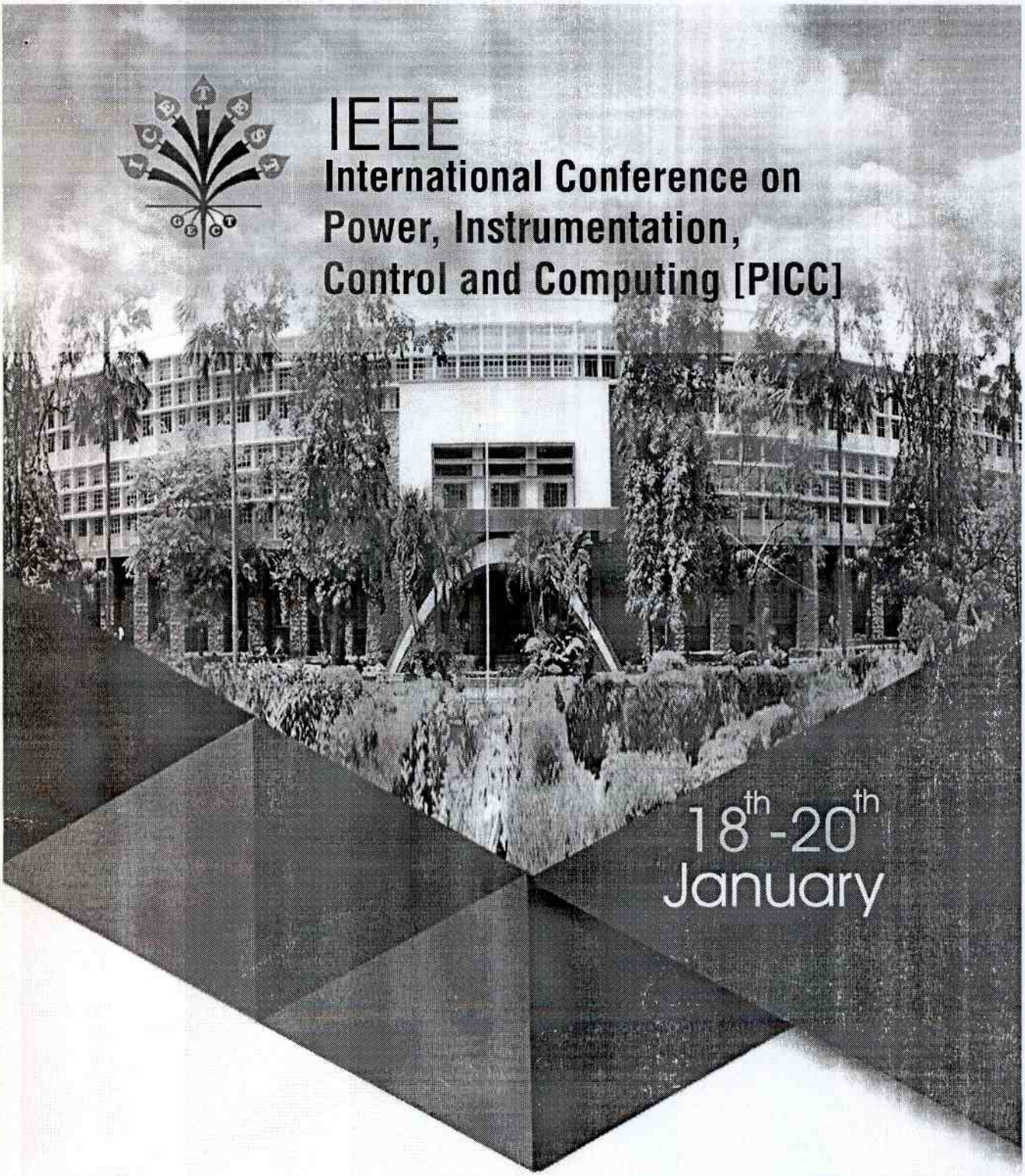

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An Intelligent Energy Bidding Strategy based on Opposition Theory Enabled Grey Wolf Optimizer

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***Abstract*—In an effort to increase competition, many countries around the world have changed their economies from monopoly to oligopoly. Restructuring of energy sector is considered as a key initiative to obtain consumer benefits and social welfare. A power generating company has opportunity to maximize their profit in electricity market through selling the energy in competitive prices under incomplete information of other competing generators. In a day-ahead energy market, generating company (GENCO) sell the energy at optimal bid prices. In this paper the problem of finding market clearing price (MCP), load dispatch (LD) and bid cost under three different capacity and price blocks is carried out by oppositional theory enabled grey wolf Optimizer (OGWO) algorithm . Normal probability distribution function is used to model the rival behaviors. The bidding strategy of a generator for each trading period in a day-ahead market is formulated as a stochastic optimization and the same is solved through Monte Carlo method. The OGWO encompasses opposition concept with the grey wolf optimizer (GWO) algorithm to accelerate the convergence rate. The approach is tested over a dynamically changing electricity market. The results are compared with other techniques namely PSO and GWO. The OGWO shows competitive results.**

***Index Terms*—Bidding strategies, Electricity market, Normal probability distribution, Market clearing price, Grey wolf optimization, Particle swarm optimization.**

NOMENCLATURE

P	Capacity of the block
MUT_m	Minimum uptime of generator of m^{th} block
MDT_m	Minimum downtime of generator of m^{th} block
$\lambda_m^{on}(t)$	Time for m^{th} block of generator has been continuously 'ON' at the end of hour(h)
$\lambda_m^{off}(t)$	Time for m^{th} block of generator has been continuously 'OFF' at the end of hour(h)
N	Total No. of Rivals
T_{off}	Unit off hours at the event of start up
C_h	Cost at the hot startup
C_c	Cost at the cold startup
T_c	Constant for Cooling time
$C_m(t)$	Operating cost for m^{th} block of generator G
C_m^u	Nonlinear exponential startup cost function
C_m^d	Constant shut down cost
β_m^N	Bid Price for m^{th} block for N^{th} Rival
$C_m^p(t)$	Non differentiable , non-convex production cost function
$\overline{P_m}$	Maximum limit of generator output of m^{th} block
$\underline{P_m}$	Minimum limit of generator output of m^{th} block
$\gamma_m(t)$	Binary Flag
K_0, K_1, K_2	Cost Coefficients
K_3 & K_4	Valve Point loading effect constants

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I. INTRODUCTION

Electricity is an essential commodity in day to day life. For the economic growth of any country, proper utilization of power and management of power supply are the key parameters. In an emerging electricity market, bidding of electric power is considered as a potential research area due to lack of information of participants behavior and dynamically changing system demand. Restructuring enables participation of GENCOs and consumers in electricity markets. The aim of restructuring is to provide a wide range of choice of power to consumer at affordable prices. In this dynamic environment, risk is always associated with each trading transaction. To overcome the risk, each GENCO work on mechanism which includes the information of risk management and financial methods to deal with volatile market price. Bidding strategies are framed with the aim to maximize the profit, hence can be considered as an optimization problem. The key parameters which affect hugely to the bidding decisions are 1. Generation cost 2. Variation in system load 3. Operating and regulatory constraints. Out of all these, the rival behavior modeling is critical and considered as the crucial issue. For development of bidding strategy, GENCO requires precise information of future electricity prices and deep information of rival behavior.

While solving this constrained optimization and expecting maximum profit is an outcome, construction of appropriate bids is a fulcrum of the process. To frame the strategy in terms of offering bid cost and power packets in a spot market so that maximum dispatch shall be allocated which results in the maximum profit is known as strategic bidding. A comprehensive review of optimal bidding strategies has been