

# Reliability Analysis of Hydro-Thermal Scheduling using Artificial Neural Network Approaches

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## ABSTRACT

The size of the power system is growing exponentially due to heavy demand of power in all the sectors viz. agricultural, industrial, residential and commercial ones. As such the chance of failure of individual units leading to practical or complete collapse of power supply is common to be encountered. Also a most successful power system is one which works with minimum interruptions. The reliability of power system is therefore most important feature to be maintained above some acceptable threshold value. Further the maintenance of individual units can also be planned and implemented once the level of reliability for given instant of time is known. The proposed Research, therefore, aims at determining the threshold reliability of hydro-thermal generation system. The hydro generation system consists of reservoir, water dam, surge tank, penstock, blade angle in turbine, shaft coupling, excitation system, generating winding, circuit breaker and relay. The thermal generation system consists of boiler, water, blade angle in turbine, shaft coupling, excitation system, generator winding, circuit breaker and relay. It is therefore the reliability of generation system shall be affected even when any one of the component's reliability is at stake. The objective of proposed research is to determine the mathematical model of reliability of individual components and equivalent reliability of entire Hydro-Thermal generation system.

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## INTRODUCTION

The Generation System is basically the heart of any power system. The collapse of generation system leads to the biggest collapse, the recovery of which is not only time consuming but tougher than any other system such as Transmission system and Distribution system. The failure of Generation System leads to prolonged interruption period besides being uneconomical. Thus the reliable operation of Generation System needs a thorough care and periodic servicing of its constituent parts such as boiler, turbine, generator and circuit breaker. Our industries, agriculture and software companies require consistent and uninterrupted power supply for topping the needs of continuous customer demand.

It therefore drew the attention of researcher to determine the condition when reliability of generation system would be at stake. Further due to complexity of generation system, the determination of its reliability is filled with risk of skipping of some important factors which are responsible for loss of reliability. Thus, it needed a trusted and full proof model to deal with the reliability of Generation System.

### Proposed Problem

It is aimed to assess the reliability of consider a Generation System consisting of :

- (a) Mechanical Unit which again consists of boiler and turbine.
- (b) Electrical Unit which again consists of Generator and Circuit Breaker as shown in Fig.1.
- (c) Obtain Mathematical model of equivalent reliability, Req of Mechanical and Electrical Units.
- (d) Obtain validation of reliability assessment made by mathematical model by way of ANN model.

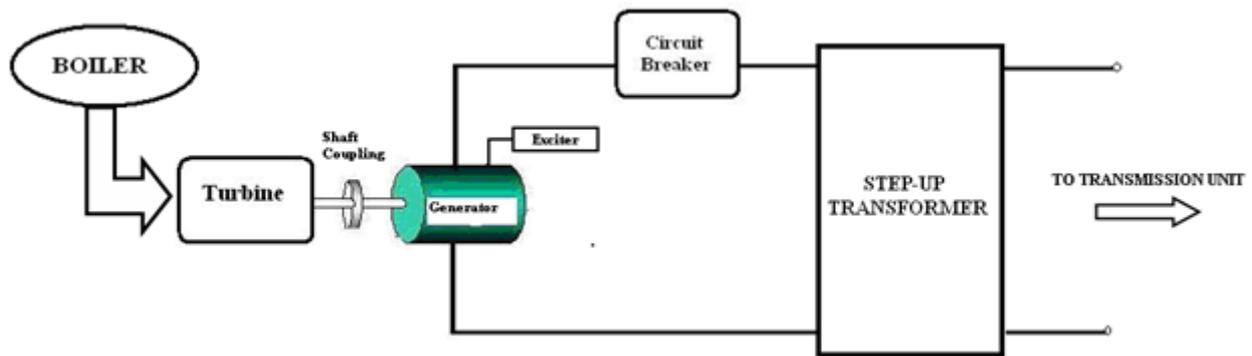


Fig.1: Proposed Generation System Model

### Real Out Come

Both Mathematical Model and ANN model for assessment of reliability of Generation System have been developed. The outcomes of one model supported the outcomes of another model. Illustration gave a satisfactory support and thus it could be possible to assess the reliability of generation system by both the approaches. The outcome of threshold value of reliability of generation system is an appreciable out come of the work. The results of reliability of constituent parts of generation system has been plotted against time. Also, the threshold reliability of generation system could be determined by graphical solution.

### LITERATURE REVIEW

Prior to the 1960's, the reliability of proposed power systems was often estimated by extrapolating the experience obtained from existing systems and using rule-of-thumb methods to forecast the reliability of new systems .During the 1960's considerable work was performed in the field of power system reliability and some papers were published in the field of generation system reliability evaluation. This section gives a detailed overview of the all research papers in the area of reliability assessment of Generation systems and composite power system.

**Roy Billinton and Kenneth E. Bollinger** analyzed that the Markov approach is limited in application because of computer storage requirements and the rounding errors which occur in the solution of large systems. Most previous publications have focused on transmission system reliability. This research focuses on distribution system reliability. This work extends previous research, which demonstrated sets used in describing power system reliability calculations.

**C. Singh and A. Lago-Gonzalez** presented a method for reliability evaluation that took into account the fluctuating nature of energy produced by renewable energy sources such as wind and solar power generators. The authors assigned the conventional or continuous fuel source units to one subsystem and the fluctuating units to several other subsystems and for each subsystem developed a generation system model. The effect of fluctuating energy was included by modifying the generation system model of the unconventional unit. The frequency of capacity deficiency and loss of load expectation for the hour concerned was calculated by combining the generation system models, where each subsystem was treated as a multi-state unit. A discrete state algorithm was used for this method. Further, the method of cumulants was also applied to combine the subsystems to produce hourly loss of load expectation.

**C. Singh and Y. Kim** observed that the proposed methods gave significantly different results from the traditional methods at high penetration of the fluctuating units, while results obtained using the method of cumulants and those using the recursive algorithm were similar at high penetrations of the fluctuating units.

**Y. Kim** developed a similar methodology to evaluate loss of load expectation and unserved energy and also improved the computational efficiency. In the proposed approach, the authors correlated the hourly load to the output of the unconventional units and assigned them to specific states using the clustering algorithm. The mean values of the output of the unconventional units, the load and the probability of each cluster were obtained by dividing the number of clusters by the total number of observations. The authors combined all the subsystems to compute the reliability indices for each cluster. A case study was conducted to validate the proposed approach. The authors observed that the computation time was reduced significantly when the clustering approach was used.

**H.J. Zimmermann** Fuzzy linear programming (FLP) is an extension of CLP and deals with such imprecise coefficients and 'soft' constraints by using fuzzy variables. In fuzzy environment, the decision maker could accept small violations of the constraints and attach different degrees of importance to the violations of different constraints.

**Robert P. Broadwater and Hesham E. Shaalan** presented the first application to apply linked lists and pointer concepts to reliability analysis. It took into account constraints associated with switching operations, but it was relatively slow due to running numerous power flow calculations. One aspect investigated here is the effect of Distributed Generators (DG) on power system reliability. Standards for connecting DGs into distribution systems are just being developed .

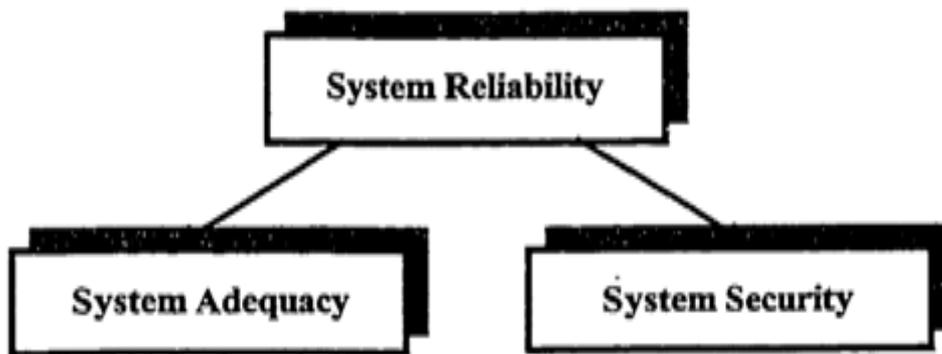
**S. Kuruganty** analyzed the impact on the HVDC system reliability, when spare components are included and the rating of the valves is increased. The spare part alternatives include the converter transformers and reactive power compensation equipment. A cost benefit analysis is performed to determine if the reliability improvements are balanced against the investments.

**Saraiva et al.** use fuzzy numbers to define loads in composite power system reliability evaluation using Monte- Carlo simulation. The authors propose a set of new indices reflecting the integration of probabilistic models and fuzzy concepts and discuss the application of variance reduction techniques (a simulation approach) if fuzzy numbers define loads.

### THEORY OF RELIABILITY

Reliability is, in a general sense, a measure of the ability of any system to perform its intended function without failure under certain conditions for a stated period of time. In the case of a generation system, reliability is usually defined in a quite different way. A Generation system is designed to perform its function for a relatively longer period of time. A Generation system can have failures at different points in the system at certain time, but these failures can always be repaired, and the system can be constantly developed to satisfy the changing demands and for improved the performance of its functionaries. It is therefore important for a power system to recognize and control the various possible system failures and to minimize the failure rate to provide uninterrupted power supply to the customers. Time of repair can be shortened by use of stand by systems.

The measurement of Generation system reliability includes the unavailability, the expected failure frequency and duration, and the expected magnitude of adverse effects on consumer service. System reliability evaluation is based on the data which make up the system. The collection of subsystem reliability data is therefore a fundamental task in system reliability evaluation. Reliability as applied to a power system is divided into the two general categories viz. system adequacy and system security as shown in Fig.2.

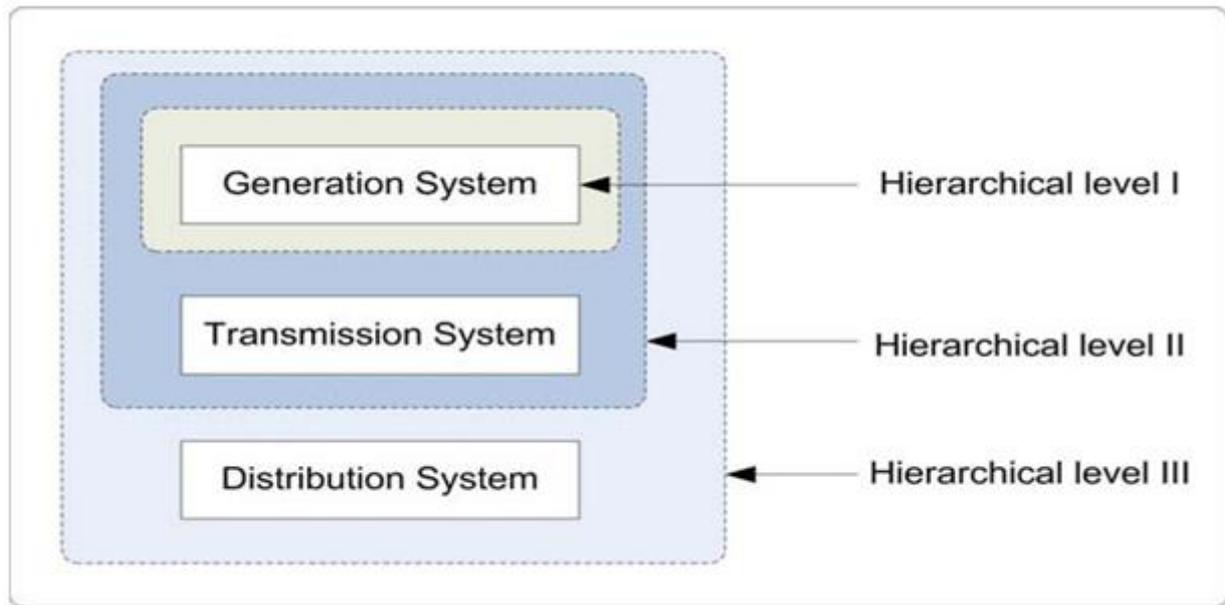


**Fig.2. Subdivision of power system reliability**

System adequacy relates to the existence of sufficient generation, transmission and distribution facilities within the system to satisfy the customer load demand. Adequacy evaluation is therefore associated with system steady state conditions. System security, on the other hand, relates to the ability of the system to cope with disturbances and is consequently associated with transient system conditions. System adequacy is usually associated with system planning for both long and short terms, but is also very important in system operation. System security is concerned with both system planning and operation.

Electric power systems are generally categorized into the three segments or functional zones of Generation, Transmission and Distribution. This division is an appropriate one as most utilities are either divided into these zones for the purpose of organization, planning, operation and analysis or are solely responsible for one of these functions. The three functional zones can be combined to give three hierarchical levels, as shown in Fig. 3.

Hierarchical Level I (HL I) is concerned only with the generation system. Hierarchical Level II (HL II) includes both generation and transmission system and HL III includes all three functional zones. System adequacy analysis is usually conducted in each of the three functional zones or in the three hierarchical levels.



**Fig. 3: Hierarchical levels of Power System for Reliability Analysis**

HL II analysis using probability methods is the oldest and most extensively developed area. Considerable effort has been applied over the last two decades to develop acceptable techniques and criteria for HL III analysis. It is also designated as composite power system or bulk power system evaluation. HL I studies are not usually done directly due to the enormity of the problem in a practical system and instead the generation functional zone is analyzed as an independent entity. The present dissertation aims at determining the reliability of Generation System.

### Reliability Equivalent Modeling Method

This method utilizes modular concepts to reduce the overall system to a simple failure logic connection diagram, which only contains series and parallel components. The conditional probability approach is then used to calculate this series and parallel arrangements. The application of this method usually needs to oversimplify component reliability parameters in order to transform the system into its functional layout. A typical example is to apply estimated failure rate values according to the number of pieces of equipment falling into each functionality group, such as protection, control, and monitoring groups.

### Cut Set Method

A cut set contains a set of system components whose failure can lead to the failure of the system. The minimum subset of a cut set is called minimal cut set, which contains the set of components that must fail in order for the system to fail. Each cut in the cut set is in series with other cuts, with the components inside a cut combined using the principle of parallel components. As the failure path of an event tree is equivalent to a cut in the cut set, the minimal cut set can be derived to reduce the size of the tree. However, even the minimal cut set can still be prohibitively large for large systems. As a common case, exhaustive evaluation for precise results is often compromised with fast calculations by using approximations, such as neglecting cut sets greater than a certain value. This is based on an assumption that high order cut sets are much less probable than low order cut sets.

## CONCLUSION

- Reliability of operation of any system is the prime attribute of that system which leads to its selection and rejection.
- Generation System is the most vital part of any power system having many links where the reliability can be question marked. It therefore needed fine study of all the constituent parts, the reliability of each of which ensures the total or equivalent reliability of the Generation System.

- A Generation System is said to possess the reliability provided its Mechanical unit and Electrical units each possess the reliability. Also, the reliability of mechanical unit further depends on the reliability of boiler and turbine & reliability of electrical unit further depends on the reliability of Generator and Circuit Breaker.
- Reliability v/s time study has been carried out for each part that affects the reliability of generation system.
- Mathematical model for equivalent reliability for both mechanical and electrical units have been found as a function of time.

### REFERENCES

- [1]. J. A. Greatbanks, D. H. Popovic, M. Begovic, A. Pregelj, and T. C. Green, "On optimization for security and reliability of power systems with distributed generation," in *Power Tech Conf. Proc.*, vol. 1, Bologna, Italy, June 2003.
- [2]. A. A. Chowdhury, S. K. Agarwal, and D. Koval, "Reliability modeling of distributed generation in conventional distribution systems planning and analysis," *IEEE Transactions on Industry Applications*, vol. 39, no. 5, pp. 1493–1498, Sept.- Oct. 2003.
- [3]. I. S. Bae, J. O. Kim, J. C. Kim, and C. Singh, "Optimal operating strategy for distributed generation considering hourly reliability worth," *IEEE Transactions on Power Systems*, vol. 19, no. 1, pp. 287–292, Feb. 2004.
- [4]. Nader Amin A. Samaan, "Reliability Assessment of Electric Power Systems Using Genetic Algorithms", University of Alexandria, Egypt, August 2004
- [5]. R. Billington and F. Gbeddy, "Effects Of Non-Utility Generators On Composite System Adequacy Evaluation", *IEEE Trans. on PWRs*, Vol. 8, No. 3, pp. 771-777, Aug. 1993.
- [6]. A. Cook and I. Rose, "A Monte-Carlo Technique For Computing The Benefits Arising From The Interconnection Of Power Systems", *IEEE Trans. on PWRs*, Vol. 8, No. 3, pp. 873-878, Aug. 1993.
- [7]. Robert P. Broadwater and Hesham E. Shaalan, "Distribution system reliability and restoration analysis", *Electric Power System Research*, 29, pp. 203-211, 1994.
- [8]. S. Kunganty, "Effect of HVDC Component Enhancement on the Overall Reliability Performance," *IEEE Transactions on Power Delivery*, vol. 9, no. 1, Jan 1994.
- [9]. J.T. Saraiva, et al., "Generation/transmission power system reliability evaluation by Monte-Carlo simulation assuming a fuzzy load description", *IEEE Trans. Power Syst.* 11 (2), 690-695, 1996.
- [10]. H.J. Zimmermann, *Fuzzy Set Theory and its Applications*, second ed., Kluwer Academic Publishers, 1991.
- [11]. M. Pereira, M. Maceira, G. Oliveira and L. Pinto, "Combining Analytical Models And Monte-Carlo Techniques In Probabilistic Power System Analysis", *IEEE Trans. on PWRs*, Vol. 7, No. 1, pp. 265-272, Feb. 1992.
- [12]. TRELSS, "A Computer Program for Transmission Reliability Evaluation of Large-Scale Systems", EPRI Report TR-100566, Palo Alto, CA, May 1992.