ABSTRACT

Economics, quality and efficiency are fundamental considerations in any enterprise planning, where investment of money and providing service comes into play. Electric power utility industry is highly capital intensive and is a service provider. The cardinal consideration in power system planning, is supply of low cost, high quality power to the consumers. The investments associated with power projects and transmission network expansions are enormous. The investments thus made have also to be serviced reasonably and competitively. Therefore a very careful investigation of the expansion of the facilities of a power system is required, so that the revenue requirements are minimum. The demand for power has been increasing throughout the last few decades and continues to increase. So it is only natural that a suitable expansion strategy is evolved for a planning horizon of five to thirty years. In such long term planning strategies, it is prudent to divide the planning period into stages, and the decisions regarding the necessary expansion at every stage made. The decisions at one stage is influenced by the decisions already taken and will influence the future decisions.

In power system expansion planning a very significant point to be considered and decided upon is the basis on which alternative expansion policies are to be evaluated. This is because a system requiring less capital investments initially can prove to be more expensive in the long run due to higher recurring
expenditure, by way of operating costs including fuel, maintenance and losses. Therefore an intensive and proper assessment of the various expenditures involved, like capital costs for construction and expansion of the facilities, the operating costs and the costs due to system losses is required. In this work models have been developed for determining the future system expansions of the generation facilities.

A model is developed in the first phase for the single stage or static generation expansion planning to meet the given future demand. The expansions of the facilities are determined by minimizing the total annual revenue requirements, which consists of the annual capital and recurring costs subject to the constraints based on future demand, system security and bounds on power plant expansions. The mathematical formulation of the problem results in a cost minimization problem of the mixed integer linear program type. The problem is solved by Bender's decomposition technique. The algorithm developed for the solution of the problem incorporates skipping and screening rules, which considerably enhances its speed and effectiveness. The algorithm developed is also interactive in nature and hence user friendly.

In the second phase the long-term expansion planning of power systems is formulated as a multistage problem and closely simulates the practice of power utilities. The total planning horizon is divided into stages and decisions regarding the expansion of the network and power plants are determined at every stage. A preference order dynamic programming approach has been developed for the
solution of the problem. The power plant expansions are considered to be discrete valued and selected from a set of available power plant sizes or generator units. The model developed also considers the effect of network losses. Connected with every power plant expansion, a set of partial policies corresponding to possible network configurations in the neighborhood of a minimum cost policy is constructed. Skipping rules have been developed to reduce the number of alternative policies to be evaluated.

The power systems and the power system planning engineer face a number of uncertainties. The uncertainties associated with future demand, generation and transmission line outages etc. have an impact on the planning decisions of the future. The uncertainties have to be properly taken care of in the planning process. Otherwise the resulting design can prove to be unreliable or costly. Therefore in the final phase a model is developed for determining the long-term generation expansion policy in electric utility industry considering the uncertainties in demand forecast and generator outages. The formulation of the problem is based on preference order dynamic programming. In the formulation, the system failure is defined in terms of the total probability for the demand to exceed the installed generation capacity. Utility of the system is calculated by assigning penalty costs for the failure of the system. The decisions at every stage is obtained by minimizing an objective function consisting of expected values of capital and operating costs, the penalty costs associated with the system over-design and failure and the deviation of the cost. The model aims at a trade off
between capital costs and the utility of the system. Skipping rules have been incorporated in the algorithm developed, which considerably reduce the number of alternatives to be evaluated at every stage.

In a nutshell, mathematical models have been developed for the expansion planning of transmission networks and power plants. The models developed and presented are for static and multistage power system planning studies and considered under deterministic and stochastic conditions.