International Journal of Electrical, Electronic and Communication Sciences
ISSN: 2517-9438
Vol:8, No:2, 2014

Reliability Assessment for Tie Line Capacity Assistance of Power Systems Based On Multi-Agent System

Nadheer A. Shalash, Abu Zaharin Bin Ahmad

Abstract**—**Technological developments in industrial innovations have currently been related to interconnected system assistance and distribution networks. This important in order to enable an electrical load to continue receive power in the event of disconnection of load from the main power grid. This paper represents a method for reliability assessment of interconnected power systems based. The multi-agent system consists of four agents. The first agent was the generator agent to using as connected the generator to the grid depending on the state of the reserve margin and the load demand. The second was a load agent is that located at the load. Meanwhile, the third is so-called "the reverse margin agent" that to limit the reserve margin between 0 - 25% depend on the load and the unit size generator. In the end, calculation reliability Agent can be calculate expected energy not supplied (EENS), loss of load expectation (LOLE) and the effecting of tie line capacity to determine the risk levels Roy Billinton Test System (RBTS) can use to evaluated the reliability indices by using the developed JADE package. The results estimated of the reliability interconnection power systems presented in this paper. The overall reliability of power system can be improved. Thus, the market becomes more concentrated against demand increasing and the generation units were operating in relation to reliability indices.

Keywords**—**Reliability indices, Load expectation, Reserve margin, Daily load, Probability, Multi-agent system.

I. INTRODUCTION

THIS template the individual system risk levels can be obtained using the capacity assistance probability approach. There are two challenges to limit the interconnection assistance from one system to the other the operating reserve and tie line transfer capability .The adequacy of the generating capacity in a power system is normally improved by interconnecting the system to other power systems. The modern electric power system is one of the largest and the most complex system which consists of uncounted numbers of facilities and structures, systems and subsystems, components and equipment. Operating availabilities of each part in this system play an important role in meeting energy demands. With the increasing size and diversity of power systems, the problems became much more complicated. The wide area control centralization in power system offers the promise of greatly increased efficiency and improved customer service. Alternatively, dispread local control may be more robust in the face of extreme contingencies [1]. The evolution of power systems goes hand in hand with the increase of generation and consumption of electrical energy and with the increase of system complexity. Therefore, the reliability of power systems should be thoroughly assessed both by the utility companies and the independent system operators [2]. Power system reliability can be defined as the ability of the system to provide sufficient generation of electrical energy to satisfy consumer demand and respond to transients and disturbances that occur in the system. Recent electrical disturbances have raised many questions about the causes and cures for such occurrences. These events demonstrated that the reliability of electrical power system should consider all factors within generation, transmission and distribution systems [3].

Reliability of the generated power system is afflicted with the load curve characteristics, peak duration and variety between levels of the peak at each hour, day and month of each season of a year. Various kinds of customers might have different load curve charts. The most frequent categorization for electrical loads is: residential, commercial and industrial which usually each load curve contains a characteristic chart. Such a process's quality is just a strong task of the dispatcher's understanding of the system topology, utilization of automation, and typical trouble call techniques [4]. Probability based models have already been advanced for precisely reflects the stochastic nature of generators behavior and determines its reliability interpretation [5]. Today the power quality and reliability are one of the most crucial features combined with the cost in the power generation.

There are two techniques for evaluating power system reliability: analytical and simulation methods. The simulation methods can be utilized to fix the issue of the distribution evaluation, assess the reliability indices by simulating the particular process and unplanned behavior of the system as randomly [6]. Monte Carlo Simulation (MCS) method is latterly receiving considerable interest as the simulation method [5]. Therefore, an MCS has been employed to approximate the required calculations for generation reliability assessment when the system is complicated.

Probability based models have been developed to accurately reflect the stochastic nature of a power system behavior and assess its reliability performance [7]. A practical approach to the reliability of protection system using synchrophasor

Nadheer A. Shalash is with the Faculty of Electrical and Electronics EngineeringUniversity Malaysia Pahang, 26600 Pekan, Malaysia (phone: +601-6979-5140; e-mail: eng_n_a_msc@yahoo.com).

Abu Zaharin Bin Ahmad is with the Faculty of Electrical and Electronics Engineering University Malaysia Pahang, 26600 Pekan, Malaysia (phone: +609-424-6002/6133; e-mail: zaharin@ump.edu.my).

monitoring of system conditions that can be incorporated into protection schemes was discussed in ref [8]. Nowadays, agents are the focus of intense attention in many areas such as computer science and artificial intelligence. In facts, agents are being used in an increasingly wide variety of applications [9]. For consistent service to the electricity consumers, power system must remain intact and be able to endure a wide variety of disturbances. It should be operated in normal and secured condition. As a result, the system must be designed and operated so that the more possible contingencies can be sustained with no loss of load [3]. In this work, represents the application of a multi-agent approach to for reliability assessment of interconnected power systems using indices adequacy of the generating capacity are considered in terms of daily load demand. The proposed technique is tested using Roy Billinton Test System (RBTS) was used to evaluate the effect of spinning reserve on the reliability indices using developed JADE package.

II. THE CONCEPT OF RELIABILITY EVALUATION

First For reliable system, the installed capacity in power system must be higher than expected consumption .One of the method used as a measure of reliability is the Loss of the largest generating unit method which provides a degree of sophistication over the percent reserve margin method by reflecting the effect of unit size on reserve requirements. A reserve power needs to be provided for frequency regulation and in case of major aggregate loss of capacity. Generation reserve margin method is a measure that shows how the capacity of the power system exceeds the peak consumption and this reserve is calculated by refer to (1), [10]:

$$\text{Reserve Margin} = \frac{(\text{Capacity in service} - \text{Peak load})}{\text{Capacity in service}} \qquad (1)$$

The percent reserve evaluation is calculated by comparing the total installed generating capacity at peak with the peak load. The criterion is based on past experience requiring reserve margins in the range of 15–25% to meet demand [11]. Unusually, the reliability indices of a system can be evaluated using one of the two basic approaches; Analytical techniques or stochastic simulation. The simulation estimates the reliability indices by analyzing the actual process and random behavior of the system. Monte Carlo Simulation which is one of the most powerful methods for statistical analysis of stochastic problems is used for reliability assessment [12].

The Most common methods used for reliability evaluation, are based on the loss of load or energy approach. In this method, the suitability index that describes generation reliability level is LOLE. It indicates the time in which the load is more than available generation. The reliability expresses the proportion time of the component if it is "in service" or "available for". However, the availability (A) of a component is expressed as refer to (2), [13]:

$$A = \frac{\sum(uptime)}{\left(\sum(uptime) + \sum(downtime)\right)} \qquad (2)$$

where the "up time" is the total time when the component is in service and "down time" is the total time when component not in service. Availability can be expressed in terms of mean time to failure (MTTF) and mean time to repair (MTTR) as refer to (3):

$$A = \frac{MTTF}{MTTF + MTTR} \qquad (3)$$

The mean time between failures (MTBF) is the sum of MTTF and MTTR and can be represented by cycle of time "T" as seen in Fig. 1.

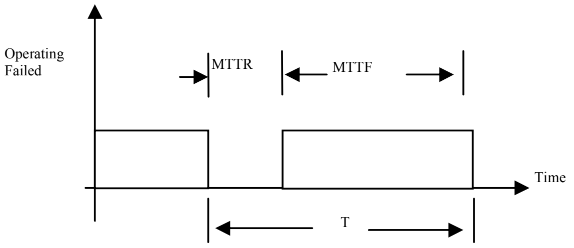


Fig. 1 Mean time diagram for a two state component

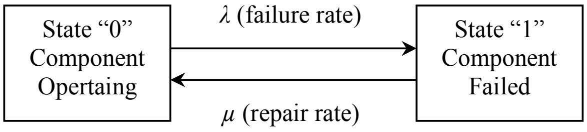


Fig. 2 State space diagram of transition rates

Power system components can be characterized by discrete system states with constant transition rates between these states. State "0" represents the healthy component in an operating condition. As for state "1" (failed state) when the component cannot perform its intended function. Transition occurs between state "0" and "1" and the transition rates between these states are the failure rate "λ " and the repair rate "μ" as shown in Fig 2. Therefore, (2) can be re-expressed in terms of failure rate and repair rate as refer to (4):

$$A = \frac{\mu}{\mu + \lambda} \qquad (4)$$

The unavailability (Q) is sometimes known as the Forced Outage Rate (FOR), it converse of the availability and can be defined in similar terms as refer to (5) or in terms of failure rate and repair rate as refer to (6).

$$Q = \frac{\Sigma\,(downtime)}{(\Sigma\,(uptime) + \Sigma\,(downtime))} \qquad (5)$$

$$Q = \frac{\lambda}{\lambda + \mu} \qquad (6)$$

The unit unavailability is a good approximation of a unit failure probability even when preventive maintenance is considered, provided that maintenance is scheduled during low demand periods. Normally, the failure and repair rates are not constant, but may be a function of time such as the Normal, Lognormal, Exponential, Gamma, Weibull, Binomial, and Poisson. In this work, Binomial Distribution Method (BDM) is used [14]. The binomial distribution can be represented by refer to (7):

$$(A + Q)^n \tag{7}$$

Equation (7) can be applicable if the fixed number of trials "n" is known and has resulted in either a success or a failure with corresponding probabilities A and Q respectively, all trials must be independent and have identical probabilities of success and therefore failure [15].

III. PROBABILITY OF AGGREGATE LOSS

The basic probability principles and combining the different Capacity size units are used for estimating the probability of total loss of generation. The success probability and its complement, that mean; failure probability of each generating unit is the input data. All combinations of success and failure generating units are presented in tabular form together with the calculated system availability.

Most of The basic indices used in the generating system adequacy evaluation are expected value of random variables (BDM). Among these indices are; A LOLP, LOLE and EENS. A LOLP is a probabilistic approach for determination of required reserves, Loss of load occurs whenever the system load exceeds the available generating capacity. Whereas the LOLP is defined as the probability of the system load exceeding available generating capacity under the assumption that the peak load is considered as constant through the day [10]. This approach examines the probabilities of simultaneous outages of generating units that together with a model of daily peak-hour loads determine the number of days per year of expected capacity shortages by refer to (8):

$$LOLP = \sum_{i=1}^{n} p_i t_i \tag{8}$$

where: p_i: the probability of system state; t_i: time interval of capacity in outage

The LOLE index gives the expected (or mean) number of days or hours (days/year or hours/year) in a given period (usually on year) in which the daily peak load or hourly load exceeds the available generating capacity as refer to (9):

$$LOLE = \sum_{i \in s} p_i T \tag{9}$$

where: T: the time unit of the index (i.e. either one day or one hour); S: set of all possible system states associated with loss of load.

Finally EENS, the basic expected energy curtailed concept can also be used to determine the expected energy produced by each unit in the system and therefore provides a relatively simple approach to production cost modeling.

$$EENS = \sum_{i \in s} p_i * C_S * Dns \tag{10}$$

where Dns: demand not supplied of state i.

IV. MULTI AGENT SYSTEM (MAS)

MAS are essentially developed as a control and reconfigure the system when this occurs. The models for this system are based on mathematical models and graph theory three models. In order to restore the network, the mathematical model is specified by a set of functions. According to Weiss, "An agent is an autonomous computational entity such as a software program that can be viewed as perceiving its environment through sensors and acting upon this environment through its effectors".

In addition, Multi-Agent can be used in many field systems composed of multiple autonomous components demonstrating the following features; 1) each agent has incomplete in terms of global control and capabilities for solving problems, 2) The data are decentralized and computation is asynchronous and 3) should be designed according to the problems under consideration [16]. An agent is a physical or virtual entity that essentially has the following properties:

1) Agents live and act in a given environment.
2) Agents are able to sense its local environment and to interact with other agents in its local environment.
3) Agents attempt to achieve particular goals or perform particular tasks.
4) Agents are able to respond in a timely fashion to change any occurs in them based on their learning ability.

All MAS must follow the similar ontology. Therefore if there are two agents in the communication then both agents will understand the communication if they are following the same ontology. JADE (Java Agent Development Environment) is typically the most famous representative middleware which accessories an agent program and a development package. JADE emerged in 2000 by the Research and Development department of Telecom Italia [17].

V. PROPOSED METHOD

In this section, we present the proposed multi agent can be developed for reliability assessment of interconnected power systems using indices adequacy of the generating capacity. Fig. 3 shows the proposed multi-agent system. Agents will be constructed in three areas, and two levels of decision making and action. First area, it has generator bus is called generator agent, second area it has loaded bus is called load agent, two agents that are located at the upper level, and third area it has set of agents (Agent for probability, Agent for No. Generator, Agent for Size Gen) are located on the lower level to calculate the reliability indices and evaluate the effect of spinning reserve. The two levels have connected to reserve margin Agent implemented on the local area management system. The introduced agents are detailed as follows:

1) Upper level

It has sets of agents as follows: first agent is the Generator Agent: this agent it can decide whether or not to connect the generator to the grid depending on the state of the system. This agent can communicate with other agents to make a decision. The second agent is the Load agent this agent is located at the load. It has control to read data of the load and can be decided whether to shed the load or not depending on the load curve of area or system.

2) Lower level

It has sets of agents as follows: the first agent Size generator agent. This agent can communicate with load and generator agents. In some time the grid has many different sizes of generators. This agents takes data from the load agent and make a decision to generator agent, the second agent is an Identical Generator No. Agent: this agent can communicate with load and Generator agents in some time the grid has many same sizes of Generators .This agent takes data from the load agent and make a decision to generator agent. Third agent is a Probability Agent. This agent can communicate with the No. generator agent and size generator agent, also the probability agent it depended on readings olden of probability to Increase accuracy of predictions. In the end, Reserve Agent (RA) can communicate with load and Generator agents to make a decision about the margin reserve and limited the reserve margin between 0 - 25% depend on the load and the unit size generator.

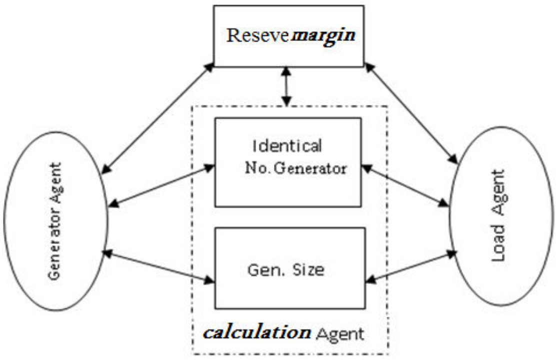


Fig. 3 The architecture of reliability based multi agent system

VI. CASE STUDY

The implemented techniques for reliability assessment were validated on a real practical power system in order to measure the response of reliability indices. The algorithm for reliability evaluation is demonstrated in the flow chart as shown in Fig. 3 and simplified by the following procedures:

1) Select the power plant for reliability evaluation, then great generator agent, load agent and reserve margin agent by JADE package.
2) Send messages to the generator agent from load agent to limit the size and number of generators in service.
3) For each selected power plant in the previous step, a random number from “0” to “1” is generated by BDM. If the generated number is more than the unavailability of generator, the generator will be considered available in the mentioned iteration.
4) Calculate the value of reserve margin and then the sum of the available power plants (generations are calculated with the LOLP.
5) A Comparison is made between the sums of the available power plants with load, if the sum is less than load, the LOLE is calculated.

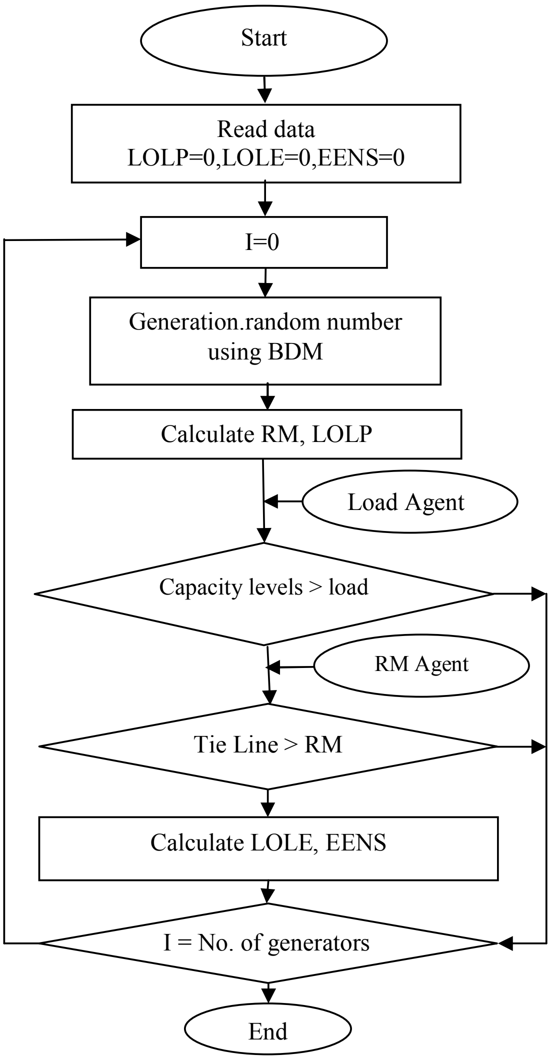


Fig. 4 The flow chart of reliability evaluation

6) A Comparison is made between Tie line capacities with operating reserve then EENS is calculated.
7) Go to the next iteration.

In this study, a simulation has been conducted on the RBTS see Fig. 4.

VII. RESULTS AND DISCUSSION

A. Measure the Reliability of the System Using Reliability Indices (LOLP & LOLE)

Fig. 5, the RBTS was an educational test system developed by the power system research group at the University of Saskatchewan [18]. This system has 6 buses with a 5 load bus, 9 transmission lines and 11 generating units located in buses 1 and 2 and ranging from 5MW to 40MW. The total installed generating capacity is 240 MW and the peak load of the system is 185 MW and system voltage level is 230 KV. The data of generating units are given in Table I. In this table, Column 4 and 5 demonstrate the calculated values of the annualized generating system adequacy indices with two statuses of generating models; failure and repair rates. The data on Tie line capacity are given in Table II. The daily load curve is calculated based on the hourly demand on the load buses as shown in Fig. 6 and Table III.

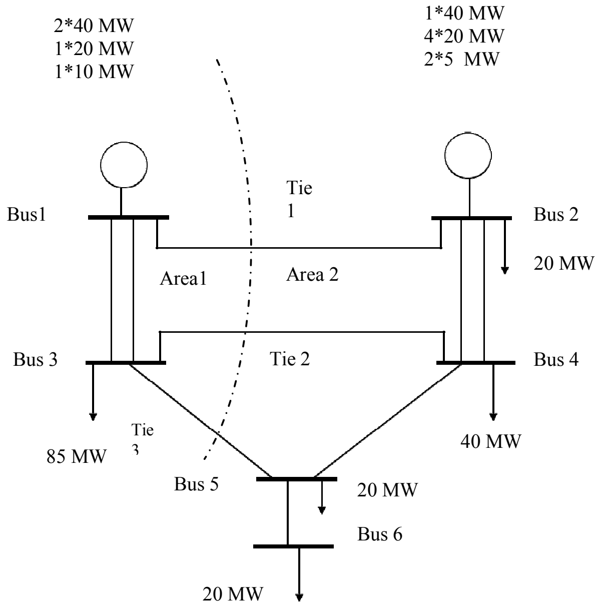


Fig. 5 Single Line Diagram of the RBTS with Customer Compositions

TABEL I
THE DATA OF GENERATING UNITS

Unit No.	Bus No.	Rating (MW)	Failure rate (occ./year)	Repair rate (hrs)
1	1	40	6	45
2	1	40	6	45
3	1	10	4	45
4	1	20	5	45
5	2	5	2	45
6	2	5	2	45
7	2	40	3	60
8	2	20	2.4	55
9	2	20	2.4	55
10	2	20	2.4	55
11	2	20	2.4	55

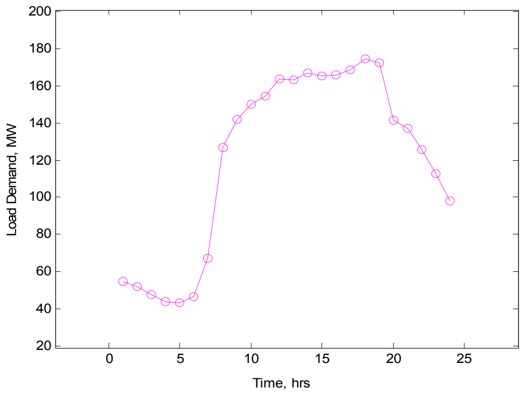


Fig. 6 The daily load curve of RBTS

TABEL II
THE DATA OF TIE LINE

Tie Line	Tie Line Connected	Tie line Capacity	Failure rate (occ./year)	Repair rate (hours)
1	Area 1 – 2	12	4	10
2	Area 2 – 1	10	1.5	10
3	Area 1 – 2	6	1	10

TABEL III
DATA OF DAILY LOAD FOR EACH BUS

Hour	Load Bus 2	Load Bus 3	Load Bus 4	Load Bus 5	Load Bus 6
1	7.4045	18.2747	15.9901	7.6515	5.3697
2	7.0420	17.5387	15.0401	7.4655	4.9772
3	6.5345	16.0347	13.7101	6.7315	4.4277
4	6.0995	14.9332	12.5701	6.2900	3.9567
5	6.0270	14.7342	12.3801	6.2010	3.8782
6	7.3470	15.0412	12.8541	7.3780	4.0693
7	10.2913	17.6724	23.8030	8.4770	6.8803
8	12.0188	69.8550	26.0200	10.4425	8.4612
9	14.3500	73.0725	28.8450	13.1625	12.4675
10	15.5375	75.2050	30.9800	14.4225	14.0775
11	16.1750	76.5700	31.9300	15.5150	14.8400
12	17.3850	79.0300	34.3000	16.8860	16.1650
13	17.3837	78.9317	34.2295	16.8582	15.9175
14	17.8738	79.8612	35.1325	17.4142	16.8850
15	17.4600	79.0425	34.5450	16.7760	17.7825
16	17.5162	79.1407	34.6155	16.8592	17.5860
17	17.9875	80.0375	35.4950	17.3875	17.8050
18	18.8025	81.8300	37.1500	18.3690	18.2305
19	17.8125	81.8300	37.1500	17.3700	18.0825
20	17.4225	53.6370	37.1050	16.5895	16.9660
21	16.4975	53.0930	36.6350	15.5905	15.3160
22	14.8625	51.0220	35.0250	13.4470	11.3450
23	12.4275	47.8750	31.9600	10.9115	9.5955
24	8.9475	44.7910	28.7440	7.4870	8.2605

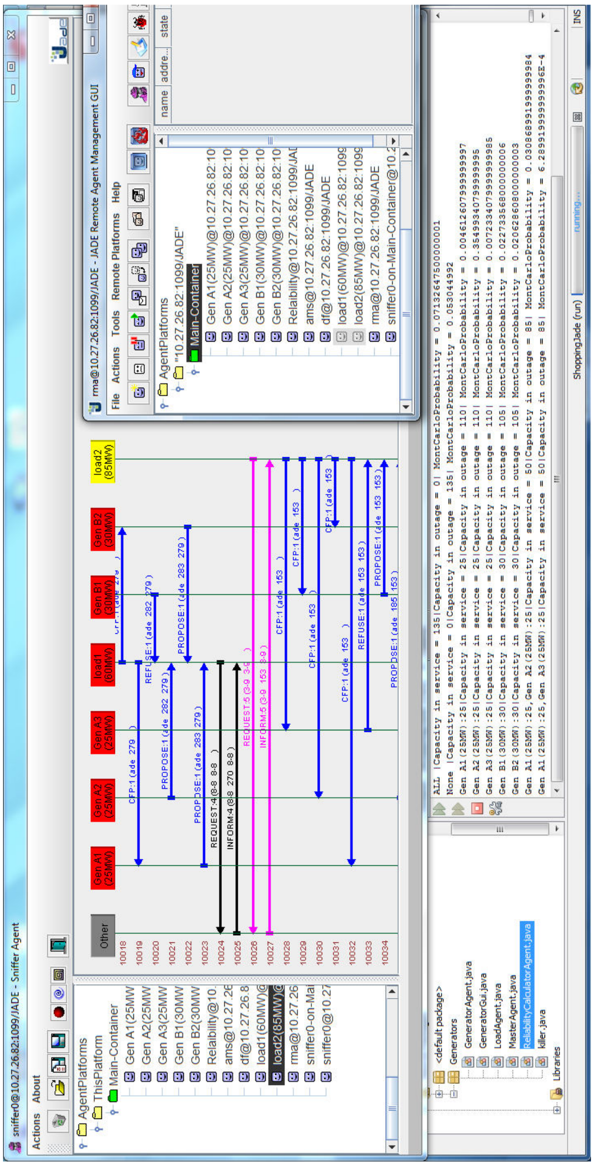
TABLE IV
SIMULATED VALUES OF INDEX LOSS OF LOAD EXPECTATION (LOLE) WITHOUT RESERVE MARGIN

Load MW	Generator Capacity Case 1	Generator Capacity Case 2	Generator Capacity Case 3	Generator Capacity Case 4
45	**(2*20,5)**	**(40, 5)**		
50	**(2*20,10)**	**(2*20,2*5)**	**(10,40)**	
55	**(2*20,10,5)**	**(40,10,5)**		
70	**(3*20,10)**	**(3*20,2*5)**	**(40,20,10)**	**(40,20,2*5)**
100	**(2*40,20)**	**(4*20,10,2*5)**	**(2*40,10,2*5)**	**(40, 2*20,10,2*5)**
115	**(2*40,20,10,5)**	**(2*20,10,5)**	**(40,3*20,10,5)**	**(5*20,10,5)**
130	**(3*40,10)**	**(3*40,2*5)**	**(2*40,10,2*20)**	**(2*40,2*5,2*20)**
140	**(3*40,20,)**	**(3*20,2*40)**	**(2*40,2*20,10,2*5)**	
145	**(3*40,20,5)**	**(2*40,3*20,5)**		
155	**(3*40,20,10,5)**	**(2*40,2*20,10,5)**		
165	**(3*40,2*20,5)**	**(2*40,4*20,5)**		
170	**(3*40,2*20,2*5)**	**(3*40,2*20,10)**	**(2*40,4*20,2*5)**	**(2*40,2*20,10)**
175	**(3*40,2*20,10,5)**	**(2*40,4*20,10,5)**		

Tables IV, V and VI describe the calculated results for annualized generating system adequacy indices for the RBTS with two state generating models with the failure and repair rates are Binomial distributed. In this paper as first step calculation of hourly load at the load buses in the RBTS as shown in Table III. Then, can draw load daily curve for this system shown in Fig 4. From load curve the agent load will be read this data at every hour and make a decision to sets of agents. When reach data and decision from load agent to these sets of agents, it will be send message to agent generator to limit size and number of generator see Fig. 7.

TABLE V
PROBALITY OF CAPACITY GENERATOR IN SERVICE WITHOUT RESERVE MARGIN IN SERVICE WITHOUT RESERVE MARGIN

Load MW	LOLE Case 1	LOLE Case 2	LOLE Case 3	LOLE Case 4
45	0.650	1.25		
50	0.85	0.7	2.9	
55	0.9	1.5		
70	1.15	1	1.75	1.6
100	2.7	1.55	2.75	1.1048
115	1.4052	1.4052	0.4301	
130	3.886	3.7	3.25	3.1
140	3.9	3.3	1.6533	
145	3.95	3.35		
155	1.9647	1.9647		
165	4.25	3.65		
170	4.3	4.45	3.7	3.85
175	2.244	2.244		



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ALL |Capacity in service = 135|Capacity in outage = 0| MontCarloProbability = 0.07132647500000001
None |Capacity in service = 0|Capacity in outage = 135| MontCarloProbability = 0.053044992
Gen A1(25MW):25|Capacity in service = 25|Capacity in outage = 110| MontCarloProbability = 0.004612607999999997
Gen A2(25MW):25|Capacity in service = 25|Capacity in outage = 110| MontCarloProbability = 0.354993407999999995
Gen A3(25MW):25|Capacity in service = 25|Capacity in outage = 110| MontCarloProbability = 0.00723340799999985
Gen B1(30MW):30|Capacity in service = 30|Capacity in outage = 105| MontCarloProbability = 0.022733568000000006
Gen B2(30MW):30|Capacity in service = 30|Capacity in outage = 105| MontCarloProbability = 0.020628608000000003
Gen A1(25MW):25,Gen A2(25MW):25|Capacity in service = 50|Capacity in outage = 85| MontCarloProbability = 0.030868991999999984
Gen A1(25MW):25,Gen A3(25MW):25|Capacity in service = 50|Capacity in outage = 85| MontCarloProbability = 6.289919999999996E-4
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Fig. 7 Virtualization of agent communication

These steps may be iteration so much therefore, the agent of probability, it can depend of this iteration to choose best state from readings olden of probability. For example see when the agent load read data from load curve is 70 MW for RBTS system, it will send message to sets of agents ,the first agent of them which reserve margin, it will limited the reserve margin after reach the message data from generator agent, in Table IV this load has many probability to choose available generating capacity as (3*20 MW, 10 MW), (3*20 MW, 2*5 MW), (40 MW, 20 MW, 10 MW), (40 MW, 20 MW, 2*5 MW) and many probability to limit size and number of generator, this probability without reserve margin, after that we can see in Table V. The calculation of the index LOLE had been variable value between 1.15 hours/day, 1 hours/day, 1.75 hours/day, and 1.6 hours/day respectively to the available generating capacity without reserve margin.

In other hand if the generator has reserve margin already that state will be increased the probability to share the generator to supply load, this is confirmed from the values of indices as presented in Table VI, it is also noted that in some cases when the system without reserve margin, the value of LOLE was higher even though the generator units with a high capacity are operated. Therefore, the reliability of the system depends on the hot reserve generation rather than the standby generation.

B. The Effecting of Tie Line Capacity to Determine the Risk Levels in the Assisted System Using EENS

In area 1, the total interconnected capacity equals 28 MW while the total load 85MW and the operating reserve 25 MW as shown in Table VII, that means the reserve margin less than the transfer generation of the tie, in this case, when the Interconnected capacity increased beyond the reserve margin, the risk level is decreased. In Area 2, the total interconnected capacity equals 28 MW while the total load 120 MW and the operating reserve 30 MW, that mean the transfer generation of the tie line less than the reserve margin. In this case, when the interconnected capacity decreased beyond the reserve margin, the reliability of capacity assistance increased.

TABLE VI
SIMULATED VALUES OF LOLP AND LOLE WITH RESERVE MARGIN

Load MW	Generator Capacity	LOLP with reserve margin 25%	LOLE with reserve margin 25%
45	(5x20+3x40+2x10+2x5)	2.00504x10^{-12}	0.9146
50	(5x20+3x40+2x10+2x5)	5.01x10^{-11}	1.0046
55	(5x20+3x40+2x10+2x5)	3.0077x10^{-11}	1.0094
70	(5x20+3x40+2x10+2x5)	3.04005x10^{-11}	1.0198
100	(5x20+3x40+2x10+2x5)	1.085713x10^{-6}	1.1046
115	(5x20+3x40+2x10+2x5)	1.143676x10^{-9}	1.2579
130	(5x20+3x40+2x10+2x5)	1.017749x10^{-7}	1.3546
140	(5x20+3x40+2x10+2x5)	1.0034x10^{-4}	1.5693
145	(5x20+3x40+2x10+2x5)	7.51927x10^{-11}	2.6546
155	(5x20+3x40+2x10+2x5)	9.601x10^{-7}	2.7046
165	(5x20+3x40+2x10+2x5)	4.07325x10^{-11}	2.8486
170	(5x20+3x40+2x10+2x5)	3.001x10^{-6}	2.8796
175	(5x20+3x40+2x10+2x5)	6.19244x10^{-8}	2.9342

TABLE VII
CHARACTERISTIC OF AREA

Tie Line Connected	Capacity MW	Total load MW	Operating reserve MW
Area 1	110	85	25
Area 2	310	100	30

The probabilities of generation capacity outage for each area after and before the tie line is obtained by considering only the Forced Outage Rate (FOR) of generating capacity for assisting areas as shown in Table VIII.

TABLE VIII
PROBABILITIES OF CAPACITY OUTAGE FOR AREAS AFTER AND BEFORE TIE LINE

Capacity Out MW	Probability Area 1	Probability Area 2	Probability after Tie Line Area 1	Probability after Tie Line Area 2
0	0.72315546	0.8012342	0.72315546	0.08909608
5	0.11582037	-	0.11582037	0.00090392
10	0.0965345	0.1026233	0.0965345	0.00013811
20	0.0639267	0.00090392	0.0639267	0.000012675
25	0.000377830	-	0.00056297	0.0000008273
30	0.000074677	0.00013811	-	0.1079836677
40	0.0000009234	0.000012675	-	-
45	0.0000038923	-	-	-
50	0.0000006784	0.0000008173	-	-
60	0.00000120	0.00000110	-	-
65	0.0000007937	-	-	-
70	0.0000004348	0.0000007134	-	-
80	0.0000001698	0.0000008831	-	-
85	0.00000007167	-	-	-
90	0.00000004122	0.00000009228	-	-
100	0.00000001723	0.00000002383	-	-
105	0.00000000912	-	-	-
110	0.00000000496	0.000000005	-	-
120	0.00000000148	-	-	-
125	0.00000000037	-	-	-
130	0.00000000004	-	-	-

In Table IX, the EENS of area 1 before interconnected was 62.345 MWh and so EENS was 54.1592 MWh at 30 MW after assistance interconnection. Meanwhile, the EENS of area 2 before interconnected was 456.22 MWh and EENS was 482.576 MWh at 30 MW after assistance interconnection. The risk level increases as the probability of the interconnection decreased.

TABLE IX
RESULTS OF EENS FOR EVERY AREA

Area	EENS (MWh) Before Tie line	EENS (MWh) after Tie line
Area 1	62.345	54.1592
Area 2	456.22	482.576

VIII. CONCLUSION

The MAS has been used to evaluate indices reliability in a power grid as one solution to the power system problems. This paper focuses on quantified impacts of a planned daily load demand on the overall system reliability, rather than the status of individual system components. The results show different levels of reliability measurements for the two considered cases “system without and with RM”. If the load demand is distributed on the capacity of identical generators with small size, the value of reliability indices is decreased and therefore the reliability of the power system is improved. The calculated values of indices in different time intervals will give guidelines for the weakest buses in a power network. In the second part, the results have been shown that the probability of tie-lines effecting of tie line capacity to determine the risk levels in the assisted system using EENS, when the interconnected capacity increased beyond the reserve margin, the risk level is decreased.

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