ABSTRACT

The need for sustainable economic growth has necessiated to enhance the power generation capacity and optimization of capacity utilization through judicious combination of centralized fossil fuel power plants and decentralized renewable energy based power plants. The renewable energy contribution has been increasing rapidly; particularly wind energy penetration is much higher than other renewable energy sources, world-wide. Statistical report of Global Wind Energy Council (GWEC) says that China is having the highest installed capacity of wind energy followed by USA, Germany, Spain and India. Hence, the optimal operation and planning of power generation systems are ranked high among the major tasks in the electric power sector. Deregulation and restructuring of electricity supply industry is one of the important global energy developments of the last century. Deregulation involves not only unbundling the responsibilities of vertically integrated power industries, but also the separation of ownership and its operation.

This thesis presents thermal and wind power profit based unit commitment using evolutionary computational algorithms. The main objective of this work is to develop a comprehensive model for profit based unit commitment problem that should yield feasible unit ON/OFF status, such as to maximize the profit of thermal and wind power generation companies, while satisfying the ‘system’ and ‘generator’ constraints including spinning reserve, minimum up/down time, ramp rate limits of thermal units and wind
power fluctuation constraints. Unit Commitment (UC) is a complex optimization problem of determining the instant of time to start up and shut down the generating units to minimize the operating cost over a specified time period, when subject to the possible constraints.

New market mechanisms have developed due to liberalization of electricity sector and changed the economics of power generation. In deregulated power systems, the UC problem has different objective than traditional system. Previously, electric utilities had an obligation to serve their customers that all demand and spinning reserve must be completely met. But this is not mandatory in restructured system and the Generation companies (Gencos) to run their UC schedule that produces lesser than the predicted load demand and reserve to maximize their own profit. This problem is referred as Profit Based Unit Commitment (PBUC) problem. The forecasted load demand and market prices are important inputs to determine the PBUC schedule for achieving maximum profit. Hence, the PBUC problem is much more complex and difficult to solve than traditional Unit Commitment Problem (UCP). Moreover, the rise in wind energy installed capacity leads to a wide range of challenges for the optimal operation of deregulated power systems. One of the major challenges associated with the PBUC problem is that the way it includes large amount of wind power generation. Hence, the Wind-Thermal Profit Based Unit Commitment (WTPBUC) problem is considered an important issue in deregulated environment.

Many methods have been employed to solve the complicated PBUC problem. More specifically, these are Dynamic Programming (DP) method, Lagrange Relaxation (LR) method, Genetic Algorithm (GA), Evolutionary
Programming (EP), Particle Swarm Optimization (PSO), Artificial Immune System (AIS) and hybrid algorithms. In this research work, the optimization algorithms such as conventional LR, GA, AIS and hybrid approach (AIS-GA) have been implemented to solve the thermal and wind-thermal PBUC problem. AIS approach is one of the optimization algorithms that imitates the natural immune system. One of the theoretical immunology principles termed as clonal selection theory has been applied for solving the PBUC problem. Clonal selection principle is the complete process of antigen recognition, cell proliferation and differentiation into memory cells. It maintains a population of candidate solutions called antibodies. The cloning of antibodies is performed followed by somatic hyper-mutation and receptor editing process to explore the search space of Gencos PBUC problem.

This dissertation proposes

- Clonal selection based AIS algorithm to determine the optimal PBUC schedule of generating units in deregulated power system. In this method, the objective function is viewed as an antigen and the feasible solutions as antibodies. The antibody that most fits the antigen is considered as the optimal solution to the Gencos PBUC problem. This algorithm overcomes the limitations of existing methods such as dimensionality problem and difficulty in obtaining feasible unit status.

- Hybrid method of AIS-GA approach is also implemented in this work, such that the standard search engine of Genetic Algorithm makes a quick decision to direct the search towards the global optimum. The hybrid method is more efficient than
single methods due to better convergence performance and lesser computational time.

In order to evaluate the performance of the algorithms, this research work considered three case studies:

Case study-1: Thermal power Genco with 10 generating units of total capacity 1662 MW,

Case study-2: Thermal power Genco with 3 generating units of total capacity 1200 MW and

Case study-3: Thermal and Wind power Genco with 10 Thermal + 2 Wind generating units of total capacity 1782 MW.

The M-file program was developed for the proposed algorithms and implemented for the three case studies using MATLAB 7.10 version. The simulation results of thermal and wind power PBUC problem obtained by the proposed methods are analyzed and compared. The test results have shown that the AIS based approach has good global searching performance. It is an efficient algorithm to solve the Thermal PBUC and Wind-Thermal PBUC problems in restructured electricity markets. Moreover, it increases the contribution of non-utility wind farms for reducing the cost of thermal units while maintaining an adequate level of supply reliability.