Optimal Reduction of electrical Loads Based on Priorities Developed Using a Genetic Algorithm

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Abstract: Most developing countries are now working to combat imbalances between power generation and load demand. In such situations, load shedding schemes have been implemented frequently as rapid solutions for unbalanced conditions to protect networks from collapsing and to sustain stability. The conventional methods of load shedding disconnect loads without considering their priorities. In this work, a logarithmic reduction method is thus proposed to reduce loads according to the priority and criticality. A Reduction Matrix is introduced as a tuning factor scaled to the size of the network, and the paper thus presents an optimisation tool based on Genetic Algorithms, developed in MATLAB, that can be applied to minimise the error between the amount of load to be reduced and the actual load reduced in electric power systems. The proposed algorithm was tested on a practical data system sample as provided by the Iraqi Ministry of Electricity from the control center of the Iraqi national grid in Baghdad, and was shown to offer optimal load reduction with reduced error, which is necessary to eliminate the impact of load reduction in electrical networks on critical loads when total demand cannot be supplied. The simulation results thus support the effectiveness and practicality of the applied method, paving the way for its possible application in power systems.

Keywords: Load Reduction, Priority of Demand, Load Matrix, Importance matrix, Reduction Matrix, Genetic Algorithm.

1. INTRODUCTION

Many countries around the globe suffer from power shortages as a result of excess load, lack of generation, and inefficient distribution networks. Which mean that power systems struggle to cater to growing demand while preserving system stability [1], [2], [3]. Load shedding (LS) is thus often a necessary strategy to reduce requirements and to compensate big differences to keep the overall load under a specified power level [4], [5], [6]; [7] was the first patent on the use of LS to maintain a system under normal conditions. Several
conventional techniques for shedding the loads can be used; under frequency load shedding (UFLS) and under voltage load shedding (UVLS) may be either excessive or insufficient, however, and are done without estimating the actual power imbalance. These techniques may also have slow response times, leading to problems with power system quality and tripping of the total power system due to restrictions on real time monitoring [8], [9], [10]. An adaptive LS scheme has been developed to improve on traditional LS methods by means of adaptive selection of the parameters of the proposed schemes and estimation of the rate change in network frequency through measuring the magnitude of the disturbance [11], [12], [13]. The authors in [14], [15], [16], proposed combinatorial algorithms for a combined UF- UV LS in which frequency and voltage signals are locally measured to enhance the adaptive LS method support power systems. However, the operations of the conventional, adaptive, and the proposed LS scheme are unsuitable for large scale power systems and are unable to handled various contingencies. In addition, these technics are also incapable of shedding a precise proportions of their loads [17], and only a few recent studies have been done on load categorization or priority based LS systems.

Several studies have been done on the LS effect [18], [19], [20] with regard to system condition, based on the demand priority. In [21], [23], [24], LS based on load importance was proposed to improve the performance of the power system during contingencies and to minimise the impact of the LS on consumers by taking social and economic factors into consideration. A work reduction strategy for LS is thus proposed based on priority demand (PD). Based on this approach, loads prioritised according to their importance and the application of a logarithmic reduction matrix. Artificial intelligence techniques are also widely applied to load shedding applications nowadays [25], [26], [27], [28]. In this work, the GA method was employed to develop optimal reduction of the load while decreasing the overall effect of the load reduction based on considering the criticality of various loads.

Data was drawn from the Iraqi national grid, and the simulation results showed a reduction in demands while the power supplies to important loads were kept intact. The use of a selective LS based on the prioritisation using a GA thus improved the reliability of the operation of critical loads.

2. MATHEMATICAL REDUCTION TECHNIQUE

2.1 Loads Categorizations

In conventional technique, a whole feeder is shed, regardless the load type on that particular feeder, based upon calculations to keep the system in nominal operational order. Whenever there is a shortage of supply in the system, an alert is sent to the control center to release certain load demands.

In practice, various types of loads, including industrial, domestic, and health care, etc. could be associated with a single feeder, which would thus have a variety of demand priorities. In the presented scheme, each feeder thus requires a priority mechanism based on its various PDs.

Any feeder included in a power system can be considered to have a lower or higher importance predicated on the number and type of its loads, including the number of critical or non-critical loads connected to a particular feeder. Non-critical loads should be selected for shedding in order to preserve the power supply to the loads with higher PDs. The definition of critical adopted in this work is based on the nature of loads associated with effects on the lives or safety of people, such as hospitals, emergency call centers, and fire stations. Such loads have high priority based on this criticality factor, though each type of load also has its
own importance; loads can thus be categorised based on their criticality, and the resulting load importance distribution is shown in Figure 1.

![Figure 1. Loads categorisations based on criticality](image)

As shown in Figure 1, each category of loads has an importance value of between 0.1 and 1.0; the value of importance increases according to the criticality of the load. The first, level loads, which are the most critical loads such as healthcare institutions, including hospitals, have high importance values of between 0.9 and 1.0.

The second level is communication installations, which must also be considered critical loads, but with slightly lower importance 0.8 to 0.9, such as data centers. The lower level of categorization, which represents non-critical loads 0.1 to 0.3, features the loads that must be the first to be shed in the implemented scheme, with the loads at the first level being the last to be reduced.

2.2 Reduction of Loads Based on Importance

In this section, the reduction method proposed to control network load distributions and to direct resources to the most important services is outlined. To convert the actual geographical distributions of the loads in the network, to workable format, a load matrix (LM) is constructed as follows:

$$LM = [a]_{m \times n}$$

$$LM = \begin{bmatrix} a_{11} & a_{21} & \cdots & a_{1m} & a_{2m} & \cdots & a_{n1} & \cdots & a_{nm} \end{bmatrix}_{m \times n}$$

(1)

where \( m = 1, 2, 3 \ldots \) is the index of the network substations and \( n = 1, 2, 3 \ldots \) is the index of the network feeders connected to each substation, respectively; thus, \( a_{11} \) is assigned to the first feeder of the first substation, and so on.

Matrix data formulation of the network feeders with various load categories based on PDs is a convenient mean of optimisation and mathematical handling, as well as following the syntheses of the control system nodes.

The total demand power \( (Pd_t) \) is then the summation of all LM elements:
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\[ Pd_j = \sum_{i=1}^{I} \sum_{j=1}^{N} a_{ij} \]  

(2)

A matrix analogous to the LM can then be constructed; this the importance matrix (IM):

\[
IM = \begin{bmatrix}
\alpha_{i1} & \alpha_{i2} & \cdots & \alpha_{im}
\end{bmatrix}
\]

\[
\begin{bmatrix}
\alpha_{n1} & \cdots & \alpha_{nm}
\end{bmatrix}_{n \times m}
\]

(3)

where \( n = 1, 2, 3 \ldots \) \( \alpha_{nm} \) is the importance factor assigned to each \( a_{nm} \) in LM, and its value is normalised between 0.1-1.0, based on the suggested categorisation of loads shown in Figure.1. Where the criticality is high the \( \alpha_{nm} \) approaches unity. The matrix sizes are equal, being based on the number of substations and feeders interconnected in the network system.

A detailed flowchart that clarifies the implementation process of the proposed reduction of loads based on importance is shown in Figure. 2. The basic process is:

1- Set the available power value and demand of the load.
2- Construct load matrix LM per Eq. (1).
3- Define the importance matrix IM per Eq. (3).
4- When the first condition occurs, all loads will be operating; if required, the load with lowest \( \alpha_{nm} \) is shed. All the loads with high importance should still be operating when the second condition is investigated; if required, the next \( N+1 \) lowest priority load is shed in order to protect as much critical load as possible.
Figure 2. Load shedding based on demand priority.

The data of the network loads and their importance are defined as the matrices (LM and IM) to enable the reduction process. The factor of reduction is implemented based on $\alpha_{nm} \alpha_{nm}$ in order retain the $a_{nm}$ with high importance without any reduction by shedding the $a_{nm}$ with low importance. The equation for the reduction factor is thus:

$$\beta_{nm} = \left(\frac{e^{\alpha_{nm}}}{e^{\alpha_{max}}}\right)^N$$

(4)$\beta_{nm}$

where $\beta_{nm}$ is the reduction factor based on the importance $\beta_{nm} = \left(\frac{e^{\alpha_{nm}}}{e^{\alpha_{max}}}\right)^N$ (3) factor $\alpha_{nm}$ in the IM, $\alpha_{max} \alpha_{max}$ is the maximum value of importance factor in the IM, and $N$ is the exponent of reduction factor. The reduction factor results from dividing the exponential of the importance factor $\alpha_{nm} \alpha_{nm}$ by the exponential of maximum importance factors $\alpha_{max}$ in the IM under the exponent of $N$ as seen in Figure 3. Each element in the LM will have its own factor of reduction based on the IM.

Figure 3. The reduction $\beta$ factor $\beta_{nm}$ Eq.(4) aginst importance as the reduction exponent (N) increases.

From Figure 3, which can be used to illustrate the effect of increasing the exponent of $N$ on the performance of the reduction formula $\beta_{nm}$ and $\alpha_{nm} \alpha_{nm}$. When the value of $N$ is doubled, the rate change of $\beta_{nm}$ increases and the reduction value increase at low values of $\alpha_{nm}$ as assigned in the second curve. As more reduction is assigned in the last curve, this case presents the system under severe disturbance conditions. These factors are represented within the Reduction Matrix (RM) as follows:

$$RM = [\beta]_{nm}$$

(5)

The structure (i.e. RM) of each matrix RM and IM depends on the dimensions of the LM associated with the size the of electrical network modelled. RM thus applies the adjudication matrix approach that generates a decision maker to reduce the elements in LM under restrictions imposed by the PDs based on the real-life situation. Under the current LS scheme, a reduction factor that depends on importance is proposed for reducing feeders of lower importance with relative reductions (not switched off or cut off). The equation for such reduction of the load is:
where the $L M[b_{nm}]$, $L M$ after reduction is shown within the matrix such that

$$L M = [b]_{nm}$$

(7)

where $b_{11}$ represents the first feeder at the first substation after balancing based on reducing the load proportionally. The processes of multiplication in RM according to implementation of IM and LM, that result in a new LM are represented in practical new loads with lower reductions to attempt supply-demand balancing. In addition, all loads continue to operate, with the varying rate of reduction. This reduction is higher for non-critical loads and low or non-existent for critical loads to maintain the operation of such important loads to the maximum extent possible. A detailed flowchart clarifying the implementation process of the proposed reduction of loads is shown in Figure 4:

1- Set the available power value and the demand of the load.
2- Construct LM and RM based on the IM and set $N = 1$ per Eq.(4).
3- When the first condition occurs, all load will be operating; if necessary, apply the reduction process in Eq.(6).
4- All the loads with high importance will be operating when the second condition is investigated; if necessary, increase $N = 1$, otherwise return back to the process in Eq.(4).

**Figure 4.** Flow chart of the reduced load process.

As seen in Figure 4, where the power system is in an abnormal operating state, the reduction scheme is applied based on load importance. When the gap between the supply and demand power is huge, the value of the $N$ in Eq. (4) increases, as shown in Figure 3, in order to increase the reduction of the loads. Certain critical loads may thus gain a relative reduction factor, and some load will be shed from critical loads until...
the balance is restored. However, the restoration of critical loads is crucial and should be achieved as quickly as possible; these must thus be prioritised over all other loads in the system.

3. GENETIC ALGORITHMS FOR OPTIMAL REDUCTION OF LOAD

The objective function in this problem is defined as the error in the quantity of the load to be reduced at the substation and the realistic load to be reduced. Practical data on the load profile is fed to the program. The load reduction, based on the demand priority, is input to the program by the operator at the substation. The amount of load reduction required is also entered into the program as input, by the operator. Actuating the reduction process based on the optimal solution obtained from the algorithm then follows.

The steps involved in the execution of the algorithm are briefly explained in the following points:

Step 1: A sample of the load system is taken from the practical system to act as an input for the GA. The factor of importance as shown in Figure 1 is then decided by the applying of the GA in conjunction with the reduction amount required to achieve the desired load. The first step of the GA is the initialisation of a population for optimisation. The minimum factor of importance is initialised randomly within the range of importance selected from the initial range as shown in Figure.1.

Step 2: The objective function is the error in load reduction (amount of load to be reduced - amount of load power actually reduced) as, evaluated for each “chromosome”. A roulette wheel strategy is adopted the GA as a selection strategy.

Step 3: Crossover and mutation is the process of evaluating the fitness of all individuals in the population and creating a new, improved population, by performing operations such as two-point crossover, where two breakpoints are selected randomly in parent chromosomes and the chromosome genes that lie between these are swapped between parent chromosomes to facilitate faster convergence in terms of error minimization.

Step 4: At the reiteration or termination point, the function of the objective is computed for all chromosomes, and if any of the chromosomes has achieved the objective, this is considered the solution to the optimisation problem. If more of the one chromosome achieves the constraint, the one with the lowest load reduction error is considered the best solution and selected. If the objective functions of all chromosomes unsatisfactory, step 3 of the procedure is repeated. Figure 5 explains shows a flowchart that illustrates the adopted method for developing a reduction program for loads.
4. RESULTS AND DISCUSSION

Real hourly demand data from this present year for Baghdad city, as provided by the Iraqi Ministry of Electricity for the control center of the Iraqi national grid in Baghdad [29], [30], were used to test and evaluate the simulation results for the load shedding and reducing program. The applied practical system includes several substations, each of which contains a number of feeders for the Baghdad National Grid (BNG). The regional power network is affected by the local geography and the actual operating parameters of the substations, which also carry different categories of loads. The implemented scheme of load shedding on BNG was developed using MATLAB R2014a.

4.1 Load shedding based on importance without a reduction factor

A sample of the practical system as a case study for the BNG was defined within the LM structure in MW as shown below:

\[
LM = \begin{bmatrix}
3.0 & 5.0 & 4.3 & 4.5 & 2.7 & 5.0 & 3.7 & 2.0 & 4.2 & 4.0 & 2.7 & 3.0 & 3.5 & 3.0 & 1.7 & 2.5 & 4.5 & 2.8 & 2.0 & 2.5 & 2.7 & 4.8 & 5.2 & 4.2 & 4.0 & 4.7 & 2.0 & 3.6 & 3.1 & 3.8 & 3.7
\end{bmatrix}
\]
where \( m = 9, n = 14 \) represents the substation number (33/11) KV and the feeder number. These feeders have different types of loads, including lighting, commercial, and industrial needs under various priorities, as shown in Figure 1. Each number in the matrix denotes consumed power by load in MW obtained from the particular control center unit. The total demand power for the sample is 432.9 MW, and each feeder in the LM has its own priority based on the load category. This priority is defined in the IM as shown in Figure 1, and this matrix using the appropriate real-life data is:

\[
\text{IM} = \begin{bmatrix}
0.62 & 0.37 & 0.94 & 0.35 & 0.47 & 0.32 & 0.93 & 0.24 & 0.81 \\
0.92 & 0.64 & 0.31 & 0.36 & 0.27 & 0.95 & 0.42 & 0.53 & 0.67 \\
0.46 & 0.42 & 0.28 & 0.32 & 0.\text{74} & 0.35 & 0.92 & 0.64 & 0.31 \\
0.36 & 0.27 & 0.95 & 0.42 & 0.53 & 0.67 & 0.46 & 0.42 & 0.28 \\
\end{bmatrix}
\]

The value of feeder 2 is 0.92 as its feed has highly critical loads, including hospital, while 0.64 is the value for feeder 3, which includes the pump station, while feeder 8 has a value of 0.35 representing its non-critical load.

The obtained simulation results showed that the loads with the lowest importance at the moment of load shedding within each classification were chosen for shedding as shown in Figure 6. The critical loads for every classification were thus kept in operation and loads which were less important were shed to zero to create a new LM:

\[
\text{LM} = \begin{bmatrix}
3.0 & 5.0 & 4.3 & 4.5 & 2.7 & 0.0 & 3.7 & 0.0 & 4.2 \\
4.0 & 2.7 & 0.0 & 3.5 & 0.0 & 1.7 & 0.0 & 4.5 & 2.8 \\
2.0 & 2.5 & 0.0 & 0.0 & 5.2 & 4.2 & 4.0 & 4.7 & 2.0 \\
3.6 & 3.1 & 3.8 & 3.7 & 4.0 & \text{4.5} & 4.3 & 4.5 & 3.7 \\
\end{bmatrix}
\]

For example, the residential load \( a_{41} \) in LM consumes 3 MW; \( \sigma_{43} \) has a 0.31 importance in IM, however, so under contingency conditions, \( a_{43} \) is shed to 0.0 MW as shown in Figure 7. The total load on the grid after shedding is thus 335.1 MW, which is lower than the supply of power, 340 MW.
Figure 7 shows that feeders 4, 5, 9, and 11 are switched off (set to 0 MW) as they have low importance factors. Shedding these feeders from substation 1 allow investigation of the balance between the demands and supply of power without risking critical feeds.

4.2 Load shedding based on importance with additional reduction factor

Most load shedding strategies based on importance are bounded by a fixed load that may be shed lower or higher than the actual loads available, as shown above in the previous section. Another reduction technique is to reduce the load slightly until the supply recovers, with practical RM implementation based on Eq. (4):

\[ RM = [0.71 0.55 0.99 0.54 0.61 0.53 0.98 0.49 0.86 0.97 0.73 0.52 0.55 0.50 0.99 0.49 0.65 0.75 0.61 0.58 0.51 0.53 0.8] \]

Each value in RM represents a reduced value for each load in the LM. Under disturbance conditions such as overloading, the gap between supply and load is thus reduced to allow the system to operate without collapse.

Where the exponent value (N) is equal to 1 in Eq. (4), loads within a particular category of low importance will be gradually reduced based on Eq. (6). Thus, a new LM is generated:

\[ LM = [3.00 2.79 4.30 2.46 2.70 2.16 3.70 0.98 4.20 4.00 2.70 1.58 1.94 1.51 1.70 1.22 4.50 2.80 2.00 1.47 1.38 2.55 5.20 2.30] \]

After reducing the load by RM, the LM does not have any zero values. For example, \( a_{41} \) in LM consumes 3 MW, and \( c_{41} \) in the IM; \( \beta_{41} \) is 0.52 in the RM, and \( a_{41} \) thus consumes 1.58 instead of 3 MW. The non zero values after reduction are shown in Figure.8. The total load after reducing the loads with RM is 337.924 instead of the 335.1 MW produced by allowing zero value; however, this value is close to the desired load shedding level. Furthermore, the strategy can reduce the load anywhere in the LM with low priority in order to recover high priority loads’ continuous supply.
Figure 8. Practical Loads After Reduction in Feeders 4, 5, 8, 9, and 11.

From the Figure 8 demonstrates that all feeders remain in operation; there is no shedding of loads, though reductions are seen in feeders 4, 5, 8, 9, and 11. In Figure 7, the feeders 4, 5, 8, 9, and 11 are switched off and their values are thus 0 MW, while in Figure 8, feeders 4, 5, 8, 9, and 11 have reduced values, dropping from 10.3 MW to 6.16MW in total as shown in Figure 9.

Figure 9. Practical Loads after Reduction

An explanation of the variance of the reduction of the loads scheme at each substation with and without $\beta_{nm}$ is shown in Table 1.

Table 1. Reduction of load based on PDs at each substation, with and without $\beta_{nm}$.

| Sub. No. | Power demand at Sub. | Reducing power at Sub. |
|----------|----------------------|------------------------|
|          | Without $\beta_{nm}$ | With $\beta_{nm}$       |
| 1        | 39.5                 | 29.2                   | 33.33919  |
| 2        | 43.8                 | 34.4                   | 28.90347  |
| 3        | 52.3                 | 32.4                   | 38.55032  |
The reduction of loads and load shedding based on importance are also shown in Table 1, along with the amount of power to be shed and the reduction in the distribution network at each substation.

Finally, Table 1 offers a summary of the comparison between the proposed load shedding and reductions based on priority of demand at each substation. This shows that the value of the load reduction scheme based on $\beta_{nm}$ is the lowest, minimising the gap between the supply and demand of power, thus maintaining critical loads under continuous operation.

### 4.3 Optimal load shedding based on importance with a reduction factor using the Genetic Algorithm

At the control center, the consumption power of each feeder at each substation can be obtained in real-time along with the importance range for each feeder. This can be used as input to the optimisation algorithm in order to compute the optimal load reductions, as shown in Figure 5. The aim of the function is to diminish the error in load reduction between the required amount of load to be reduced and the actual amount of the load. For the real system of 126 feeders with the importance range shown in Figure 1, using each feeder as an input to the GA to obtain the optimal importance as shown in $IM$ produces the following:

$$IM = \begin{bmatrix} 0.6179 & 0.3026 & 0.9821 & 0.3690 & 0.9724 & 0.7484 & 0.9756 & 0.5172 & 0.3634 & 0.9203 & 0.9307 & 0.3120 & 0.3595 & 0.2618 & 0.9936 & 0.4451 \end{bmatrix}$$

The importance of each feeder is determined high or low in order to investigate the amount of the load required for reduction. The optimal reduction value is then obtained, as the $RM$ is based on the reduction factor, which depends on the importance factor as calculated by the GA in order to obtain a minimum error in reducing the load:

$$RM = \begin{bmatrix} 0.6794 & 0.5429 & 0.9971 & 0.5186 & 0.5322 & 0.9897 & 0.4921 & 0.8823 & 0.9302 & 0.7431 & 0.5121 & 0.4875 & 0.9792 \end{bmatrix}$$

At this point, the feeder with the lowest importance is included for reduction, and the GA is applied to it. When the feeder has the highest priority, it is not incorporated for reduction. The GA was executed on the remaining feeders until the supply exceeded the loads as follows:

$$LM = \begin{bmatrix} 3.000 & 2.714 & 4.300 & 2.734 & 2.700 & 2.660 & 3.700 & 0.984 & 4.200 & 4.000 & 2.700 & 1.563 & 1.856 & 1.462 & 1.700 & 2.500 & 4.500 & 2.800 & 2 \end{bmatrix}$$

From the final load matrix, the loads with priorities greater than 0.36 are not incorporated into any reduction. The GA is executed on the residual loads with priorities less than 0.36, as the load to be reduced is lower than the aggregate of the low priority loads as shown in Figure 10.
Figure 10. Load reduction of the feeders at the substation S1 with RM, GA, and PDs.

From the final $LM$, the sum of the domestic and residential load, which has an importance lower than 0.36, is equal to or slightly less than the amount of load to be reduced. The remaining loads, which have importance levels greater than 0.36, are thus not considered for reduction and are kept in operation to the maximum extent possible. The total load after reducing the loads with GA is 339.9615 MW as compared to the 337.924 MW in the initial removal of loads, with an error 0.0385 MW. Table 2 illustrates the variance of the load reduction scheme at each substation with and without GA.

Table 2. Load reduction of the feeders at each substation with and without GA.

| Sub. No. | Power demand at Sub. With PDs | Power demand at Sub. After reduction With $\beta_{\text{RM}}$ | Power demand at Sub. After reduction With GA |
|---------|------------------------------|------------------------------------------------|----------------------------------|
| 1       | 39.5                         | 29.2                                        | 33.33919                         | 34.184                           |
| 2       | 43.8                         | 34.4                                        | 28.90347                         | 29.2176                          |
| 3       | 52.3                         | 32.4                                        | 38.55032                         | 39.1318                          |
| 4       | 43.4                         | 37.4                                        | 32.00796                         | 35.8992                          |
| 5       | 56.3                         | 37                                          | 40.12515                         | 39.3274                          |
| 6       | 52                            | 45                                          | 41.86672                         | 41.6828                          |
| 7       | 42                            | 35.2                                        | 38.72081                         | 38.7239                          |
| 8       | 47.9                         | 42.5                                        | 40.63529                         | 38.6718                          |
| 9       | 55.7                         | 42                                          | 43.77512                         | 43.123                           |
| Total   | 432.9                        | 335.1                                       | 337.924                          | 339.9615                         |
Table 2 explains the system with GA, which provides a large reduction in loads with a minimum error; the fitness function convergence behavior is illustrated in Figure 11, showing convergence on the optimal importance and reduction factor that minimise the error of the reduced loads.

![Fitness convergence of GA.](image)

Figure 11. Fitness convergence of GA.

Figure 11 illustrates the variance in convergence of the fitness function. The GA runs until the required minimisation error, creating a rate value. During the process, the GA algorithm focuses on seeking appropriate solutions to the problem for a maximum number of 1,000 iterations; 12 independent runs of up to 1,000 iterations were thus run. The algorithm generally offered suitable solutions to that minimised the error in the reduced load problem and stabilized near to optimum values.

5. CONCLUSION

The LS process initially presented occurs at feeder level, based on feeder importance. Feeders are disconnected according to the criticality of their demands, with low priority feeders switched off along with all the attached loads. This causes these loads to be over-shed, making the process impractical.

A reduction strategy was suggested to reduce shedding impact on both critical loads and non-critical loads by reducing the effect on the later gradually by utilizing a logarithmic reduction factor. The process includes the multiplication of RM, by implementing IM and LM, resulting on new LM representing the practical new loads based on a lower reduction to allowing investigation of supply-demand balancing. In addition, all loads continue to operate, with greater or lesser reductions in supply. Critical loads such as health care and security installations are thus kept intact without any interruption, while other disturbance is minimised. The results of a practical implementation show the effectiveness of the proposed load reducing scheme, and the logarithmic RM. The strategy for selective reduction of the load was developed with the help of an artificially intelligence technique, GA, an algorithm that can efficiently control the loads based on priority. This successfully minimised the error in load reduction to 0.0385, within 3 % of the required reduction. With the help of this algorithm, critical loads such as hospitals, and data centers, can be exempted from any load reduction, and the method can be extended to enable partial reductions of load, ensuring a certain amount of power supply to critical loads even where load reduction becomes inevitable. By
determining the LS capacity of each feeder, reductions can be distributed between all the non-critical loads to achieve an effective process and improve the reliability for both essential and unessential loads.

6. FUTURE DEVELOPMENT

Under current schemes, there is no control of individual loads in many countries, and the probability of using power on unimportant loads rather than important loads is quite high. Each load has its own importance level and if supplies are not controlled on this basis, important loads may suffer from shedding. Basic advantages for load shedding based on PDs include the fact that each load can be separately controlled based on the data. This provides opportunities to implement methods for the preserving the continuous operation of critical loads and obtaining the right level of LS. The proposed method offers a unique way to control the loads individually in smart grid environment as well as optimising the value of load to be reduced based on priority assignment. Applying this algorithm could thus allow a control center could manage the load and power distribution to ensure that all available power is utilised appropriately.

LIST OF ABBREVIATIONS

- **LS** = Load shedding
- **PDs** = Priority of demands
- **LM** = Load matrix
- **n** = Index of the network feeders
- **m** = Index of the network substations
- **a_{11}** = Assign to the first feeder of the first substation
- **a_{nm}** = Assigned to each element in load matrix
- **Pd_1** = Total demand power.
- **IM** = Importance matrix
- **α_{nm}** = Importance factor.
- **RM** = Reduction matrix.
- **β_{nm}** = Reduction factor.
- **NN** = Exponent of reduction factor.
- **α^{max}** = Maximum value of importance Factor
- **b_{11}** = Assign to the first feeder at the first
substation after reducing the load.

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