International Journal of Engineering, Management, Humanities and Social Sciences Paradigms (IJEMHS)
(Volume 24, Issue 01)
Publishing Month: October 2016
An Indexed and Referred Journal with Impact Factor: 2.75
ISSN: 2347-601X
www.ijemhs.com

A Review on Spinning Reserves Optimization

Monia[1], Er. Sweety Sharma[2] and Dr. Dalvinder Kaur Mangal[3]

[1]Research Scholar, IIET, Kinana, Jind, Haryana (India)

[2]Assistant Professor, IIET, Kinana, Jind, Haryana (India)

[3]Professor, Department of EE, BMIET, Sonepat, Haryana (India)

Publishing Date: October 06, 2016

Abstract

Today the consumers require more reliable system for the supply of electricity. This increases competition among the electrical utilities providing electrical energy. Thus to maintain the quality of the electricity supply market more services are required. The main purpose of these services is to maintain the quality level and security of the power supply industry. Now to control the frequency of the system it is required that a certain amount of active power is to be kept in reserve which can be used in re-establishment of the balance between the demand and the generation at all times. A general definition of reserve is given as the amount of generation capacity that can be used to produce active power over a given period of time. This generation capacity is not committed to produce energy for normal time periods.

Keywords: *Spinning Reserve, Reserve Capacity, Operating Cost.*

1. Introduction

Different views which are given by different authors about spinning reserve capacity in power system are discussed here. British Electricity International: “the additional output which is part-loaded generating plant is able to supply and sustain within 5 minutes. This category also includes pumped-storage plant operating in the pumping mode, whose demand can be disconnected within 5 minutes”.

Hirst and Kirby: “generators online, synchronized to the grid that can increase output immediately in response to a major outage and can reach full capacity within 10 minutes”. NERC: “Unloaded generation that is synchronized and ready to serve additional demand”. UCTE: tertiary reserve available within 15 minutes “that is provided chiefly by storage stations, pumped-storage stations, gas turbines and by thermal power stations operating at less than full output”; Wood and Wollenberg: the total synchronized capacity, minus the losses and the load. Zhu, Jordan and Ihara: “the unloaded section of synchronized that is able to respond immediately to serve load, and is fully available within ten minutes”.

2. Literature Survey

A literature survey is done on the spinning reserves to find the problems and the work done so far. There are several approaches for the spinning reserves optimization. Anstine and Burke [9] were the first to consider the probabilistic nature of the outages in the calculation of the spinning reserve provision. They proposed a technique that takes into account the forced outage probabilities of the generating units. Then, they establish the level of risk probability that should be maintained throughout the scheduling horizon. The spinning reserve requirement is adjusted at each scheduling period to maintain a uniform level of reliability. The effect of such factors as changes in load level, changes in short-time load forecasting error probabilities and changes in the size of units scheduled to operate are taken into account.

The procedure described has been adopted by the Pennsylvania New Jersey Maryland interconnection. Combining the reliability calculation with the unit commitment, paper [10] brings forward a novel model on scheduling of the spinning reserve. In this research, system operators are supposed to buy predetermined reserve capacity.

The spinning reserve capacity should be scheduled in the power market circumstance, according to benefits and cost analysis. It is clear that more expensive the spinning reserve capacity, the less spinning reserve capacity should be purchased and bigger the interrupted energy assessment rate then more spinning reserve capacity should be purchased. In this paper the author discussed that the deregulated market structure makes explicit the implicit softness that has always been recognized in the reserve constraints, additional spinning reserves may have value even when a minimum reserve requirement has been met. Also the scheduling coordinators who match suppliers and demands may either self-provide spinning reserves, or depend on Independent System Operator to provide spinning reserves at the spot price. The method proposed in this paper is embedded in the Lagrangian relaxation approach. In this section, a two-firm model is used to interpret this approach. In the Price-based adaptive spinning reserve requirement the independent system operator has ultimate responsibility for meeting the reserve requirements based on predetermined operating guidelines. The coordinators can fulfillment all of the required spinning reserve requirement or the system operator can provide the reserve on the spot price. But the main problem that a coordinator faces is to estimate the requirement of reserve. In this paper [11], the author propose a scheme for obtaining an optimal level of spinning reserves requirement, on the assumption that additional reserves have value in at least some hours. The flexible spinning reserves requirement avoids uneconomic solutions in which expensive units are unnecessarily committed. It also suggested that this approach can used for both reducing the cost and improved performance. Here the scheduling coordinators have the option of self-providing spinning reserves and will find their most appropriate reserve levels. Thus, the proper spinning reserve capacity varies with its cost and the benefit. We call this varied spinning reserve capacity flexible reserve. A novel model of flexible reserve and relative algorithm is discussed in the paper. In this paper spinning reserve is allocated by using a quadratic programming.

Here the author said that quadratic programming offers a good technique for power system dispatch problem. To locate the reserve requirements he used a technique quadratic approximation programming. Here the system reliability and security will determine the post outage interval after which the spinning reserve power from the generating units must be provided. Here he also mentioned that in maximum spinning reserve problems it is necessary to determine the pattern of generation which meets the demand, satisfies all the constraints and posses the maximum level of spinning reserve. Here the line outage constraints are also included in this problem. The spinning reserve requirements were set between those of the minimum cost and the maximum spinning reserve solutions. As expected, the cost of running the system increases as the spinning reserve requirement is pushed up. This post-outage time interval and the maximum loading rate of a generating unit will fix its ceiling of spinning reserve. Only a limited fraction of the apparent capacity of a thermal unit will be available at the end of the specified post-outage interval. The dispatch algorithm using quadratic approximation programming requires a couple of extra iterations to arrive at the solution compared to the simple quadratic programming optimization of cost or spinning reserve. The reason is that quadratic approximation programming by nature a more approximate technique than quadratic programming as it involves an estimate of the shadow price of the spinning reserve requirement.

3. Problem Identification

On the basis of the fixed reserve criteria, the operating cost can be minimized by dividing the requirement of spinning reserve among the various generating units to get the minimum operating cost. Here the operating cost is minimized, but the social benefit is not maximized because the amount of spinning reserve so provided will not account the likelihood of contingencies and their extent. It also neglects the value that the consumers attach to the continuity of power supply. Instead of following the fixed reserve criteria for the system security of the system, suggest that a cost/benefit analysis could be performed. In this analysis the spinning reserve cost is estimated directly from the actual payments to the various generators. Here the question arises is that how much spinning reserve should be provided? The sum of the operating cost and cost of outages exhibits a minimum, and this will define the optimal amount of spinning reserve to be scheduled. The optimal spinning reserve reduces the total cost at its minimum.

4. Pricing of the Reserve Capacity

Reserve cost depends on the payment mode. There are two kinds of payment modes: the uniform-price mode and the pay-as-bid (PAB) mode. Generators are paid by uniform market-clearing prices in the uniform-price mode and paid by bid prices in the PAB mode. They suggest that adopting Auction Pricing for electricity markets may be preferable to the current practice of using a Uniform Price Auction.

Pay-as-bid is unlikely to result in any immediate decrease in wholesale prices for generation through eliminating supplier margins or reducing opportunities to strategically withhold. The prospect that pay-as-bid auctions might offer immediate relief to consumers facing rising electricity prices is in fact illusory. Price increases are largely a consequence of market forces well beyond the control of those charged with regulating electricity markets.

The margins that suppliers earn between their marginal generation costs and the market-clearing prices provides a means for plant owners to recover plant fixed and capital costs, and provides them with an incentive to improve plant performance. Although pay-as-bid auctions are frequently promoted as a way to reduce consumers' overall expenditures for wholesale power, we conclude that switching to a pay-as-bid approach would likely produce just the opposite result.

This counter-intuitive outcome stems from the propensity for strategic bidding behavior, as well as the resulting inefficiencies in plant dispatch and capacity investment. A change in auction design would do little to address other pressing market concerns, including ensuring adequate transmission and generation resources and increasing the role of demand response, and could even exacerbate these investment challenges in light of the on-going concern that continued changing of market rules creates regulatory uncertainty and fears of regulator opportunism that may discourage investment in new generation facilities.

5. Present Work

The principle of clearing spinning reserve capacity under the pay as bid mode can be illustrated by Fig. 1. First, we sort the spinning reserve capacity provided by suppliers into a merit order based on the ascending order of their price as shown below

$$P_{R1} < P_{R2} < P_{R3} < \cdots$$

The costs of keeping spinning reserve must be compared with the benefits that it provides in terms of lower expected costs of interruptions. In essence, the optimal spinning reserve level can be set so that the marginal cost of carrying an additional MW equals the marginal reduction of the expected load curtailment costs.

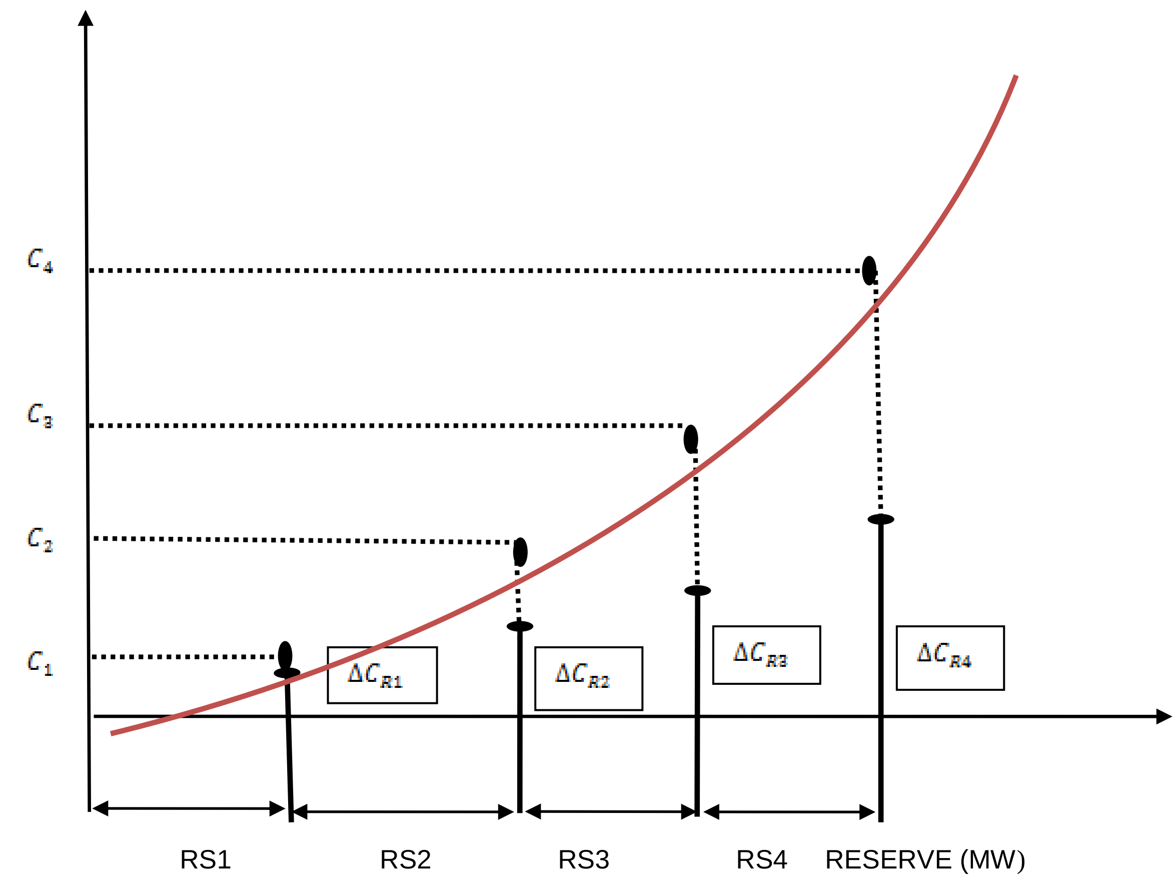

Figure 1: Operating Cost Curve of Spinning Reserve

From equation (4.6), the cost of spinning reserve in the pay as bid mode can be represented by:

$\Delta C_{Ri} = P_{Ri} * R_i$

Thus we can establish the operating cost curve C(R) as shown in the Figure 1. $R_{si}(i = 1,2,3, \dots)$ and $C_i(i = 1,2,3, \dots)$ shown in the Figure 1 are the cumulative spinning reserve capacity and the cumulative cost after purchasing R_i.

6. Conclusion

The spinning reserve can be differentiated on basis of the reserve services which respond to different types of events over different time periods and so the term spinning reserve is defined in different ways which lead to some confusion about the reserve definition. To overcome this confusion we study the different definitions given by different authors.

References

[1] UCTE, "UCTE Operation Handbook", V 2.5E, 20th of July 2004.
[2] British Electricity International, “Modern power station practice: incorporating modern power system practice”, Pergamon, 1991.

[3] E. Hirst and B. Kirby, Unbundling Generation and Transmission Services for Competitive Electricity Markets: Ancillary Services, NRRI-98-05, National Regulatory Research Institute, Columbus, OH, Jan. 1998;
[4] NERC, "Operating manual", 15th of June 2004.
[5] UCTE,http://www.ucte.org/statistics/terms_power_balance/e_default_explanation.asp.
[6] A. J. Wood and F. Wollenberg, "Power Generation, Operation and Control," Wiley, 1996.
[7] J. Zhu, G. Jordan, and S. Ihara, "The market for spinning reserve and its impacts on energy prices", proceedings of the IEEE Power Engineering Society, Winter Meeting, 2000.
[8] Y. Rebours and D. Kirschen, "A Survey of Definitions and Specifications of Reserve Services", Release 1, the University of Manchester, the September 2005.
[9] L. T. Anstine, R. E. Burke, J. E. Casey, R. Holgate, R. S. John, and H. G. Stewart, "Application of probability methods to the determination of spinning reserve requirements for the Pennsylvania-New Jersey-Maryland interconnection," IEEE Transactions on Power Apparatus and Systems, Vol. PAS-82, No.68, pp. 720–735, Oct. 1963.
[10] C. L. Tseng et al., "Price-based adaptive spinning reserve requirements in power system scheduling," International Journal of Electrical Power and Energy Systems, Vol. 21, pp. 137–145, 1999.
[11] Billinton and karki, "Capacity reserve assessment using system well being analysis," IEEE Transactions on Power Systems, Vol.14, pp. 433-438, 1999.
[12] D. Chattopadhyay, and R. Baldick, "Unit Commitment with probabilistic reserve" Proceedings IEEE power Engineering Society, Winter Meeting, pp. 280-285, 2002
[13] CAISO(2005) Spinning Reserve Requirements, In the California ISO, 2005 Available from: http://www.caiso.com