

**RISK CONSTRAINED STOCHASTIC PROGRAMMING BASED  
OPTIMIZATION FOR OPERATION OF A POWER PRODUCER  
IN INDIA**

by

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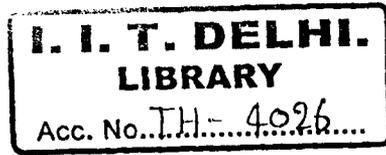
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## CERTIFICATE

This is to certify that the thesis entitled, “**RISK CONSTRAINED STOCHASTIC PROGRAMMING BASED OPTIMISATION FOR OPERATION OF A POWER PRODUCER IN INDIA**” being submitted by **Mr.N.Vaitheeswaran** to the Indian Institute of Technology, Delhi for the award of Doctor of Philosophy is a record of bonafide research work carried out by him under my guidance and supervision in conformity with the rules and regulations of Indian Institute of Technology Delhi.

The research report and results presented in this thesis have not been submitted, in part or full, to any other university or institute for the award of any degree or diploma.

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## ABSTRACT

Computational models of power producers for restructured markets in Europe and the US is a well researched subject. Many deterministic and stochastic models have been developed to address the optimization problems of generators accounting for various uncertainties. Complex stochastic models incorporating risk constraints have also been formulated for revenue maximization.

In India, the power supply industry has witnessed major reforms and restructuring to make electricity cost competitive. However, the operational issues, rules and constraints of power system in India are vastly different from that of the developed economies. Therefore, the optimization models developed for overseas are not adaptable in the Indian context. The pricing of bulk power and day ahead operation in India is governed by Availability Based Tariff (ABT) through performance based regulation, where the benchmarks are set by the regulator. The pricing norms set by the regulator give incentives to utilities to reduce their internal costs and enhance their returns. In this situation, the generators face the challenge of uncertainty of various parameters while formulating optimal operational policy in midterm time horizon. In order to maximize the expected yearly earnings, the decision strategy of the generator involves estimating the optimal availability target at different time intervals over a year and achieving the target through short term optimal decision strategy on a daily basis. Limited research has been done to address these operation planning problems in the ABT context.

In the post ABT scenario, the introduction of frequency linked pricing mechanism has made the system frequency an uncertain variable in the operation of electric utilities. In this thesis, the research work intends to develop an optimization

model for midterm operation planning of a power producer in the condition applicable to India. It considers the operational conditions, constraints and risks faced by a power producer in the Indian context. The objective of the power producer is to maximize the expected profit over a yearly period, under '*Availability Based Tariff*' (ABT), considering the power utility's risk profile. Two levels of optimizations are performed in this model.

The first level is a midterm planning model for estimating the 'Optimal Availability Target' at different time intervals of the year, which is solved by risk constrained stochastic programming approach. The scenarios of stochastic programming have been reduced to a realistic number by fast forward algorithm. The stochastic parameters involved in the midterm planning model are a) Scheduled Generation of the genco by independent system operator b) the random outage of generating units which follow Markov process and exponential distribution and c) the Unscheduled Interchange (UI) of power by the generator with the grid. The risk aversion of the generator is defined by Conditional Value at Risk. The stochastic programming has been solved using "GAMS" software.

The second level of optimization estimates the 'Daily Availability for Declaration' in the day ahead pool, linking with the annual target and constraints. This is solved by an iterative approach, where the stochastic parameters are generated by Monte Carlo simulation. The computer implementation of daily optimization has been done in C++ program.

A case study of a combined cycle station has been taken up for illustration and the individual generating units are modeled as a composite equivalent unit. The solved case study investigates the outcome by the rigorous quantitative approach and compares the results with the traditional approach. The impact of further uncertainties

like change of fuel, fuel price variation, selection of number of scenarios for the stochastic programming and changing risk perceptions of the power producer, from risk neutral to risk averse, are all analyzed.

# CONTENTS

TOPIC	PAGE NO
CERTIFICATE	i
ACKNOWLEDGEMENTS	ii
ABSTRACT	iii
CONTENTS	vii
LIST OF FIGURES	xi
LIST OF TABLES	xiv
LIST OF ABBREVIATIONS	xvi
LIST OF SYMBOLS	xvi
<b>CHAPTER 1</b>	<b>1-18</b>
INTRODUCTION	
1.1 Preamble	1
1.2 Review of literature	1
1.3 Power market structure in India	4
1.3.1 ABT outline	6
1.4 Problem definition and objective	8
1.4.1 Traditional approach	8
1.4.2 Concept of availability optimization in ABT	9
1.5 Methodology	11
1.6 Organization of the thesis	14
1.7 Summary of research work	16
<b>CHAPTER 2</b>	<b>19-50</b>
STOCHASTIC MODELING OF UNCERTAINTIES	
2.1 Introduction	19
2.2 Probabilistic generating unit models by analytical method	19
2.2.1 State space diagram of two state Markov process	20
2.2.2 Mathematical formulation of Markov process model of two state unit	22

2.2.3 Probability density function of forced outage or available capacity	23
2.2.4 Recursive algorithm for capacity modeling	24
2.3 Monte Carlo simulation of generating unit states	26
2.3.1 Generating exponentially distributed random variates by Inverse Transform method	26
2.3.2 Monte Carlo simulation of capacity outage	27
2.3.3 Simulation of unit states by state sampling	27
2.3.4 Simulation of unit states by state duration sampling	28
2.4 Probabilistic representation of scheduled generation and block frequency	29
2.4.1 Generating normally distributed random variates by Inverse Transform	31
2.5 Probability density of uniform distribution	32
2.6 Joint probability representation of Independent random variables	34
2.6.1 Joint probability distribution of continuous random variables	35
2.6.2 Joint probability distribution of discrete random variables	35
2.7 Fitting probability functions for scheduled generation and frequency	36
2.8 Summary of stochastic modeling	50
<b>CHAPTER 3</b>	<b>51-95</b>
<b>COMPUTATIONAL MODEL FOR MID TERM OPERATION OF A GENCO IN ABT</b>	
3.1 Preamble to availability planning	51
3.2 Decision framework	52
3.3 Mathematical formulation of midterm planning	55
3.4 Risk constrained optimization	63
3.4.1 Conditional value at risk	63
3.4.2 Mathematical formulation of conditional value at risk	65
3.4.3 Risk constrained objective function	66
3.5 Solution methodology	67
3.5.1 General formulation of stochastic linear program	67
3.5.2 Deterministic equivalent of stochastic linear program	68

3.6 Optimization of annual model	69
3.6.1 Scenario reduction algorithm	70
3.6.1.1 Scenario tree formation	70
3.6.1.2 Scenario optimization	72
3.6.2 Flow chart of optimization	74
3.6.3 Equivalent unit representation by composite generation cost function	75
3.7 Results of a Case Study	80
3.7.1 Objective function value for a scenario	80
3.7.2 Optimal value of decision variables	81
3.7.3 Impact of scenario reduction on convergence	83
3.7.4 Sensitivity of objective function with risk parameters	84
3.7.5 Efficient frontier for different risk profile	86
3.7.6 Analysis of optimal value on gas and liquid fuel	87
3.7.7 Expected value solution versus stochastic solution	88
3.7.8 Impact of UI on optimality	89
3.7.9 Discrete and cumulative distribution of objective function value	90
3.7.10 Investigation of varying confidence level on optimality	92
3.7.11 Scheduled generation and available capacity of one scenario	93
3.8 Summary of midterm planning model	95
<b>CHAPTER 4</b>	<b>96-118</b>
OPTIMAL DAILY AVAILABILITY DECLARATION MODEL	
4.1 Introduction	96
4.2 Monte Carlo simulation(MCS) of discrete distributions	96
4.3 Uniform distribution for MCS	97
4.4 Mathematical model for day ahead declaration	99
4.4.1 Optimization procedure	102
4.4.2 Convergence process of MCS	105
4.5 Results and Analysis	106
4.5.1 Optimal target versus achievement	106
4.5.2 Error bounds for different sample sizes	109
4.5.3 Convergence of day ahead optimization	111

4.5.4 Width of confidence interval of MCS	112
4.5.5 MCS of Daily Generation Availability for 96 time blocks	113
4.5.6 MCS of UI, Generation Schedule, ENS for 96 time blocks	114
4.6 Summing up of daily optimization	118
<b>CHAPTER 5</b>	<b>119-123</b>
<b>CONCLUSION</b>	
5.1 Thesis Summary	119
5.2 Key contributions	120
5.3 Future scope	121
<b>REFERENCES</b>	<b>124-128</b>
<b>APPENDIX</b>	<b>129-141</b>
APPENDIX I	129
APPENDIX II	134
APPENDIX III	137
<b>Bio-data</b>	<b>142</b>