has not been accepted for any degree so far, and is also not being currently submitted for any other degree by any other individual.

UOM Verified Signature

H.D.S.Thimothies

24-01-2006

We endorse the declaration by the candidate.

UOM Verified Signature

Prof. P.D.C.Wijayathunga

.....

Dr. D.J.T. Siyambalapitiya

Contents

Declaration	Pg
	i
Abstract	v – vi
Acknowledgement	vii
List of Figures	viii
List of Tables	ix

Chapters

Chapter-1	Pg
1. Introduction to the working environment	1
1.1 Background	1
1.2 Motivation	2
1.3 Goal	2
1.4 Achievement	3
1.4.1. Unit Commitment Model	3
1.4.2. Optimal Dispatch Model	3
1.4.3. Dynamic Stability Model	3
Chapter-2	
2. Problem Identification	4
2.1 Introduction	4
2.1.1. General introduction to Mahaweli complex	4 - 5
2.1.2. General introduction to Laxapana complex	7 - 8
2.1.3 General introduction to CEB other hydro	8
2.1.4 General introduction to CEB Mini hydro	9
2.1.5 General introduction to Thermal Generation	9
2.1.5.1 CEB	9
2.1.5.2 Independent Power Producers	9



2.2	Options to Optimal Dispatch	10
2.2.1	Introduction to METRO	10
2.2.1.1	Capabilities of METRO	10 - 11
2.2.1.2	Inputs to STD from METRO	12
2.3	System Dynamic Stability	13
2.3.1	Introduction	13
2.3.2	System Dynamic Stability Study	13 -19
2.4	Conclusion	19

Chapter-3

3.	Development of the Software model.	20
3.1	Theoretical Approach	20
3.1.1	Unit commitment	20
3.1.2	Optimal dispatch	21 - 23
3.1.3	Optimal Load flow.	23
3.1.4	Reliability	23
3.1.5	Dynamic Stability	24
3.2	Practical approach in adapting to Sri Lanka power system	24
3.2.1	Unit Commitment	24
3.2.2	Optimal dispatch	25
3.2.3	Dynamic Stability	26 - 28
3.3	Algorithms	29
3.3.1	Optimal/Economic dispatch	29
3.3.2	Dynamic Stability	30
3.4	Application models	31
3.4.1	Unit Commitment	31
3.4.2	Optimal dispatch Model	31
3.4.2.1	Introduction to MATLAB.	31
3.4.2.2	Application Program	31 - 32
3.4.3	Dynamic Stability Model	32
3.4.3.1	Dynamic Stability Simulator.	32

Chapter-4

4. Application of the Model	36
4.1 Case Studies	36
4.1.1 Sample study	36
4.2 Results and Analysis	37
4.2.1 Optimal Dispatch schedule	37
4.2.2 Optimal Dispatch schedule in graphical form	38 -39
4.2.3 Cost comparison between actual and scheduled	40 – 41
4.2.4 Operation cost.	41
4.3 Dynamic Stability under peak load conditions	44 – 46

Chapter-5

5. Summery of results and Conclusions	47
5.1. Summery of Results	47
5.1.1 Optimal Dispatch Model	47
5.1.2 Dynamic Stability Simulator Model	47-48
5.2 Discussion and Conclusion	48
5.3 Recommendations for future research	50

References

Appendices

Annex-1	Installed capacity of CEB Thermal plants.	x
Annex-2	MATLAB Script for optimal dispatch model	xi-xvii
Annex-3	MATLAB Script for cost comparison model	xviii-xxi
Annex-4	EXCEL program for the Stability model.	xxi-xlii
Annex-5	Automatic Under frequency load shedding scheme.	xlii

Abstract:

As a short-term dispatch guide, presently manual methods are used by CEB with experience gathered for years and with the directions given by a computer model named Medium Term Reservoir Optimization (METRO) model, which is for medium term dispatch planning. This is done for one-year time horizon in monthly rolling basis.

There is no **Short Term Dispatch** tool used for power dispatch in CEB power system. A **Short Term Dispatch Model (STDM)** consisting of three sub models of Unit Commitment Model, Optimal Dispatch Model and Dynamic Stability Model were developed in my research project.

This is virtually a user-friendly operational model, which may be applicable for the present system and may be used without any change in the five-year transmission and generation planning horizon and may be developed with further development of the Transmission/Generation expansions [14].

The Unit Commitment Model is a judgmental model. Thus unit commitment can be decided by the operator depends on the water requirement for irrigation purposes, sudden unexpected inflows to hydro catchments, plant outages for routine and breakdown maintenance etc.

According to the unique characteristic of Sri Lanka power system almost all of the available plants are to be committed. The plants not to be committed are covered by the optimal/economic dispatch solution in the optimal dispatch model [ODM].

Optimal Dispatch Model [ODM] was developed on MATLAB platform based on incremental cost principal developed by the method of Lagrange Multipliers based on Kuhn-Tucker Theory. [2]; [8] . MATLAB is a language of Engineering Computation. The user interface for input and output are user friendly Excel Work Sheets. Further graphical out puts also given on MATLAB platform.

The inputs are twenty-four hours demand on hourly basis, the plant Maximum and Minimum MW limits and cost parameters. The cost parameters are the unit costs of thermal plants and water values given by the **Medium Term Reservoir Optimization** model used by System Control Center of CEB.

Dynamic Stability Model was developed based on the definitions of rate of change of frequency and the load reduction factor to see the frequency response of the power system under generation throw off condition of the power system. Frequency is the main dynamic indicator used in system operation [11]; [12]; [13]. The model covers the frequency response with the effect of the system inertia, load reduction factor, all automatic under frequency load shedding stages and the governor response of the system[6].

This is a single bus model and with the application it was found to be very user-friendly to the CEB system operator to use at the control desk.

ACKNOWLEDGEMENT

In presenting this research I extend my very sincere thanks to my worthy supervisors in Prof. P.D.C.Wijayathunga and Dr. D.J.T Siyambalapitiya. If I have achieved anything spectacular in this effort it was purely due to this guidance and utmost cordiality.

My heartfelt thanks also go to my course coordinators and lecturers of postgraduate study course of Faculty of Electrical Engineering, University of Moratuwa, Sri Lanka, who gave me the theoretical knowledge and encouragement in bringing up this academic work in time with excellent corporation and guidance.

My sincere gratitude is also extended to the support staff of the Department of Electrical Engineering for helping in various ways during the course of study.

Lastly I should thank many individuals, friends and colleagues, who have not been mentioned here personally, for making this educational product a success.

May be I would not have been able to accomplish this task without their support.

List of Figures	Pg.
2.1 Schematic diagram of Mahaweli Complex	4
2.2 Schematic diagram of Laxapana Complex	7
2.3 - 2.9 Frequency response curves under different generation throw off Conditions.	14 - 19
3.1 Graphical Solution for Economic dispatch	23
3.2 - 3.4 Frequency response curves of DFR under defined conditions	27 - 28
3.5 - 3.6 Frequency response curves of the dynamic stability model	34 - 35
4.1 Input interface for optimal dispatch model	36
4.2 Output of optimal dispatch model	37
4.3 - 4.6 Graphical output of optimal dispatch model	38 - 39
4.7 Actual unit costs input interface for cost calculation	40
4.8 Actual generation input interface for cost calculation	40
4.9 Scheduled generation input interface for cost calculation	41
4.10 - 4.13 Cost comparison charts.	41 - 43
4.14 Frequency response curve of DSM after tripping of largest machine under critical situation of scheduled dispatch scenario.	46
5.1 Frequency response curve of DSM	48
5.2 Frequency response curve of DFR	48
A-1 - A-63 Dynamic Stability model developed on Excel.	xxi-xlii
A-64 Under frequency load shedding scheme.	xlii

List of Tables		Pg
2.1	Features of Mahaweli hydro power scheme.	6
2.2	Features of Laxapana hydro power scheme	8
2.3	CEB Other hydro	8
2.4	CEB Mini Hydro	9
2.5	Independent Power Producers	9
2.6	METRO data for optimal dispatch model	12
3.1	Settings of Under frequency load shedding scheme	32
3.2	Machine Inertia constants.	33
3.3	Generator Under Frequency Trip settings	34
4.1	Input interface to dynamic stability model	45
4.2	Operation cost of daily generation	43
A-1	CEB Thermal Power stations	x