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

by

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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