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A practical approach to assessment of the base power contracts and peak power contracts for a distribution utility

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ABSTRACT

Mix of long term and short term contracts are essential in the portfolio optimisation of the distribution utility for meeting the unrestricted demand of the consumers at the minimum cost. Opening up of power market and the increasing open access transactions in India has made it essential to the distribution utilities to have optimum operation strategy for keeping the competitiveness in the industry. Further, the distribution utilities in India are also mandated with universal supply obligation, due to which the meticulous planning in long term has become more significant for their survival itself. Another aspect to be considered is the social impact on the cost optimisation of electricity procurement as the electricity consumption has direct links to the industrialisation and living comfort of the people. The gestation period of conventional generators is more than five years. Transmission line construction also requires a time span of 3 to 4 years from concept to completion. The influx of renewable energy characterised by the short gestation period, poor predictability and high degree of forecast error are also to be considered. Hence the portfolio optimisation problem becomes more of a management decision than a technical solution of constraint based mathematical modelling.

The basic requirement for application in the electricity industry is that the method shall be simple and robust. After considering the several options available the authors have identified modified load profile forecast as the most suitable means for long range forecast of demand. The model relies on the suppression of local peaks when the demand is unitised and then deriving the cardinal points on a linearised load curve from the energy forecast. The method was applied with the actual demand of Kerala and the results are found to be good.

Introduction

The distribution licensee has to meet the entire electricity requirement of all consumers and in addition shall be prepared to meet even the unscheduled requirements of embedded customers who may not be even consumers. In the traditional optimisation attempts, the utilities had little choices as the purchases were all tied up through firm Power Purchase Agreements (PPA) and internal generation available. The increasing penetration of renewable energy sources and merchant plants depending on market operation has changed the scenario. The present situation has thrown out umpteen opportunities for optimisation on power purchase at the same time imposed stiff competition which requires proactive steps.

The economy of operation is possible through optimisation of the purchase portfolio of the distribution companies. The commitment towards fixed costs contributed by firm contracts and the risks associated with the volatility of the short term or over the counter contracts are to be evaluated. To achieve this, the basic requirement is to assess the demand of electricity in advance. In view of the gestation period involved in the operationalisation of the generation, transmission and distribution projects, the forecasts are to be made with different timeframes. The real time operation requires accurate forecasting in short range. The basic issue remains in the quality of forecast. The research world has recognised the need for developing methods for improving the accuracy of forecast. However, the studies are focussed mainly towards the optimisation on real time scheduling and annual planning. Conventionally planners take a cue from the econometric models and extrapolation methods for finding out the requirement for the future years. The scheme was sufficient when the electricity

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industry was functioning in vertically integrated mode enjoying the monopoly in a statutorily controlled environment. The proposal in India to separate carrier and content in distribution sector has put immediate response on the distribution utilities to scale up the accuracy of the long term forecast.

The power purchase policy evolves in any utility as a combination of long term, medium term and short term commitments. This paper deals with a novel procedure to reduce the forecast error with simple to use methods in practical filed conditions, which can be used for medium and long term purposes.

A literature survey is presented in Section 'Literature survey'. It can be seen that the papers which cover the practical requirement are very less. Sections 'Long term demand profile forecast' and 'Long-term vs. short-term' describe the background and the relevance of the variables considered for the study. Sections 'Solution methodology' and 'Assessment of cardinal points in the load curve' describe the problem in detail and explains the solution methodology. In Section 'Verification of accuracy of the new method', comparison of the solution obtained through the method and actual conditions are compared. The conclusions are also arrived at. The numerical example is taken with the data available with the State Load Dispatch Centre, Kalamassery, Kerala.

Literature survey

The optimisation of grid management is mostly on commercial aspects and is a hot topic in research field. Long term forecast of load-generation balance forms the basis of the power procurement policy. This forecast has to factor the uncertainties on supply side as well as demand side. The forecast methods and the various economic load dispatch methods that could be potential candidates for easy and robust implementation in the industrial space were analysed.

Economic load dispatching solution is attempted through an evolutionary algorithm called Cuckoo Search algorithm [1] by Sahoo et al. which considers technical limits of generation, ramp rates power balance, etc. Rongrong et al. investigate the allocation of loads as thermal and hydro and solve the optimal dispatch [2]. These attempts are excellent in terms of optimal dispatch decision, but they do not consider the assessment of requirement. Rather, they present a good method for optimum under known load conditions. Rahi [3] attempts particle swarm optimisation method for the optimisation of hydro power plant design, but does not consider the total requirement and thermal/renewable input that is possible. Naimo et al. [4] attempts economical operation of the grid with injection of wind power. Enhanced hydro power planning formulation in a long term expansion model is presented by Brovold et al. [5]. The method assigns value for water through a marginal cost determination. However, this paper assumes the water values from other sources and tries to optimise the generation from each source. The basic objective of our paper is different, but the inputs from the paper cited 5th is taken for ascertaining the need for the present approach. Vijayamohanan Pillai in his paper [6] gives a brief, but exhaustive list of the methods employed in the forecast studies. This paper is one of the earliest references and is must-reference in related topics. Refs. [7,8] are appropriately discussed in the body of the paper. In paper cited as [9], the authors discuss about an algorithm for solving the short term management of water reservoirs with variable waterfall. Najafi et al. [10] discusses an innovative solution based on modified harmony search algorithm for unit commitment in large power systems. The method can be adopted for optimising the existing resources but does not shed any light on the future requirements and contract requirements. Bensalem et al. [11] compares two different reservoir management strategies in the optimisation of hydro generation. The concept is adopted in the present work in the assessment of internal generation capability. A method for demand management is presented by Benyun et al. in paper [12], which was considered in the determination of load generation balance in futuristic scenario. Kherfane et al. describes meta-heuristic methods with harmony search algorithm in [13], which found application in determining the LGB in futuristic condition and to what extent the variability could be provided. The paper by Bilil et al. [14] was read in conjunction with the probability of firmness of contracts that has to be entered into. Paper cited [15] gives a review of the price forecasting methods over a large horizon, which has prompted us to develop a method by which the requirement can also be projected over a long horizon.

Cruz et al. [16] discusses about the maximisation of profitability of pumped storage and wind generation in tandem. Fichter et al. [17] discusses capacity expansion and unit commitment optimisation with renewable energy input. Marques et al. [18] describes the various technologies that could affect the energy scenario in future with specific emphasis to heat pumps. Sowa et al. [19] modelled power to heat systems as a component of virtual power plant with a high share of renewable energy content. McLean et al. [20] has made an evaluation of the sea water PSS for regulating the power availability in the control area by exporting power to other control area. The storage capacity and transmission system requirement in the event of 100% self-supply is worked out by Bussar et al. [21]. Schuller et al. [22] investigates the individual optimisation approach based on weekly empirical driving profile of electric vehicles in Germany to increase the renewable injection capability. The study details of 100% renewable supply scenario are presented by Pleßmann et al. in [23]. The injection of renewables into the grid is an important matter in deciding the purchase quantum. Hence these papers were reviewed during the literature review. After detailed analysis, it was found that the impact of renewable injection is to be addressed separately in different context and it was found that such assumptions have little effect on the method proposed by us, mainly on commercial angle.

Taylor et al. [27] has proposed the methods of profiling for demand projection by combining weights for prediction upto 48 h. While the method of adopting weights is appropriate for durations upto say, 7 days, on longer horizon, the prediction of weightage itself is a challenge. Mohamed and Bodger [28] have described the different forecasts over several periods in the context of New Zealand with different methods. Hsu and Chen [29] propose use of Grey theory for load forecast and verified with Taiwan power system. Xu and Nagasaka [30] discuss the application of ANN tools for forecasts. Vaccaro and Villaci [31] discuss the decision support systems for optimising the energy sources to meet the demand. The issues covered are with reference to market operation and bidding portfolio. Xu et al. [32] discusses a surrogate optimisation framework enabling decomposition and coordination approach for portfolio optimisation with risk management in power market.

From the above survey, it was observed that there is a need for developing a robust, easy to use and yet accurate method for load forecasting in long term. Further, this was a requirement in the industry also. The method developed here is out of the industrial requirement and was put into successful application in practical situations.

Long term demand profile forecast

Several methods have been developed for long-term forecast [6]. In India, the national power survey reports [7] by the Central Electricity Authority of India forms the basis of investment decisions and action plans.