DEMAND SIDE BIDDING IN DEREGULATED ELECTRICITY MARKET

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Certificate of Recommendation

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All information in this thesis have been obtained and presented in accordance with academic rules and ethical conduct.

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TABLE OF CONTENTS

Chapter 1

INTRODUCTION

1.1. Background & Motivation of the Thesis

Deregulation in power industry is a very hot topic in the modern era. This deregulation mainly observed in Sweden, Finland, Norway, Sweden, U.S. and some other countries of South America. In nineties decade all electrical company change their views of operation & business mode of conduction.

Demand of power is high for all developing countries. Because they realize without electricity a nation cannot be developed properly. In other hand, developed countries provide electricity at lower cost is the main issue. In a country there are so many power generating company & there are so many purchaser. But the thing is that purchaser want to purchase power at the economic rate. So, if we use deregulation in the electricity market then competition will be enhanced & consumers will also get choices for purchasing power at lower cost [1].

Under Deregulation vertically integrated utility is disaggregated into separate companies. The deregulation is much more needed to improve the efficiency in technical aspects & as well as cost is expected to drop & customer focus will also be improved. By the deregulation competition between the power generating companies improve so that the may introduce new technology for their own betterment. Here reliability of the system & power quality is also a big part of this industry. They observe inflows & outflows from the grid as well as voltage profile throughout the day.

Mainly regulated system has risk free environment. Electric industry required huge capital. On the other hand regulation provided both sides with risk minimization system. In monopoly market company will generate, sell commercial electric power with in its limited area & they think for a return of its investment. But in deregulated system competitors are involved to generate energy and look after the customers & give all facilities also [1&3].

1.2. Objective Of The Thesis

The main objective of the thesis is to achieve the benefit maximization of Supplier & consumer side by the bidding technique. Each supplier tries to maximize its profit with the help of information announced by system operator.

So, to maximize the revenue function we have to optimize the biding coefficient of supplier & consumer. Mainly those bidding coefficient are related with the revenue function. Here in the problem

I have to maximize the profit using Particle Swarm Optimization (PSO). All algorithms are implemented in MATLAB version-13 environments written in house.

1.3. Outline Of The Thesis

In chapter 2: Covers the literature review of demand side bidding in deregulated industry.

In chapter 3: The concept of demand side bidding have been discussed. This chapter also represents different types of market structure & design, different entities and market model also.

In chapter 4: Covers the important topic of the optimization techniques & soft computing. At first different types of optimization techniques has been discussed and after that implementation of soft computing in different types of optimization technique has been discussed.

In chapter 5: The particle swarm optimization algorithm has been discussed in details. Also different control parameters of PSO & its effect on PSO algorithm has been described in details. Furthermore this chapter gives a details overview of PSO strategies.

In chapter 6: Deals with the detail problem description & problem formulation detail description of the PSO system & its different operating modes has been presented. Here all operating constraints' input parameters & final objective function has been presented. Finally application of PSO in the specific problem has been discussed elaborately.

In chapter 7: Simulation results and discussion are presented. Also the effect of variation of different control parameter in PSO method has been discussed. All calculated database which are based on MATLAB are shown in here.

In chapter 8: General conclusion of the thesis & scope of the future work has been presented.

Finally referencing has been done.

Chapter 2

LITERATURE REVIEW

Abhyankar et al [1] worked with the ongoing research project and presented demand side bidding in deregulated industry . Demand side bidding is now the hot topic in our country. The absent of demand side participation has been noted as the prime reasons for causing price spikes, shortages. Since Schweppes's seminar work on spot pricing of electricity (1988), has been widely recognized demand side participation. That has a significant impact on the operation of competitive electricity market. The focus of my project is on the centralized pool market model. The pool market provides a mechanism to determine the market equilibrium of the interaction between the suppliers and the consumers. Pool operator accepts bid from suppliers and consumers and then dispatches the power.

Kumar et al [2] shows in an open electricity market supplier & buyer need a suitable bidding model for maximizing their profit. So, they bid strategically. Here this bidding strategy problem solved using PSO. Bidding strategy is based on bidding coefficient. Power market has changed now a days. Due to competitive bidding, growth of bilateral trading & power exchange also. Around the world power trading are carrying out by power exchange. After deregulation large consumer and generators starts to interact regarding power transaction & maintain system security through system operator i.e. competitive market consists of generating company , transmission company & distribution company along with system operator .Bidding are various types i.e. based on estimation of market clearing price (M.C.P.) ,based on estimation of bidding behaviours of the rival participants, and based on game theory. Among them first one is easy and most of the power exchange follow that type of bidding. Adaptive Particle Swarm Optimization (APSO) technique show much better result as compare to PSO in following respect. The overall profit has increased using APSO. In APSO method MCP is increased, so power exchange will also be benefited.

Frances et al [3] shows in this paper some mathematical programming models used for power producers in day ahead electricity market. The models include linear and nonlinear programming with equilibrium constraints. Mainly that type of transformation from regulation to competition in power industries around the world have led to development of market of power. Here clearing price based on the submitted bids are determined by the ISO.

Kumar et al [4] presents a new methodology based on PSO for the preparation of optimal bidding strategies by power supplier in acompetetive electricity market.Competetion implies between generating companies to get more profit considering all risks . So ,to select bidding parameter optimally they increase their own profit.The main moto of the paper is maximizing the profit & minimizing the risk by bidding strategy. Hence each bidder has an optimal bidding strategy for clearing price auction of power.

Singh et al [5] represents a suitable bidding model for enhancing their profit. Power market has changed abruptly day by day. Due to three factors i.e. competitive bidding, bilateral trading ,& introduction of power exchange. Around the world, the power system market is undergoing restructuring process during last decades. Before deregulation a monopoly market was exist & after deregulation large consumer and buyer starts to interact regarding power transaction & maintain system security through system operator. Mainly bidding are three types Multipart bidding , single part bidding and iterative bidding. In this paper PSO is used to solved random biding problem.

Philpott et al [6] presents a model of a purchaser of electricity in a whole sale electricity pool market that operates a day head of dispatch. In this paper some condition under which the purchaser should bid their expected demand & examine single generator & purchaser in the presence of competitive market. In this paper they use some simple optimization models to study the optimization behavior of large purchaser of electricity in the whole sale market.

Wu et al [7] represents the interaction of long term contracting & spot market transaction between multi Gencos and multi discos for electric power .They may sell or buy power in a spot market .In this paper firstly we consider Gencos with heterogeneous production cost, secondly uncertain acess to the spot market by Gencos, third capacity and output. Here we model Gencos and discos interact through an electronic bulletin board, posting bids and offers until agreement has been reached.

Kumar et al [8] shows In an electricity market generating companies and large consumers need suitable bidding models to maximize their profits .Here also supplier and consumers will bid strategically for choosing the bidding coefficient. In this paper PSO is used for an optimized the problem. Restructing of power industry mainly aims at abolishing the monopoly in the generation and trading sectors. So competition is introduced in the power market. Theoretically in a perfectly competitive market supplier should bid at their marginal production cost. They increase their profit by bidding a price higher than marginal production cost.

Shikoski et al [9] discuss new technology are used in deregulated power sector. By new technology we can increase the benefits or decrease the operational cost also. Modern technology play an important role in several stages of effective system operation .The main economical benefit expected from deregulation include improved quality of electricity, power reliability. Reliable & high quality power are main objective of the power industry.

Thomas et al [10] shows price volatility have been observed in electric power markets. Demand side participation has to increase market efficiency. In current retail market consumers rarely buy electric energy at spot prices. Most of the consumer participation should promote market efficiency. Demand side participation is too much necessary because some consumer sacrifice reliability to reduce the price of electricity and some of them believe in high degree of reliability and high quality of power.

Mala de et al [11] gives an idea in pricing of system security in deregulated environment. A pricing system for power system security in deregulated electricity market that includes voltage stability constraint in a multi objective OPF problem. The OPF maximizes social benefit as well as the distance from the voltage-collapse point. While pricing system security , ancillary service such as reactive power has been included. Effect of N1 contingency on pricing is analysed. Price is decided one day ahead using forecasted demand data. The market participants bid according to their marginal price and market clearing price is decided by matching the generation and demand side bidding. ATC is computed by repeated power flow, considering bus voltage limit and line thermal limit. The ATC shows the amount of congestion. This pricing system is tested on IEEE 14 bus test system and is implemented using MATLAB .

Safaee et al [12] worked in risk assessment of demand side bidding strategy for retailer in day a head market. Competition of electrical industry has lead to appearance of participant such as retailers in demand side. Retailers as one of the demand side participants look for maximizing profit resulted from energy sale to their customers. There are uncertainties and risk in demand side, which influence on the retailers behavior. IN this paper different types of uncertainties and risk that retailers phased with and the risk type in day a head and regulated market where studied , proper mathematical model for these risks was suggested and the effect of retailer volume and price risk in bidding strategy of demand side has been studied and optimal bidding curve has been calculated in presence and absence of volume risk factor.

Schisler et al [13] shows demand response in ancillary services in bidding purposes. Many Regional Transmission Organizations independent System Operators are structuring the rules of ancillary services markets such that demand response can participate alongside traditional supply side resources. Enernoc is one of the few Curtailment Service Providers that actively bids demand response resources into reserves markets. This paper will detail how Enernoc works with commercial and industrial customers to provide reliable reductions in these markets. In the last five years, Enernoc has developed technology to facilitate and monetize demand response. Advanced metering now facilitates measurement and verification of performance and settlement process. Enernoc Network Operations Center can fully automate demand response at customer sites. Such automation enables market participants to provide relief quickly and easily, making demand response a valuable asset for participation in ancillary

Alzeni et al [14] shows day ahead bidding strategies for demand side expected cost minimization. This paper proposes a day-ahead bidding system based on a pricing model that combines: i) a price per unit of energy depending on the day-ahead bid energy needs of the demand-side users, and ii) a penalty system that limits the real time fluctuations around the bid energy loads. In this day-ahead bidding process, demand-side users, possibly having energy production and storage capabilities, are interested in minimizing their expected monetary expense. The resulting optimization problem is formulated as a non cooperative game and is solved by means of suitable distributed algorithms.

Zhang et al [15] represented reducing uplift payment in electricity markets in deregulated industry. In current U.S. deregulated wholesale electricity markets, an auction mechanism that minimizes the total bid cost is used to select bids and their output levels. Energy market clearing prices are derived from the shadow prices associated with the system demand constraints in an economic dispatch process with fixed unit commitment status. Therefore they do not reflect no-load and start-up costs, resulting in the uplift payments. To reduce such side payments and improve the market transparency, the “convex hull pricing model” is adopted, and “online capacity constraints” are introduced to the energy market, requiring the total online capacities to be greater than or equal to the system demand. With the associated multipliers serving as uniform “no-load clearing prices,” the total uplift payment is proved to be reduced based on optimality conditions for multipliers. Numerical examples support the analytical results and shed insights on different types of uplift payments.

Adilov et al [16] shows market structure and the predictability of electricity system. This experimental analysis demonstrates that letting the customers participate fully in the market re-establishes the predictability of line flows as a function of system load. In all of these experiments there are no restrictions on permissible offering behaviour by suppliers (e.g. no price caps, prohibitions on withholding capacity or automated mitigation procedures). Two alternative forms of demand side participation are considered: 1) a demand response program (DRP) where customers are alerted to high prices in the subsequent period and are paid a pre-specified amount for each kWh less than their benchmark level of usage for that period, and 2) a real time pricing program (RTP) where customers are given forecasts of prices for each period over the subsequent day and they then pay the actual period-by-period market clearing price. As a benchmark, these experiments with six suppliers and seventeen buyers are also repeated where customers pay an average constant price in all periods (FP); although in all cases sellers receive the market-clearing price in each period. R-squares were greater, variances were smaller and the t-tests on regression coefficients were stronger on the relationship between line-flow and system load for RTP, as compared to the FP system that is commonly used in most electricity markets. DRP was usually somewhere in between. Not only does inducing active customer participation in the market through RTP lead to better system predictability, it also reduces price spikes and leads to greater overall economic efficiency in these markets. It is a winner on both economic and operational grounds.

Tambe et al [17] shows critical review on demand response scenario in deregulated industry in power market. Deregulation of electrical market permits direct participation of various entities in market operation. The end users which were never active elements in market dealing have been provided liberty of bidding for electricity and can select the time zone of operation based on various tariffs, incentives and penalty structures offered. Effectively, system stability and reliability issues at peak periods started getting handled by redistribution of the load. Such a change in load structure is called as Demand Response (DR). The effectiveness of demand response on system behaviour is carried out by applying various optimization algorithms on DR based load models. Load model is developed using price elasticity matrix of demand of various types of end users.

Molina et al [18] represented new opportunities and bids for residential users in a deregulated market. The purpose of this paper is to describe a useful tool for the initial analysis to assess the possibilities of residential electrical thermal storage , taking into account heat storage and cool storage devices. These load models are based on an energy balance between the indoor environment, the dwelling constructive parameters, the ETS device and the internal mass through a discrete state space equation system. The main application of this load model has been oriented towards the simulation of Electrical thermal storage (ETS) performance in order to evaluate the possibilities of Load Management in the new de-regulated structures of Electrical Power Systems. The proposed model has been implemented and validated for heat storage, using real data collected during the last years in residential areas to evaluate its accuracy and flexibility. Finally, a simulation case study is presented to show the possibilities of modifying the actual residential demand profile through a storage period re-scheduling proposed by the authors, taking into account the customer minimum comfort levels and avoiding program rejection.

Cheng et al [19] bidding strategies of power suppliers in electricity market. It is an inexorable trend to introduce competition into generation and demand side of electricity market. For power suppliers, the most important is to optimize bidding strategies and reduce power transaction cost, so they can improve their marketing competitive capacity and obtain more profit. With a view to wholesale competition, this article studies the bidding strategies that are closely based on cost analysis. The cost analysis is accomplished on the basis of power purchase cost of power suppliers together with the prediction of the bidding price of competitors and other marketing factors. Last, the article sets up the power supplier bidding strategy optimization model with maximizing revenue in target function.

Barroso et al [20] shows market mechanism in south America. South America is facing important challenges in electricity supply to allow for future economic development. Current electricity market designs are being reviewed to avoid supply difficulties and couple with existing outlook of primary energy resources and investment interest by the private sector. Examples of these developments are the giant Brazil, the economically troubled Argentina, and the pioneer of electricity reform, Chile. While Brazil and Chile progress into a second stage of reforms with public PPA auctions in a private environment, Argentina makes a backward movement to significant State intervention, as in the times previous to reform. This presentation will describe and analyze these diverging approaches, through which these countries are relying to ensure sufficient capacity and investment to reliably serve their growing economies.

Hammons et al [21] represented market mechanisms in power sector reforms in Latin America. The process of transformation in government and operations in the power sector leads to interaction between increasing integrated markets and public agencies in charge of policy making, regulation and control. This is examined for Latin America. First, state reform and state policies in Latin America are considered, where present concerns, state-market relationship (the position of regulation, globalization, internationalization), and state market in the energy sector (correction and adjustments) are reviewed. Here, case studies for Argentina and Brazil are briefly reviewed. The paper then examines solutions that are being explored to face supply problems over recent year. Chilean electricity market, given the unexpected restriction in natural gas transfers from Argentina. The final part of the paper discusses auctions of contracts and energy call options to ensure supply adequacy in the

Brazilian power sector reform. Then, reform being proposed to the electric regulatory framework for wholesale transactions in Peru is reviewed. It represents an effort to solve some problems with the electricity market, particularly the perception that investment in new generation resources is, or may be in the future, inadequate.

Alverez et al shows [22] demand potential in end user facilities. Many problems have appeared with the practical implementation of restructured electrical business in the U.S. and European Union such as lack of generation, network constraints, etc. A good example of these problems is the scarce participation of the demand in the electricity markets energy, reserve, and other ancillary services problems that could be solved through new demand responsive programs, aimed to replace the traditional demand side management programs into voluntary demand participation programs. A methodology for the generation of demand side bids and offers in large customer facilities and a real application to a university customer is presented in this paper. The methodology is based on the knowledge of the physical processes involved in the electricity consumption and on the flexibility of the required supply. The result of the methodology proposed is a set of demand packages that can be used to participate in different electricity markets, whose possibilities in the market area will be explored in a consequent paper.

Lee et al [23] shows an assessment of load participation in the ERCOT nodal market. The purpose of the restructured power market is to obtain maximum social benefits, including power generation and load customers. Although the power generation sector has been fully participating in the power market, relatively limited market options for demand sector to participate in the power market exist. Several Independent System Operators (ISOs) have deployed several terms of Demand Response (DR) programs in the auction power market. As an "intra-state" ISO, Electric Reliability Council of Texas (ERCOT) is responsible for the electric market in Texas. During the past several years, the demand response program in ERCOT had provided promising outcomes from both economic and reliability prospective. Both the improvement of the existing program and feasibility to create new program are always ERCOT's goal to increase the market efficiency and system reliability. Currently, demand-side resources, mainly on the industrial load class can participate into ancillary service market. To further promote demand-side response program, the market operation, regulatory intervention and special demand-side programs are needed. In addition, to meet the requirement of demand-side resource, the program may pay more attention to the commercial and residential customer in the future.

P.R. Kleindorfer et al [24] gives an idea on optimal bidding and contracting strategies in the deregulated electric power market. We study the interaction of long term contracting and spot market transactions between multi Gencos and multi discos for electric power. Gencos and Discos may either contract for delivery in advance or they may sell or buy some or all of their output or input in a spot market. Contract pricing involves both a reservation fee per unit of capacity and an execution fee per unit of output if capacity is called. Disco's optimal portfolios are shown to follow a merit order shopping rule. When Genco's properly anticipate demands to their bids, then bidding a contract execution fee equal to variable cost dominates all other bidding strategies. The optimal capacity reservations fees are determined by Gencos to trade off the risk of underutilized capacity against unit capacity cost. Existence and structure of market equilibrium are characterized for the associated competitive game between Genco..

Salazar et al [25] shows demand response resources management is one of the most investigated solutions oriented to improve the efficiency in electricity markets. In this paper, the capability of customers to participate in short term markets is analyzed. An available methodology to analyze the daily and monthly energy consumptions of large customers is used to create energy offers and bids. This allows customers to participate in energy markets in order to buy, as first step, the usual electricity surplus for their consumption and, additionally, to offer demand reductions in the short term electricity markets. This paper shows the customer potential to participate in the Spanish Electricity Markets.

Alikhanzadeh et al [26] shows bilateral electricity market model using conjectural variation equilibrium and hierarchical optimization. In liberalized electricity markets utilities have incentives to manage their positions in the market and they have considerable interests in making decisions to reduce the risks and modifying several strategies to maximize their profit. In such electricity markets all the participants are responsible for their decisions; therefore various modelling techniques such as optimization, simulation and equilibrium methods are introduced to manage the risks of participating in electricity markets, especially in an environment where participants compete in both spot market bidding and bilateral contract trading. Equilibrium models using a conjectural variation approach to optimize the participants' behaviours in oligopolistic and oligopolistic market frameworks have been represented in this paper. This conjecture is a belief or estimation of a player, which can be formulized as a rival's sensitivity response to changes in output of each firm. This paper reviews the UK electricity market as a bilateral electricity market structure, analyses the conjectural equilibrium formula for both generation and demand sides of the market also shows how to determine the bilateral market equilibrium point based on Conjectural Variation method and Direct-Search optimization method in a hierarchical algorithm.

Panapakidis et al [27] provides a state of the survey on the load profiling applications in the deregulated market. The survey is focused on topics like tariff design, load forecasting and various power distribution issues. The procedure of the formulation of the load profiles is analysed, as well as the algorithms used for the aforementioned procedure. New opportunities are continually appearing for the participators. So many countries with liberalized markets the focus of the interest is gathered in retail side. The profit of retailer are dependent on the information of their customer demand patterns. To see the load profile consumers are grouped in the number of classes. Detailed information of customer demand patterns is a beneficial tool for the deregulated market participants and linking between wholesale and retail market.

Ma et al [28] shows optimal hierarchical allocation in deregulated electricity market under auction mechanism. In hierarchical electricity market, the retailers buy electricity from generation provider and then sell it to users. Retailers play an important role in the distribution channel by matching supply and demand, but they also potentially cause inefficiencies in electricity allocation. To induce an efficient allocation of electricity, we propose a novel hierarchical distributed method under PSP auction mechanism. Under this mechanism, each of players, either the generation provider or the retailers, obtains their electricity allocation through the PSP auction method by submitting a multi-dimensional bid profile, instead of telling their private cost or valuation function, then the retailers economically distribute the electricity, acquired in the PSP auction, among users. Moreover, the valuation function of retailers depends on the revenues that they sell the electricity to users. As a main result, in this paper we show that there exists an efficient Nash equilibrium (NE) for the underlying auction games.

Hammons et al [29] shows the process of transformation in government and operations in the power sector leads to interaction between increasing integrated markets and public agencies in charge of policy making, regulation and control. Then reform being proposed to the electric regulatory framework for wholesale transactions in Peru is reviewed. It represents an effort to solve some problems with the electricity market. The accumulated experience so far has shown many positive aspects, such as greater efficiency of private utilities, the positive effect of eligible consumers as market benchmark, and transparency brought by the regulatory agencies, which provide confidence for investor. The final part of the paper discusses auctions of contracts and energy call options to ensure supply adequacy in the Brazilian power sector reform.

Kling et al [30] shows demand side management is currently becoming more important than ever, in parallel with the further deregulation of the electricity sector, and the increasing integration of renewable energy sources. The scope of this paper is to provide a set of infrastructural, architectural and operational criteria for demand response systems, to support the process of establishing standards and procedures. The purpose of this paper is to define a set of criteria to support the design and integration efforts for the wide development of demand response system.

CHAPTER 3

Demand Side Bidding

3.1. OVERVIEW OF DEMAND SIDE BIDDING

Government has fixed some rules, laws and define some limits so that a particular industry or company follow these rules. Deregulation in power industry is a restructuring of the rules & economic incentives that govt. sets up to control & drive the electric power industry. In a competitive electricity market ,the sellers and buyers submit their bids for energy buy and sell. The bids are generally set up based upon the power quality and quantity. Bidding price is fixed upon that how much power will be sell and buy at what price. Mainly market operator fixed all the things. When buyer and seller bid the amount of energy & the price, the power exchange forms an aggregate supply bid curve for consumers and suppliers.

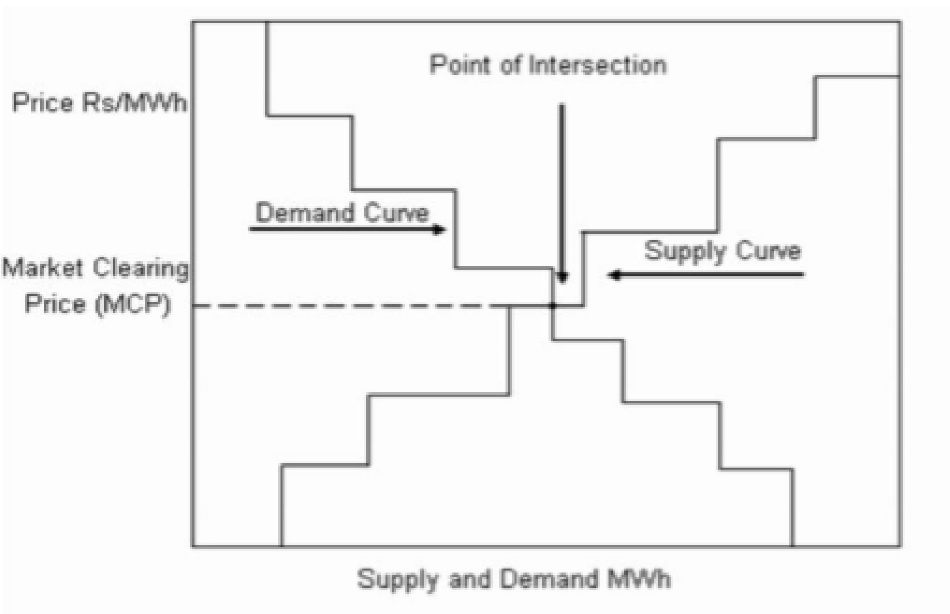

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fig 1

The point of intersection of two curves determines the market clearing price (MCP).These point supply satisfies the demand. MCP is the highest sell bid or lowest sell bid or lowest buy bid accepted in the auction. If the seller bids less than his marginal cost, he would lose money bidding price is set at a fixed price that is MCP. If he bids more than his marginal cost, he may bid more than other sellers & fail to be selected in the auction. If the sellers bid sets the MCP then he would recover his running cost & if the MCP is higher than his marginal cost, then he would earn profit. Buyer itself makes the similar considerations[1].

3.2 Scenario in Deregulation

3.2.1. Deregulation scenario around the World

a. Chile in 1982

b. U.K. in 1990

c. Argentina in1992

d. Sweden in 1992

e. Norway in 1992

f. Bolivia in 1993

g. Colombia in 1993

h. Australia in 1994

i. Newzeland in 1996

j. Panama in 1997

k. Salvador in 1997

l. Guatemala in 1997

m. Nicaragua in 1997

n. Costarica in 1997

o. Honduras in 1997

p. California in 1998

q. U.S.A in 1998

3.2.2. Indian Scenario of Deregulation

Indian power sector was mainly under the government ownership under various states and central government utility till 1991.The remarkable growth of physical infrastructure was facilitated by four main policies. 1) centralized supply and expansion of grid 2)support from government 3) sector wise development 4)subsidy.

In 1990, Orissa began a process of restructuring of the state power sector with the World Bank loan by consisting of prolonged strategy i.e. unbundling the integrated utility in three separate sectors of generation, transmission, distribution. There after several other states such as Andhra Pradesh, Haryana, Uttar Pradesh, Rajasthan also take similar steps. The conceptual framework underlying this new legislation is that the electricity sector must be opened for competition under electricity Act 2003.The Act also seeks to update, rationalize laws related to generation, transmission, distribution, trading and use of power. It focuses on creating competition in the industry, protecting consumer interest, rationalizing tariff etc. .It focuses on the following points:[1].

a. Protecting consumer interest.
b. Rationalizing tariff.
c. Lowering the subsidy.
d. Ensuring supply of electricity of all areas.

3.3 Market Structure

All the competitive markets are classified into three categories. These are

a. Poolco. b. Bilateral trading. c. Power exchange

There is only one buyer in this system. POOLCO is a Govt. or Quasi Govt. agency that buys for everyone taking, from all sellers to meet up total needs by taking the lowest cost bidding.

Bilateral is a multi-seller multi buyer system. Here individual buyer & seller makes idea to exchange power at a price privately.

Power exchange which operates much like a stock exchange. The buyer and the seller enter their needs into power exchange. After mutual understanding price of electric energy is determined and that is called market clearing price which is to be paid by the customer at best and it varies time to time as per situation demand.

Many power exchange permits trading of power for only day ahead and an hour ahead Trading for example in California power transaction is made through bilateral exchange. In western power exchange, power transaction is made on a real time basis that is hourly basis or daily basis[1]-[5].

3.3.1 Market Model

There are mainly two models of deregulation presently preferred in the various countries all over the world. The POOLCO model adopted primarily in U.K. and ISO model adopted in California in U.S.

Pool Model:

There is only a single buyer for all the energy generated by GENCO’s. The U.K. POOLCO is responsible for inviting bids for energy and decided the energy price for a particular periods in the future market like day ahead market. Here the buyer is POOLCO, responsible for real time operation and system also. The traditional unit commitment and economic dispatch the actual cost of the energy generated is being considered in deregulated environment. POOLCO being the system operator and auctioneer takes care of network congestion .As POOLCO is the only buyer so POOLCO is must have for all GENCO’s and single sided auction exp: U.K .

Open access model:

The energy auction and future markets are conducted by an independent entity called power exchange (PX) and the system is operated by another independent agency called independent system operator (ISO) who assures equal opportunities to all sellers and buyers through open access. Exp: California of U.S.

3.3.2 ISO:

The first and the most common one is the pool structure in which the ISO is responsible for both market structure and settlement including scheduling and dispatch, and transmission system management including transmission pricing, and security aspects. Here, ISO is also known as Poolco operator.

The other structure is that of open access, one dominated by bilateral contracts. In this system, bulk of energy transactions are directly organized between the generator and the customer, the ISO has no role in generation scheduling or dispatch and is only responsible for system operation. The role of ISO is minimal and limited to maintenance of system security and reliability functions.

3.3.3 Ancillary Service

Ancillary service are defined as all those activities on the interconnected grid that are necessary to support the transmission of power while maintaining the reliable operation and ensuring the required degree of quality and safety. Two important factors in evaluating ancillary services markets are the market clearing price and the size of the markets. The volume of capacity procured in a market is one indicator of how robust it will be to these new entrants. When analysed together, the market volume and the price paid for a service in that market indicate how much money is at stake.[7] This analysis focuses on the two most valuable ancillary services: Regulation and spinning reserves. So, the following ancillary services are:

1. Back up supply.

2. System control.

3. Dynamic scheduling.

4. Energy balance properly.

5. Reserve spinning.

3.4 Different Entities

The introduction of deregulation has been brought out several new entities in the electricity market. Various exist across market structure over how is entity is particularly defined and plays role in the system.

The various entities are:

I. GENCO. (Generating Company) II. TRANSCO. (Transmission Company) III. DISCO.(Distribution Company) IV. RESCO. (Retail Energy Service Company) V. ISO. (Independent System Operator) VI. CUSTOMER. VII. ANCILLARY SERVICE COMPANY.

Genco: It is an owner operator of one or more generators that runs them and bids the power into the competitive market place. Genco sells energy only.

Transco: It moves power in bulk quantities from where it is produced to where it is delivered .Transco owns and maintains the transmission facilities.

Disco: It is the monopoly franchise owner operator of the local power delivery system, which delivers power to individual business and home owners.

Resco: It is the retailer of electric power. It buys power from gencos and sells it directly to the consumers.

ISO: It is an independent authority and does not participate in the electricity market trades. It usually does not own generating resources, except for some reserve capacity in certain cases. It provides system security and reliability.

Customer: Customer only consuming electricity. In deregulated market customer has several options for buying electricity through bidding procedure.

Ancillary Service Company: It support the transmission of power while maintaining reliable operation and ensuring the required degree of quality and safety.

1) **Reactive Power & Voltage Control:** Reactive power injection and absorption has to be controlled with in a specified limit to maintain a voltage profile constant. For these purpose capacitor bank or FACTs devices are used.

2) **Power System Reliability**: If there is a imbalance, the speed of system will increase or decrease for these system frequency will deviate and at that moment generating units will disconnect from the supply. Therefore frequency control is fundamental thing.

3) **Back Up Supply :** Back Up supply is needed for fulfilling the load demand in the continuous manner. Suddenly when Generating units are collapsed the Back Up supply plays the main role.

4) **Dynamic Scheduling:** It is a priority scheduling algorithm in which the priorities are calculated during the execution of the system. [1&6].

In deregulated environment competition exists in generating market and retail power market where transmission and distribution remains the monopoly franchise. In demand side bidding customer communicates to the retailer, retailer contacts to the generating company for purchasing the power and makes it transfer to its customers place via regulated transmissions and distribution lines. The ISO is responsible for keeping transactions taking place among the various entities

3.5 Benefit of Demand Side Bidding (DSB)

DSB is all about involving the Demand-Side (the actual consumers of electricity) in the processes of setting prices and maintaining the quality of supply. This is done through encouraging and rewarding the Demand-Side for flexibility in its use of electricity (both when and how much.

DSB has several important implications in terms of the overall efficiency of electricity supply, both from an economic and an environmental point of view. In the short term, avoiding the need to call upon expensive, reserve generators reduces overall market costs. In the long term, reducing both the size of networks and the number of generators required may result in lower costs. Almost always, reserve generators will be less efficient, and produce higher CO_2 emissions, than base load unit.

There is also an added energy penalty in starting them up and holding them in a state of readiness. DSB can thus be regarded as a means of optimizing overall system energy efficiency, by reducing the need for such plant. In Demand side bidding scheduling is also necessary. It also based on priority basis. So many consumers are available with their requirement but we have to choose the consumer priority basis. Technology also related with that means some times requirement is very high then retail energy company can fulfil their demand but transmission line power capacity fails to transmit the power to the consumer. We also have to concentrate on technological advancement area that’s why we can easily fulfil consumer requirement also.[1&10].

Chapter-4

Optimization Technique & Soft Computing

Perfect solution to the corresponding objective function are called optimization. Optimized parameters are required designing purpose either minimize or maximize the function. There are two types of objective function. Where in the problem we deals with the one objective then it is called one objective function & where we deals with multi objective function then it is called multi objective function . In the real life problems are associated with multi objective function. We have to deals with so many parameters & constraints simultaneously to minimize or maximize the objectives.

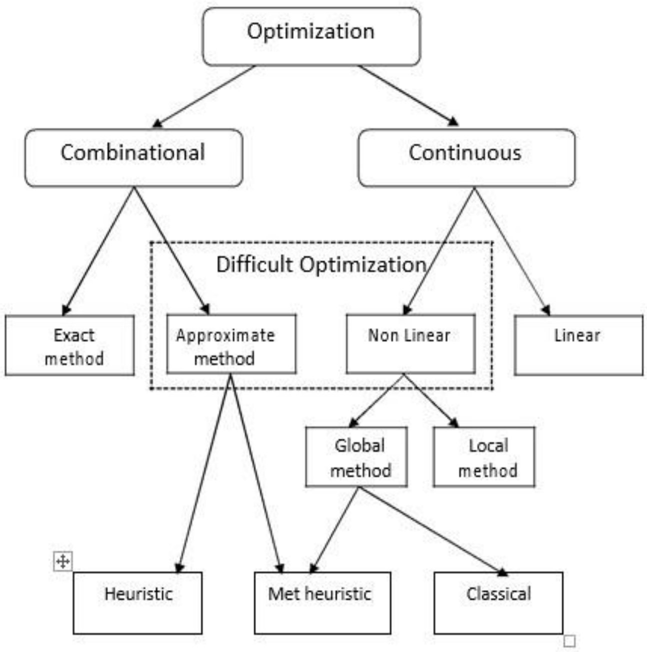


fig 2

4.2. Different types of optimization Techniques

Optimization algorithms are basically two types :

(1) Deterministic : In computer science, a deterministic algorithm is an algorithm which, given a particular input, will always produce the same output, with the underlying machine always passing through the same sequence of states.

(2) Probabilistic : A randomized algorithm is an algorithm that employs a degree of randomness as part of its logic. The algorithm typically uses uniformly random bits as an auxiliary input to guide its behaviour, in the hope of achieving good performance in the "average case" over all possible choices of random bits.

4.2.1. Classical optimization Technique

Classical optimization techniques are useful for getting up optimum solution of maximum or minimum different table functions. Classical optimization techniques are developed from the most of the numerical techniques. There methods have limited scope in practical application.

There are 3 main types of problems can be handled by classical optimization technique.

(i) Single variable function.

(ii) Multi variable function with no constraints.

(iii) Multi variable function with both equality & inequality constraints.

For equality constraints → Lagrange multiplier method can be used.

For inequality constraints → Kuhn – Tucker conditions can be used.

The other methods of optimization can be included

(1) Linear programming.
(2) Integer programming.
(3) Quadratic programming.
(4) Non Liner programming.
(5) Dynamic programming.

4.2.2. Heuristic Optimization Technique

There technique will hopefully find good answer. It is a part of an optimization

Algorithm by which solution should be tested & how the next individual can be produce. It is used to solve large, nonlinear, non-convex thing. Heuristics are not guaranteed to find the true global optimal solutions.

These methods are covered by two cases:

- **(i)** Construction methods : It will first find a feasible solution & then improve it.
- **(ii)** Improvement methods : It starts with a feasible solution & just tries to improve it.

4.2.3.Meta heuristic Optimization Techniques

It is a high level procedure of find, generate, or select a heuristic method that may provide a good solution for optimization problem, especially with incomplete or imperfect information or limited computation capacity. Met heuristics sample a set of solution which is to large to be completely sampled. Met heuristics may make few assumptions about the optimization problem being solved & so it may be usable for a variety of problems.

Compared to optimization of algorithms & iterative methods, met heuristics do not guarantee that a globally optimal solution can be found on some class of problems. So, that solution found on the set of random variables which are generated so far.

Meta heuristics can be roughly categorized into three part;

(1). Iterative method, (2). Population method, (3). Constructive method. Solution that may have locally optimal but not globally optimal. The properties or feature of optimization method basically included in two parameters & they are speed & precision. Speed & precision are conflicting objective, at least in terms of probabilistic algorithms. A general rule of thumb is that you can gain improvement in accuracy of optimization only by investing more time. Scientist in the area of global optimization try to investing new approaches &enhancing optimization cases

(1) Online optimization, (2) offline optimization.

Online Optimization:

Online optimization problems need to be solved quickly in a time span between ten millisecond to a few minutes.

Offline Optimization:

In offline, optimization problems takes some times. Knowing that an user may wait long time if he get an optimal or close to optimal result correctly [35].

4.3. Overview of soft computing Technique:

In general, collection of computing tools & techniques, shared by closely related disciplines that include fuzzy logic, genetic algorithms & some aspects of machine learning like inductive logic programming. Soft computing is the fusion of methodologies that were deigned to model & enable solution to real world problems, which are not modelled or too difficult to model, mathematically. These problems are typically associated with fuzzy, complex and dynamical system with uncertain parameters. These systems are the ones that model the real world & are of most of 8interest to the modern science. These tools are used independently as well as jointly depending on the type of the domain of application. Potential application of soft computing technology for power systems are in the following areas load forecasting, fault diagnosis & power system operational planning. The application of soft computing have proved two main advantages.

Firstly, it makes solving nonlinear problems in which mathematical models are not available.

Secondly, it introduces the knowledge such as cogitation, recognition, understanding, learning & others into the field of computation. Soft computing differs from conventional computing.

Hard computing requires a precisely stated analytically model & often requires a lot of computation time. Also in hard computing may analytical models which are valid for ideal cases & may not suggest any particular solution. But most of the real world problems exist in a non-ideal environment. There are some unique properties of soft computing which makes it a perfect choice for solution non-linear real world problems. Some properties are as follows:

(1).Learning from experimental data.

(2).Generalization is usually done in a high dimensional space.

(3).Soft computing is likely to play an especially important role in science & engineering, soft computing is still growing & developing. Some main components & techniques of soft computing are discussed in the following paras.

4.4.1. Genetic Algorithm:

Genetic algorithm is a soft computing technique. It was invented by John Holland in the year 1960 & it was developed later by Goldberg. Basic G A has four principle components: chromosome, fitness function, cross over operator & mutation operator. The candidate solution are represented by chromosomes. New candidate solution are produced from parent chromosomes by the cross over operation. The parent chromosome can be selected by the roulette wheel technique.

The mutation operator will then be applied to the population & at this point a generation or iteration is completed. The new chromosome in a population are rated by their fitness measured according to fitness function. When chromosome with the fitness is formed it will be taken as the optimum solution& the optimization process is terminated. Otherwise the process is repeated until the maximum no of generation is reached and the fitness chromosome so far formed is for optimum solution.

The advantage of GA with which it can be handle arbitrary kind of constraints or objective function, all such things can be used as weighted components to the fitness function of a very wide range of possible over all objectives.[35]

4.4.2 PSO

In 1995, Kennedy and Eberhard first introduce the PSO method motivated by social behaviour of organism such as fish schooling & bird flocking. It is also a population based search technique. PSO can be easily implemented &convenience rate is very fast than other optimization techniques. In the PSO, first of all we randomly initialize the particles position according to problem constraints. The set of all particles positions is called initial population or initial swarm. After that we generate random velocities for each particle. According to the objective function, objective value is evaluated. In the initial condition, position corresponds to optimum value is called personal best or “pbest” (pb) as well as global best (gb) or “gbest” . Update the particles’ velocities and positions according to personal influence and social influence [8].

4.4.3 Differential Evolution:

Differential evolution is a population based optimizing tool which was introduced by storm and price in 1995 .It can be used to minimize nonlinear functions with real valued parameters. It likes a genetic algorithm using the similar operators; crossover, mutation, and selection.

The main difference in constructing better solutions is that genetic algorithms based on crossover while DE based on mutation operation.it has three advantages:

1. Finding the true global minimum regardless of the initial parameter values.

2. Fast convergence.

3. Few control parameters.

The convergence speed of DE is significantly better than genetic algorithms.DE algorithms has promising approach for engineering optimization problems.[35]

Chapter 5

5.1 Overview of basic PSO:

PSO is an iterative search technique in which particle moves around the wide area of search space according to objective function. Movement of each particle is based on its own experience as well as other experiences.

This theory can be understood by the concept of techniques used by birds or fishes for searching the food in wide area. Group of birds or fishes are randomly searching for food in a wide area. Only one piece of food in the area being searched. All the birds & fishes do not know the exact location where the food is. In that condition to the own experience as well as neighbor's experience. So, after the one iteration they compare the distance between its own location & the target with respect to its previous experience as well as the best position of neighbor's which is closest to the target. After that they modify its own speed for the basic strategy to find the food. This is the basic principle of particle swarm optimization (PSO) algorithm. In technical term each bird or fish is called particle & its flock is called "particle population." All the particles have own fitness or objective value which is calculated by the objective function (OF). For the optimization of OF particle positions are updated by velocity vector which depends on its personal influence as well as social influence.[31]-[34].
In the PSO, first of all we randomly initialize the particles position according to problem constraints. The set of all particles positions is called initial population or initial swarm. After that we generate random velocities for each particle. According to the objective function, objective value is evaluated. In the initial condition, position corresponds to optimum value is called personal best or "pbest" (pb) as well as global best (gb) or "gbest" (only for initial condition). Update the particles' velocities and positions according to personal influence and social influence. In the mathematical form, velocity is updated according to the following expression:

$$r_i^{t+1} = \underbrace{r_i^t}_{\textit{Inertia}} + \underbrace{c_1 U_1^t \left(pb_i^t - x_i^t\right)}_{\textit{Personal Influence}} + \underbrace{c_2 U_2^t \left(gb^t - x_i^t\right)}_{\textit{Social Influence}}$$

And position is updated according to following expression:

$$x_i^{t+1} = x_i^t + r_i^{t+1}$$

Where, c_1 is called ***cognitive parameter*** and c_2 is called ***social parameter***. Both are called ***acceleration coefficients.***

U_1^t & U_2^t are two ***random numbers*** varies between 0 to 1.

In the next iteration, updated velocity & positions are used as the present velocity & position. Now these particle corresponding to optimum value is called new "g-best" & position of particle corresponds to optimum value that was evaluated by itself is called new "p-best". And these above processes are repeated until stopping criteria is satisfied. [32]-[34].

5.1.1. Basic Algorithm

1. Start.
2. Create a population of agents (called Particle) uniformly distributed over search space (x).
3. Evaluate each particle's position according to the objective function.
4. If a particle's current position is better than its previous best position, update it.
5. Determine the best particle (according to the particles previous best positions).
6. Update particles velocities according to

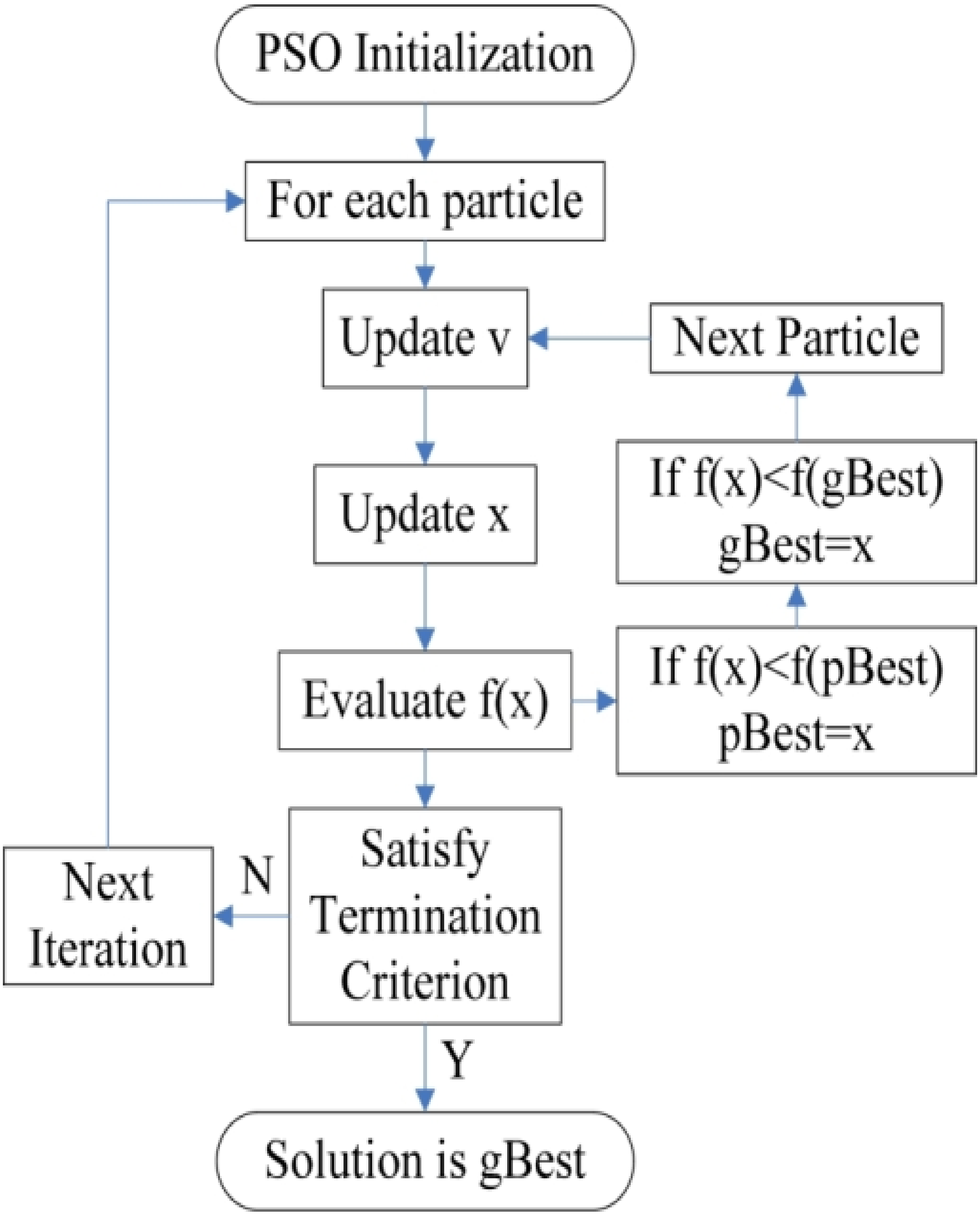
$$r_i^{t+1} = r_i^t + c_1 U_1 (pb_i^t - x_i^t) + c_2 U_2 (gb^t - x_i^t)$$

7. Move particles to their new positions according to

$$x_i^{t+1} = x_i^t + r_i^{t+1}$$

8. Go to step 2 until stopping criteria is satisfied.
9. Stop.

5.1.2 Flow Chart :



Chapter 6

Problem Formulation & Constraints.

6.1. Introduction

As discussed earlier optimal bidding strategy in an open electricity market is avery important task.For maximization of profit of supplier and consumer has to be maintained.In this regard , so many optimisation tools have been proposed. so ,in these case standard IEEE 14 bus, 30 bus ,57 bus network system are used.But in this problem IEEE 30 bus system is used.

6.1.2 IEEE-30 BUS NETWORK SYSTEM.

Mainly standard IEEE 30 bus system is used for test case for evaluating various analytical methods and for many programs of power system. Power flow analysis is the backbone of power system analysis and design. They are necessary for planning, operation, economic scheduling and exchange of power between utilities. The principal information of power flow analysis is to find the magnitude and phase angle of voltage at each bus and the real and reactive power flowing in each transmission lines. In this standard IEEE 30 bus network five PVbus and remaining four are voltage control bus.Bus no 1 is slack bus and rest of the buses are i.e. twenty four buses are load bus or PQ bus. Bus no 2 a generator of 40 MW is connected and synchronous condenser are connected with remaining four buses.Here in my thesis i also use IEEE 30 bus loss coefficient i.e. beta value.The single line diagram and all system data are given in .

6.2. OPERATING CONSTRAINTS

This section presents the operating constraints used here. We have to satify these constraints to solve the problem. Constraints are as shown below.

6.2.1 POWER & LOAD LIMIT CONSTRAINTS

In these bidding problem firstly we have to generate power with in a specified limit i.e. a minimun and maximum boundary condition.Minimum limit is called Pmin and maximum limit is called Pmax. Same thing is used for load also.Load has a minimum limit and a maximum limit. Minimum limit is called Lmin and maximum limit is called Lmax.

$$P_{min},i \leq Pi \leq P_{max},i \qquad i=1,2,......m \qquad ..(6.1)$$

$$L_{min},j \leq Lj \leq L_{max},j \qquad j=1,2.......n \qquad ..6.2)$$

6.2.2 Load flow contraints

Here ai,bi,cj,dj are non negative and bidding coefficient. ai & bi bidding coefficient of ith supplier and cj&dj bidding coefficient of jth large consumer.R is the market clearing price and Q(R) is the aggregate pool forecast by power exchange[8].

$$ai + bi.Pi = R \quad i = 1,2,.....m \qquad ..(6.3)$$

$$cj - dj.Lj = R \quad J =1,2,......n \qquad ..(6.4)$$

$$\sum_{i=1}^{m} Pi = Q(R) + \sum_{j=1}^{n} Lj \qquad ..(6.5)$$

6.3. OBJECTIVE FUNCTION

Main objective of this thesis is to maximize the benefit of suplier & consumer while maintain the aoll constraints.

$$\text{maximize } F\ (a_{i,}b_i)=RP_i-C_i\ (P_i) \qquad ..(6.6)$$

$$\text{maximize } B\ (c_{j,}d_j)=B_J\ (L_J)-RL_J \qquad ..(6.7)$$

$$\text{here} \quad C_i(P_i)=e_iP_i + f_ip_i^2 \qquad ..(6.8)$$

e_i & fi are cost function co-efficient.

$$B_{j\ (}L_{j)}=g_j\ L_j - h_j\ L_j^2 \qquad ..(6.9)$$

g_j & h_j are demand function co-efficient

6.4. Problem Formulation

Here the system has "m" no. of generators & "n" no of large consumers who participating in demand side bidding & the generators are interconnected network controlled by an ISO. Here power exchange (PX) plays a vital role. They determine generation or demand & dispatch on schedule power flow with the objective of maximizing profit.[8]

$a_i + bi.\ Pi = R \qquad i=1,2,\ldots\ldots m$

$cj - dj.\ Lj = R \qquad j=1,2\ldots\ldots n$

$$\sum_{i=1}^{m} Pi = Q\ R + \sum_{j=1}^{n} Lj$$

$$Q(R) = Q0 - K.R \qquad ..(6.10)$$

$$R= \frac{Q0+\sum_{i=1}^{m}\frac{ai}{bi}+\sum_{j=1}^{n}\frac{cj}{dj}}{K+\sum_{i=1}^{m}\frac{1}{bi}+\sum_{j=1}^{n}\frac{1}{dj}} \qquad ..(6.11)$$

$$P_i= \frac{R-ai}{bi} \qquad i= 1,2\ldots\ldots m \qquad ..(6.12)$$

$$L_j= \frac{cj-R}{bj} \qquad j=1,2,\ldots\ldots n \qquad ..(6.13)$$

Maximize $F(ai,bi) =RPi-Ci(Pi)$

Maximize $B(cj,dj)=Bj(Lj)-R\ Lj$

6.5 Application of PSO in this problem

PSO is an optimization tool. Here in this problem PSO is used to optimized the profit.

1. Start.
2. **Initializing of variables.**

   population size, no of particles, pmin, pmax,lmin, lmax, e_i, f_i ,g_j, h_j.

3. **Initializing swarm & velocities**

   par (:,1:6)=(ones(popsize,1)*pmin)+rand (popsize,6).*(ones(popsize,1)*(pmax-pmin));

   par (:,7:8)=(ones(popsize,1)*Lmin)+ rand(popsize,2).*(ones(popsize,1)*(Lmax-Lmin));

   vel= rand (popsize,npar);

   Here max size & min size represent power limit, popsize indicate population size, load limit & initialize the random velocities of all particles.
4. Evaluation of initial population

   calculate the (R) is market clearing price that"s why we get theobjective function.
5. Finding best particle in initial population.

   Then we get global max. (initially global max = local max)
6. Start iteration iter = 1
7. Updating particles velocity & position.
8. Checking validating of particles.
9. Evaluation of particles cost.
10. Updating pbest & gbest.
11. Increment iteration counter iter=iter+1
12. Checking convergence condition.
13. Printing the result & graphs.
14. Stop.

CHAPTER 7

RESULTS & DISCUSSION

Now a days so many optimization technique are available. Here PSO technique is used for demand side bidding. The PSO algorithm has been implemented in Matlab 13.Result has been calculated for different variation of PSO control parameter.Programme for all possible cases run so many times and generate several data. Among them best result is considered.

7.1.1 Case Study 1

A. Input Data

Table No:1

Generator and Large Consumer Data

Generator	e (dollar/MWhr)	f (dollar/MWhr^2)	Pmin(MW)	Demand
1	6.0	0.01125	40	160
2	5.25	0.0525	30	130
3	3.0	0.1375	20	90
4	9.75	0.02532	20	120
5	9.0	0.075	20	100
6	9.0	0.075	20	100
Large Consumer	g(dollar/MWhr)	h(dollar/MWhr^2)	Lmin(MW)	Lmax(MW)
1	30	0.04	0	200
2	25	0.03	0	150

Here ei and fi are the cost coefficient of supplier and gj and hj are the demand parameter. Here Pmin and Pmax are the limit of the generation and Lmin and Lmax are the limit of the load side [8] .

B. Output Data

Bidding Coefficient: Here bi and di are the bidding coefficient.From my programme I get the value of bi and di.These values are 0.0270,0.1260,0.3300,0.0608,0.1800,0.1800,0.0960, 0.0720.

Scheduled Generation & Load: Here Pi and Lj are the scheduled power and load .each generator and load has a specified limit which are given in the Table 1. I generate all generation and load data .These are 159.31, 90.73,52.14,104.61,47.05,53.63,159.43,130.63.

Market Clearing Price: Here market clearing price is that price where supplier and purchaser both are agreed to buy and sell the power. In my thesis market clearing price is 16.51

Total Profit : Here Total profit means summation of all generator's profit. I get 4844.6 rupees totally.

C. Data Validation

Table 2

Bidding Strategies of Generators and Consumers

	PSO
Generator	**bi**
1	**0.062**
2	**0.079**
3	**0.243**
4	**0.046**
5	**0.124**
6	**0.124**
Large Consumer	**dj**
7	**0.072**
8	**0.051**

Table 3

Bid Price ($/MWh) and Profit ($) of Generators and consumers

	PSO	
Generator	**P (MW)**	**Profit**
1	**156.00**	**1320.3**
2	**104.38**	**574.1**
3	**47.271**	**316.2**
4	**119.38**	**416.1**
5	**48.76**	**178.4**
6	**48.76**	**178.4**
Large consumer	**L (MW)**	**Profit**
7	**168.97**	**1146**
8	**140.92**	**611.8**
MCP	**16.47**	
Total Profit	**4741.3**	

[8]

Table 4

Bidding Strategies of Generators and Consumers

	PSO
Generator	**bi**
1	**0.0270**
2	**0.1260**
3	**0.3300**
4	**0.0608**
5	**0.1800**
6	**0.1800**
Large Consumer	**dj**
7	**0.0960**
8	**0.0720**

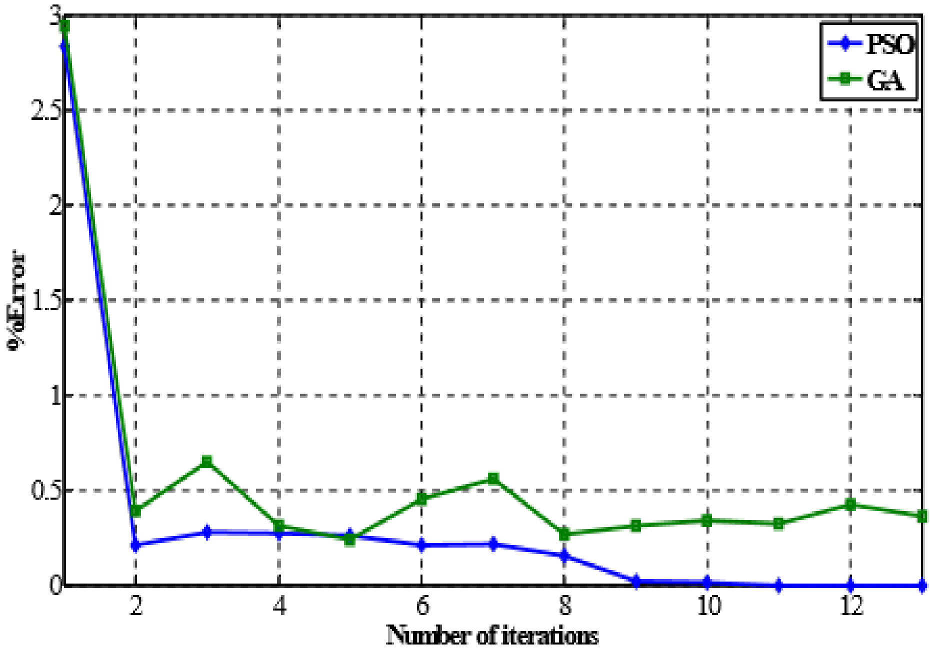
Table 5

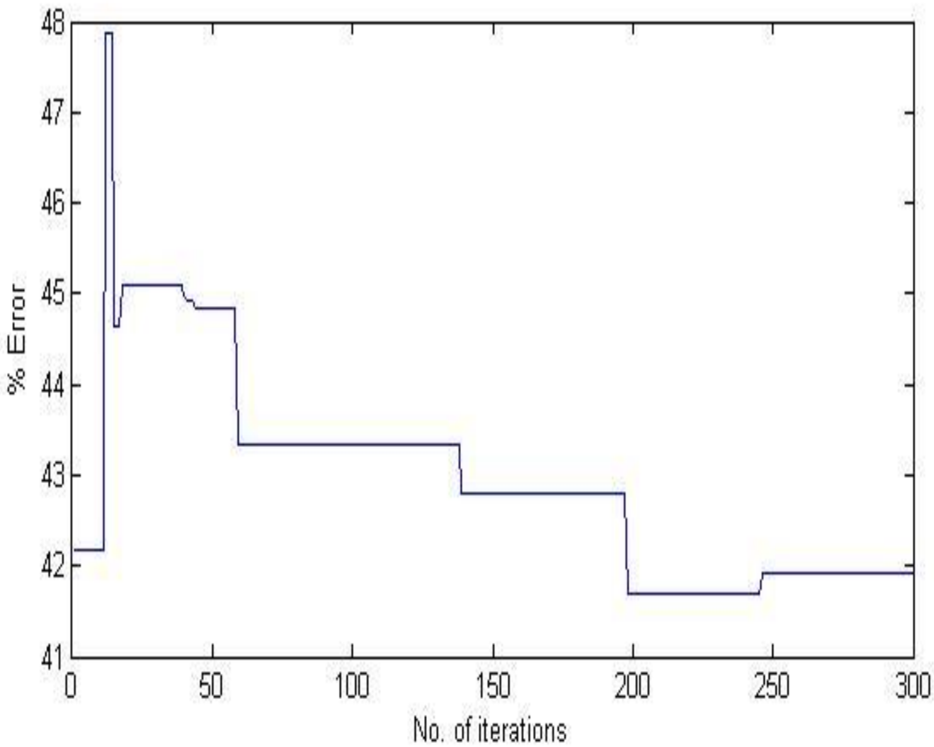
Bid Price ($/MWh) and Profit ($) of Generators and consumers

	PSO	
Generator	**P (MW)**	**Profit**
1	**159.31**	**1388.9**
2	**90.73**	**589.5**
3	**52.14**	**330.6**
4	**104.61**	**430.1**
5	**47.05**	**187.3**
6	**53.63**	**187.1**
Large consumer	**L (MW)**	**Profit**
7	**159.43**	**1133.9**
8	**130.63**	**597.1**
MCP	**16.51**	
Total Profit	**4844.6**	

Table 4 & Table 5 is my output data. I get bi ,dj ,P,L,MCP and total profit using 6.11,6.12,6.13 equations which are given in chapter 6 elaborately and Table 2 & Table 3 are from the reference paper [8].My output data are almost nearest to the reference paper. For doing these PSO optimizating tool is used.

D.Graph


PSO
GA
%Error
Number of iterations
3
2.5
2
1.5
1
0.5
0
2
4
6
8
10
12


% Error
No. of iterations
48
47
46
45
44
43
42
41
0
50
100
150
200
250
300

E. Discussion

Here bi and dj are the bidding coefficient, by this coefficient bidding strategy will be decided. Supply side bidding coefficient is bi and consumer side bidding coefficient is dj. In my thesis I also get six supply side and two consumer side bidding coefficient that has an nearest value to the reference paper. In these paper market clearing price is also evaluated. Market clearing price means at what price the power will sell or buy. This value is given in my validation table which is also nearest to the reference paper. Total profit is also tabulated in my thesis.

7.1.2 Case Study 2 (IEEE 30 BUS DATA)

A. Input Data:

Table 6:

Generator and Large Consumer Data

Generator	e (dollar/MWhr)	f (dollar/MWhr^{2})	Pmin(MW)	Pmax(MW)
1	2.00	.00375	50	200
2	1.75	.01750	20	80
3	1.00	.06250	15	50
4	3.25	.00834	10	35
5	3.00	.02500	10	30
6	3.00	.02500	12	40
Large Consumer	g (dollar/MWhr)	h (dollar/MWhr)	Lmin(MW)	Lmax(MW)
1	30	0.04	0	200
2	25	0.03	0	150

B. Output Data

Table 7:

Bidding Strategies of Generators and Consumers

	PSO
Generator	**bi**
1	**.0090**
2	**.0420**
3	**.1500**
4	**.0200**
5	**.0600**
6	**.0600**
Large Consumer	**dj**
7	**.0960**
8	**.0720**

Bid Price ($/MWh) and Profit ($) of Generators and consumers

	PSO	
Generator	**P (MW)**	**Profit**
1	**195.89**	**1539.9**
2	**76.52**	**520.1**
3	**39.97**	**302.5**
4	**33.04**	**181.0**
5	**26.32**	**134.0**
6	**38.63**	**161.0**
Large consumer	**L (MW)**	**Profit**
7	**96.46**	**972.1**
8	**94.25**	**575.7**
MCP	**16.06**	
Total Profit	**4386.30**	

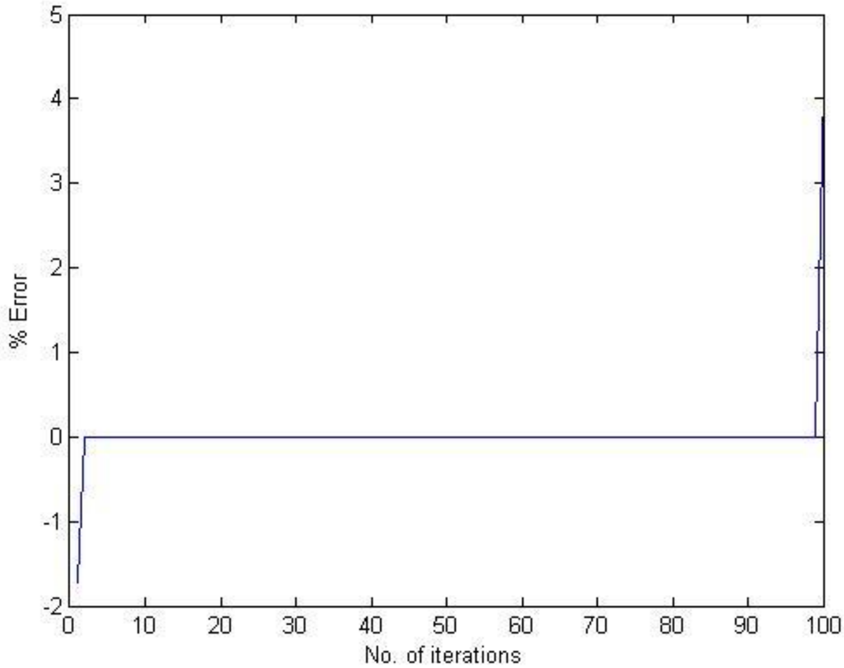
Bidding Coefficient: Here bi and di are the bidding coefficient.From my programme I get the value of bi and di.These values are 0.0090, .0420,.1500,.0200,.0600,.0600,.0960,.0720.

Scheduled Generation & Load: Here Pi and Lj are the scheduled power and load .each generator and load has a specified limit which are given in the Table 1. I generate all generation and load data .These are 195.89,76.52,39.97,33.04,26.32,38.63,96.46,94.25.

Market Clearing Price: Here market clearing price is that price where supplier and purchaser both are agreed to buy and sell the power. In my thesis market clearing price is 16.06

Total Profit : Here Total profit means summation of all generator's profit. I get 4386.30 rupees totally.

C.Graph:



This is the programme generated graph.Here we plot error vs no of iteration.

D.Discussion

Here bi and dj are the bidding coefficient, by this coefficient bidding strategy will be decided. Supply side bidding coefficient is bi and consumer side bidding coefficient is dj .Here IEEE 30 bus loss data also considered.

When iteration reaches hundered then error is minimum also.From all these this it is clear if bidding coefficient and cost is less then scheduled generation is also less.

CHAPTER 8

CONCLUSION & FUTURE WORK

8.1 Conclusion

Demand side bidding is the main thing now a days. By these concept power trading has much more developed. Profit has been given both supplier and consumer that's why all people are interested to participate in this game.

8.2 Future Scope

I try to develop my concept and thinking in realistic way but time is a boundary limit. So in future I will try to develop my programme for IEEE 120 bus data and more and more conditions included in my programme.

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APPENDIX

1. Standard IEEE-30 Bus Data

The System data is taken from reference [1], [79], [80]. The one line diagram of an IEEE- 30 bus system is shown in figure B-2. The line data, bus data and load flow results are given in Tables B-5 and B-6 respectively. The generator cost and emission coefficients, transformers tap setting, shunt capacitor data are provided in Table B-7, B-8, and B-9 respectively. The data is on I00 MVA base.

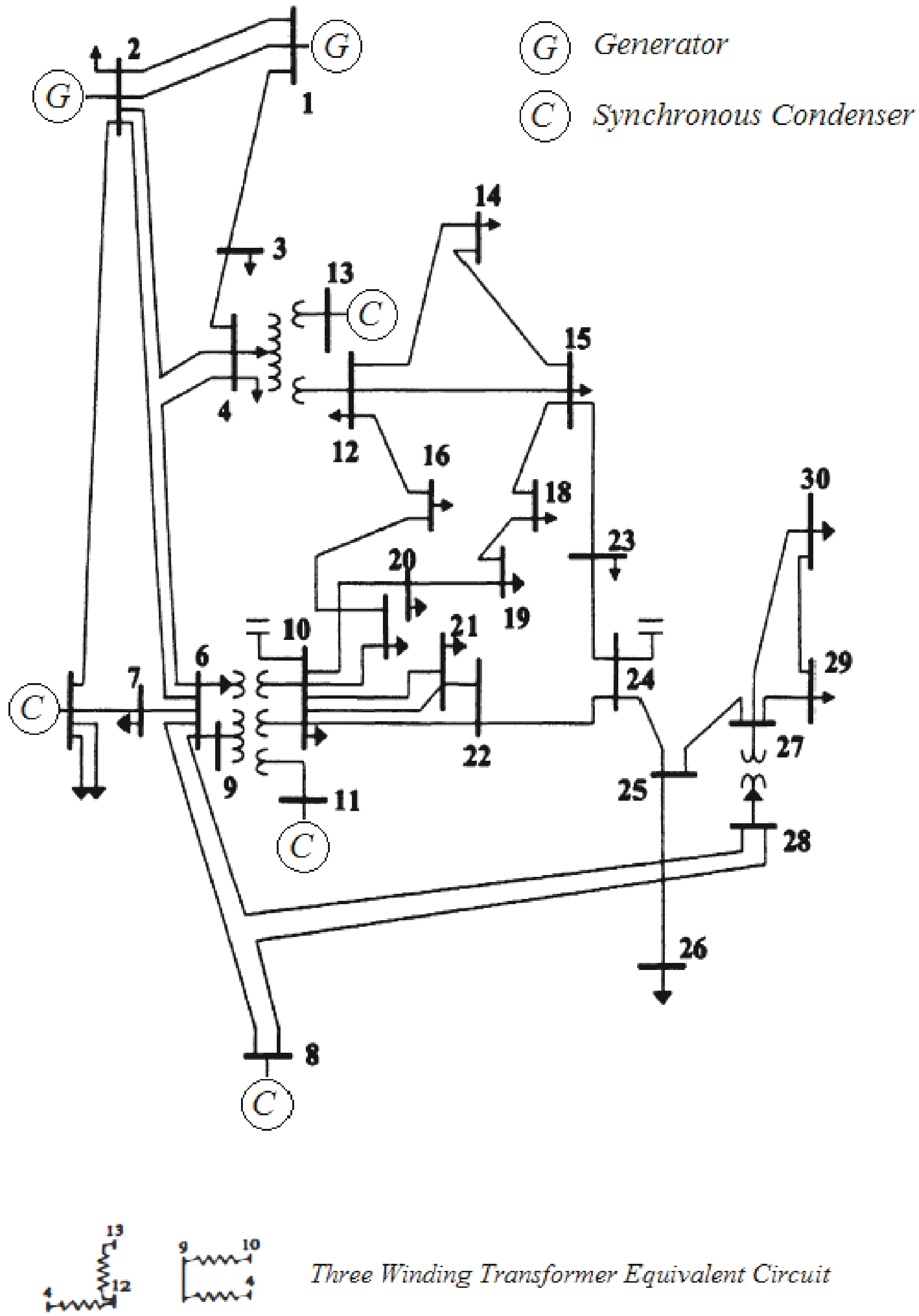

Figure -2 One Line Diagram of IEEE-30 Bus System

Table B-5 Line Data of IEEE-30 Bus System

Line No.	From Bus	To Bus	Line Impedance		Half Line Charging Susceptance	MVA Rating
			Resistance (p.u.)	Reactance (p.u.)		
1	1	2	0.0192	0.0575	0.0264	130
2	1	3	0.0452	0.1652	0.0204	130
3	2	4	0.570	0.1737	0.0184	65
4	3	4	0.0132	0.0379	0.0042	130
5	2	5	0.0472	0.1983	0.0209	130
6	2	6	0.0581	0.1763	0.0187	65
7	4	6	0.0119	0.0414	0.0045	90
8	5	7	0.0460	0.1160	0.0102	70
9	6	7	0.0267	0.0820	0.0085	130
10	6	8	0.0120	0.0420	0.0045	32
11	6	9	0	0.2080	0.0045	65
12	6	10	0	0.5560	0	32
13	9	11	0	0.2080	0	65
14	9	10	0	0.1100	0	65
15	4	12	0	0.2560	0	65
16	12	13	0	0.1400	0	65
17	12	14	0.1231	0.2559	0	32
18	12	15	0.0662	0.1304	0	32
19	12	16	0.0945	0.1987	0	16
20	14	15	0.2210	0.1997	0	16
21	16	17	0.0524	0.1923	0	16
22	15	18	0.1073	0.2185	0	16
23	18	19	0.0639	0.1292	0	16
24	19	20	0.0340	0.0680	0	16
25	10	20	0.0936	0.2090	0	32
26	10	17	0.0324	0.0845	0	32
27	10	21	0.0348	0.0749	0	32
28	10	22	0.0348	0.0749	0	32
29	21	22	0.0116	0.0236	0	32

30	15	23	0.1000	0.2020	0	16
31	22	24	0.1150	0.1790	0	16
32	23	24	0.1320	0.2700	0	16
33	24	25	0.1885	0.3292	0	16
34	25	26	0.2544	0.3800	0	16
35	25	27	0.1093	0.2087	0	16
36	28	27	0	0.3960	0	65
37	27	29	0.2198	0.4153	0	16
38	27	30	0.3202	0.6027	0	16
39	29	30	0.2399	0.4533	0	26
40	8	28	0.0636	0.2000	0.0214	32
41	6	28	0.0169	0.0599	0.0065	32

Table B-6 Bus Data & Load Flow Results of IEEE-30 Bus System

Bus No.	**Bus Voltage**		**Generation**		**Load**		**Reactive Power Limits**	
	Magnitude (p.u.)	**Phase Angle**	**Real Power**	**Reactive Power**	**Real power**	**Reactive Power**	**Q_{min} (p.u.)**	**Q_{max} (p.u.)**
1	1.06	0.000	1.3848	-0.0279	0.000	0.000	-	-
2	1.045	0.000	0.400	0.500	0.217	0.127	-0.2	0.6
3	1.000	0.000	0.000	0.000	0.024	0.012	-	-
4	1.060	0.000	0.000	0.000	0.076	0.016	-	-
5	1.010	0.000	0.000	0.370	0.942	0.190	-0.13	0.625
6	1.000	0.000	0.000	0.000	0.000	0.000	-	-
7	1.000	0.000	0.000	0.000	0.228	0.109	-	-
8	1.010	0.000	0.000	0.373	0.300	0.300	-0.15	0.50
9	1.000	0.000	0.000	0.000	0.000	0.000	-	-
10	1.000	0.000	0.000	0.000	0.058	0.020	-	-
11	1.082	0.000	0.000	0.162	0.000	0.000	-0.10	0.40
12	1.000	0.000	0.000	0.000	0.112	0.075	-	-
13	1.071	0.000	0.000	0.106	0.000	0.000	-0.15	0.45
14	1.000	0.000	0.000	0.000	0.062	0.016	-	-

15	1.000	0.000	0.000	0.000	0.082	0.025	-	-
16	1.000	0.000	0.000	0.000	0.035	0.018	-	-
17	1.000	0.000	0.000	0.000	0.032	0.009	-	-
18	1.000	0.000	0.000	0.000	0.032	0.009	-	-
19	1.000	0.000	0.000	0.000	0.095	0.034	-	-
20	1.000	0.000	0.000	0.000	0.022	0.007	-	-
21	1.000	0.000	0.000	0.000	0.175	0.112	-	-
22	1.000	0.000	0.000	0.000	0.000	0.000	-	-
23	1.000	0.000	0.000	0.000	0.032	0.016	-	-
24	1.000	0.000	0.000	0.000	0.087	0.067	-	-
25	1.000	0.000	0.000	0.000	0.000	0.000	-	-
26	1.000	0.000	0.000	0.000	0.035	0.023	-	-
27	1.000	0.000	0.000	0.000	0.000	0.000	-	-
28	1.000	0.000	0.000	0.000	0.000	0.000	-	-
29	1.000	0.000	0.000	0.000	0.024	0.009	-	-
30	1.000	0.000	0.000	0.000	0.106	0.019	-	-

Table B-7 Generator Cost and Emission Coefficients

Unit	**P_i^{min} (MW)**	**P_i^{max} (MW)**	**a_i (S/MWh^2)**	**b_i (S/MWh^2)**	**c_i**	**α_i (Kg/MWh^2)**	**β_i (Kg/MWh^2)**	**γ_i**
1	50	200	0.00375	2.00	0	0.0126	-1.1000	22.983
2	20	80	0.01750	1.75	0	0.0200	-0.1000	22.313
5	15	50	0.06250	1.00	0	0.0270	-0.1000	25.505
8	10	35	0.00834	3.25	0	0.0291	-0.0400	24.700
11	10	30	0.02500	3.00	0	0.0290	-0.0400	24.700
13	12	40	0.02500	3.00	0	0.0271	-0.0055	25.300

Table B-8 Transformer Tap Setting Data

From Bus	To Bus	Tap Setting Value (p.u.)
6	9	0.978
6	10	0.969
4	12	0.932
28	27	0.968

Table B-9 Shunt Capacitor Data

Bus No.	Susceptance (p.u.)
10	0.19
24	0.043