International Journal of Engineering &Technology, 7 (4) (2018) 6528-6533

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET
doi: 10.14419/ijet.v7i4.28196
Research paper

Investigation study to achieve a logarithmic reduction strategy for load shedding based on priority demand

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Abstract

Many countries around the globe suffer from a long time power shortage as a result of excess load, lack of generation, and inefficient distribution networks. The load shedding scheme has been extremely implemented as a fast solution for unbalance conditions. Therefore, load shedding is crucial to investigate supply-demand balancing in order to protect the network from collapsing and to sustain stability as possible; however, its implementation is mostly undesirable. The conventional methods of load shedding lead to over or under shedding and this may lead to many problems with the network. Under the scheme, these methods disconnect the load or the entire feeder without considering their priorities and may not perform as anticipated. In this work, we propose a logarithmic reduction method to reduce the load according to the priority and day life criticality. The method for shedding the loads base on Reduction Matrix and which in turn depend on the priority demands. The higher priority demands are fed with a reliable power source by the real-time monitoring of the network accompanied with power reducing for the lower priority demands. We test a real data sample provided by the Iraqi national grid control center in Baghdad. Our simulation results prove the effectiveness and practicality of the applied method paving the way for possible applications in power systems.

Keywords: *Load Shedding; Load Matrix; Priority of Demand; Importance matrix; Reduction Matrix.*

1. Introduction

Most non-developing and under developing countries strive hard to tackle the situation of power crisis and to combat the imbalance between the power generation and load demand especially in the case of increasing of the population which leads to the load exceeds the limitation of the network. Thus, it will be a challenge to the power system to cater the increasing of demand while maintaining the system stability[1]–[4]. In this scheme, load shedding (LS) is a necessary strategy to reduce the requirements of some loads to compensate for big difference and to keep the load under specified power[5]–[8].

Several of the conventional techniques shedding the loads–under frequency load shedding (UFLS) and under voltage load shedding (UVLS) are independent design, either excessive or insufficient and without estimating the actual power imbalance.

These techniques may have a slow response time so that this fact may lead to problems in power system quality and tripping in the total power system because of the restriction on the real-time monitoring[9]–[11]. Adaptive LS scheme then was developed to improve the traditional LS methods by adaptive selection the parameters of the proposed schemes and estimation the rate change of the network frequency through measuring the magnitude of the disturbance[12]–[14]. The authors in ref. [15], [16]proposed combinatorial algorithms to combine (UF- UV) LS that the frequency and voltage signals are locally measured to enhance the adaptive LS method in the power system. However, the operations of the conventional, adaptive and the proposed LS scheme are unsuitable to perform in large scale power system and unhandled the various forms of the contingencies. In addition, these technics are also incapable to shed a precise amount of the loads[17].

However, there are a few research works have done the load categorization/priority based LS systems. In [18]–[20] for example, the LS based on importance has been proposed for loads to improve the performance of the power system during contingencies and to minimize the impact of the LS on the consumers by taking the social factors into consideration.

In this work, we propose a reduction strategy for LS based on priority demands (PDs). Through this approach, we first prioritize the loads according to their importance and apply a logarithmic reduction matrix. We test a practical case in the Iraqi national grid and the simulation results showed a reduction in demands while the supplied power to the important loads kept intact. The selective LS improved the system reliability and effectiveness for the critical loads.

In what follows, we first in section 2.1 underlay the categorization strategy of loads importance. Section 2.2 presents the main theoretical result of this work. We present the reduction algorithm and drive the mathematical modeling for reducing the shedding process. The response of a power system without the suggested logarithmic reduction method is shown in section 3.1. Finally, we put in section 3.2 the full system with the reduction factor in to test using real data.

2. Mathematical background

2.1. Loads categorizations

Whenever there is a shortage of supply in a system, an alert is sent to the control center in order to release certain load demands. In the conventional technique, a whole feeder is switched off regardless of the load type which belongs to that particular feeder based upon the demonstrative calculations for keeping the system in nominal operating.
In practice, different types of loads, such as domestic, health care, etc. could be connected to a single feeder. Thus, that single feeder could have a variance of demand priorities which may be considered to include the diverse type of loads. Hence, in the presented scheme, a feeder will have a priority mechanism based on the PDs.
In other words, any feeder included in a power system can be considered to have lower or higher importance predicated on the number and type of the loads e.g. critical or non-critical loads which connected to a particular feeder. So, non-critical loads which have been selected for shedding in order to preserve the power supply to the load with higher PDs. Critically definition in this paper depends only on the nature of loads that are associated with its effect on the life safety of people, these loads consist of healthy installations such as hospitals, call center, and fire stations. Since such loads have high priority, it consists of criticality factor. Each type of load will have its own importance and can be categorized based on their criticality and the range of load importance distribution is shown in Table.1.

Table 1: Loads Categorizations Based on the Importance

Categorization	Sample of loads	Importance
Healthcare	Hospitals, Health care units, Medicals…	0.9 – 1.0
Communication, Transportation	Telephony, Datacenters , Airport	0.8 – 0.9
Security	Defense installations, jails …	0.7 – 0.8
Services, financial	Water works, pump station, banks…..	0.6 – 0.7
Industrial	Factories , maintenance centers	0.5 – 0.6
Commercial	Residential Shops center, malls, theatres….	0.4 – 0.5
Residential	Residential congregation	0.3 – 0.4
Domestic	Public utilities, lighting loads	0.1 – 0.3

From table 1, each category of loads will its own importance value between (0.1 - 1.0) so the value of the importance will be increasing according to the criticality of the load itself. At the first type, which has been considered as critical loads like health care includes hospitals will have high importance value between (0.9 - 1.0). The second type is the communication installations that considered also as critical loads, but with the importance (0.8 - 0.9) such as data centers. Consequently, the last type of categorization which has been considered as non-critical loads (0.1 - 0.3) is the first one to be shed in the implemented scheme while the loads at the first type are the last one being shed.

2.2. Importance scheme for loads

In this section, we propose a reduction method to control network load distributions and to direct its resources to the most important services. To convert the actual geographical distributions of the loads in the network, we construct the load matrix (LM) as follows:

$$Load\ Matrix\ (LM)\ =\begin{bmatrix} a_{11} & \cdots\cdots & a_{1m} \\ a_{21} & & a_{2m} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots\cdots & a_{nm} \end{bmatrix}_{n\times m} \qquad (1)$$

Where m = 1, 2, 3… index the network substations and n = 1,2,3…index the network feeders that connected to each substation, respectively. For instance, $\boldsymbol{a_{11}}$ assign 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 convenient for optimization and mathematical handling, and also, for the syntheses of the control system nodes.
Next, we construct a matrix analogous to the LM and refer to it as the importance matrix (IM):

$$Importance\ Matrix\ (IM)\ =\begin{bmatrix} \propto_{11} & \cdots\cdots & \propto_{1m} \\ \propto_{21} & & \propto_{2m} \\ \vdots & \ddots & \vdots \\ \propto_{n1} & \cdots\cdots & \propto_{nm} \end{bmatrix}_{n\times m} \qquad (2)$$

Where m, n =1, 2, 3 …, $\propto_{nm}$ is the importance factor assigned to each a_{nm} in LM, and its value normalized between (0.1-1.0) basing on the suggested categorization of loads in Table.1. When the criticality is high the $\propto_{nm}$ approach unity. Obviously, matrices sizes are equal and depend on the number of a particular substation and feeders that interconnected in the network system.
Up to this point, we define the data of the network loads and their importance as the matrices entries (LM and IM) to the reduction process. The factor of reduction is implemented based on $\propto_{nm}$ in order to keep a_{nm} that has a high importance without reduction and reduce a_{nm} with low importance. So, the equation of the reduction factor is shown as:

$$\beta_{nm} = \left(\frac{e^{\propto_{nm}}}{e^{\propto_{max}}}\right)^N \qquad (3)$$

Where β_{nm} is the reduction factor based on the importance factor $\propto_{nm}$ in the IM.
$\propto_{max}$ is the maximum value of importance factor in the IM
N is the exponent of rtheeeducationfactor
The reduction factor results from dividing the exponential of the importance factor $\propto_{nm}$ to the exponential of maximum importance factor $\propto_{max}$ in the IM under the exponent of N that can be seen in Fig.1. Each element in the LM will have its own factor of reduction that based on IM.

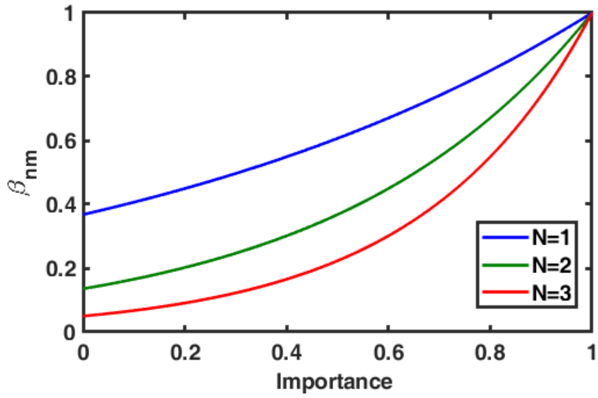


Fig. 1: The Reduction Factor β_{nm} (Eq.3) with the Importance as the Reduction Exponent (N) Increase.

From Fig.1, which can be used to illustrate the effect of increasing the exponent of N on the performance of the reduction formula β_{nm} and $\propto_{nm}$. When the value of N is doubled, the rate change of β_{nm} is increasing and the reduction value is also increasing at the low value of $\propto_{nm}$ is assigned in the second curve. Furthermore, as more of the reducing is assigned in the last curve.
These factors are represented within a matrix called Reduction Matrix (RM) as follow:

$$Reduction\ Matrix\ (RM)\ =\begin{bmatrix} \beta_{11} & \cdots\cdots & \beta_{1m} \\ \beta_{21} & & \beta_{2m} \\ \vdots & \ddots & \vdots \\ \beta_{n1} & \cdots\cdots & \beta_{nm} \end{bmatrix}_{n\times m} \qquad (4)$$

Where m, n =1, 2, 3 …, β_{nm} is the reduction factor. The structure (i.e. n x m) of each matrix RM and IM depend on the dimension of

the LM that associated with the size of the electrical network that modeled. RM is considered as the adjudication matrix approach. This approach is generated by making a decision for reducing the elements in LM under restriction imposed by the PDs and the real life situation.
Under the current LS scheme, the reduction factor that depends on the importance is proposed for reducing the feeders under lower importance with relative reducing (i.e. not switched off or cut off). The equation of reduction of the load as shown below:

$$LM\,[b_{nm}] = RM[\beta_{nm}] \times LM[a_{nm}] \quad (5)$$

Where the $LM\,[b_{nm}]$ after reduction is shown within the matrix:

$$LM\,[b_{nm}] = \begin{bmatrix} b_{11} & \cdots\cdots & b_{1m} \\ b_{21} & & b_{2m} \\ \vdots & \ddots & \vdots \\ b_{n1} & \cdots\cdots & b_{nm} \end{bmatrix}_{n\times m} \quad (6)$$

Where b_{11} is represented the first feeder at the first substation after balancing by reducing the load proportionality through

$(b_{nm} = \beta_{nm} \times a_{nm})$.

Processes of the multiplication RM according to implementing IM and LM, resulting in new LM is represented the practical new loads with a lower reduction to investigate supply-demand balancing.
In addition, all the loads will operate, but with the different relativity of reduction.
This reduction is higher for non-critical loads and low or not exists for critical loads in order to maintain the operation of the important loads to the maximum extension possible.
A detailed flowchart that clarifies the implementation process of the proposed reduction of loads is as shown in Fig. 2:

1) Set the available power value and the demand of the load.
2) Construct LM and RM that based on the IM and set N = 1 in Eq.3.
3) When the first condition takes place, all the loads will be operating and if not then apply the reduction process in Eq.5.
4) All the loads with high importance will be operating when the second condition is investigated, if not then increase N + 1, otherwise return back to the process in Eq.5.

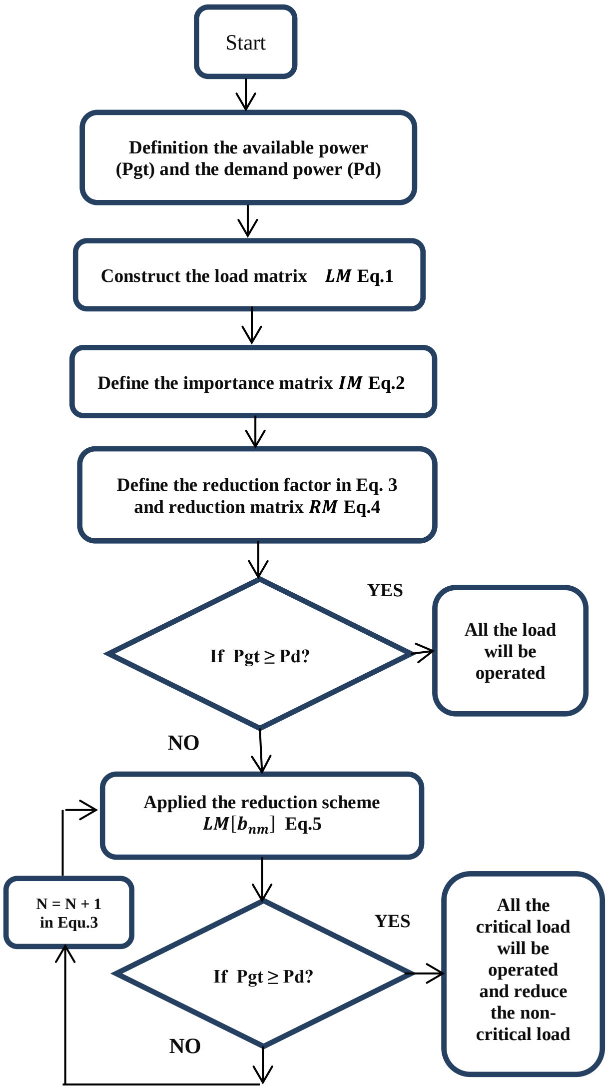


Fig. 2: Flowchart of the Reduction Loads Process.

From the Fig.2, in case of the power system is in an abnormal operating state, the reduction scheme is applied based on the load importance. When the gap between the supply and demand power is huge, the value of the N in the Equ.1 is increasing as shown in the Fig.2 in order to increase the reduction of the loads.
Perhaps some critical loads will have a relative of the reduction factor so that the amount of load to be shed should be from critical loads until investigating the balance. Furthermore, the restoration of critical loads is crucial and should be achieved as quickly as possible and must be high prioritized over all other loads in the system.

3. Case study and result

A real hourly demand data of the present year for the capital of Iraq (Baghdad city), [20] were used to test and evaluate the simulation results of the load shedding and reducing program. The applied practical system includes a number of substations and each of them contains a number of feeders for Baghdad National Grid (BNG). Choosing of a regional power network is according to the geography and the actual operating parameters of the substations are belonging to different categories of loads. The implemented scheme of the load shedding on BNG developed by using MATLAB of R2014 a version.

3.1. Load shedding based on importance without a reduction factor

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

$$LM = \begin{bmatrix} 3 & 5 & 4.3 & 4.5 & 2.7 & 5 & 3.7 & 2 & 4.2 \\ 4 & 3.5 & 2.5 & 2 & 4.8 & 4 & 3.6 & 3.7 & 4.5 \\ 2.7 & 3 & 4.5 & 2.5 & 5.2 & 4.7 & 3.1 & 4 & 5 \\ 3 & 1.7 & 2.8 & 2.7 & 4.2 & 2 & 3.8 & 3.8 & 3.8 \\ 3.3 & 2.3 & 4 & 3 & 4.7 & 4.8 & 2.8 & 3 & 3.3 \\ 2.2 & 2.5 & 3.7 & 2.5 & 5 & 3.4 & 2.3 & 4 & 3.7 \\ 3 & 1.8 & 2.3 & 3.3 & 4.8 & 2.5 & 2.8 & 3.7 & 4.2 \\ 2.5 & 3.5 & 1.8 & 2.3 & 3.7 & 3 & 2.3 & 3.4 & 4 \\ 2 & 2.3 & 5 & 3.3 & 2.5 & 3.8 & 4 & 2.3 & 3.5 \\ 2.5 & 3.5 & 5.2 & 3.3 & 5 & 2 & 2.9 & 3.7 & 4.6 \\ 2 & 5.2 & 4.7 & 5 & 5.2 & 5 & 4.6 & 4.5 & 4.5 \\ 4 & 2.8 & 4.3 & 3 & 2.8 & 4.3 & 2.6 & 3.5 & 2.2 \\ 2.8 & 3.8 & 4.2 & 3.7 & 3 & 5 & 0.3 & 3 & 4.2 \\ 2.5 & 2.9 & 3 & 2.3 & 2.7 & 2.5 & 3.2 & 3.3 & 4 \end{bmatrix}$$

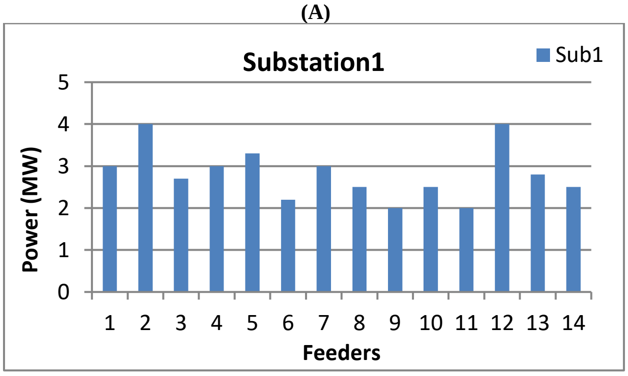
Where m = 9, n = 14 represents the substations number (33/11) KV and the feeders number. These feeders will have different types of loads such as (lighting loads, commercial, industrial … etc.) under various priorities as shown in Fig.3.a. Each number in the matrix denotes the consumed power by load in (MW) which obtained from the particular control center unit. The total demand power for utilized a sample of the BNG is 432.9 MW.

Each feeder in the LM will have its own priority based on the load category and this priority will be defined in the IM as shown in Fig.3.b. Add this matrix also imported the real-life data as shown:

$$IM = \begin{bmatrix} 0.62 & 0.37 & 0.94 & 0.35 & 0.47 & 0.32 & 0.93 & 0.24 & 0.81 \\ 0.92 & 0.36 & 0.42 & 0.46 & 0.32 & 0.54 & 0.72 & 0.87 & 0.33 \\ 0.64 & 0.27 & 0.53 & 0.42 & 0.74 & 0.37 & 0.95 & 0.84 & 0.31 \\ 0.31 & 0.95 & 0.67 & 0.28 & 0.35 & 0.46 & 0.64 & 0.34 & 0.59 \\ 0.32 & 0.86 & 0.31 & 0.73 & 0.18 & 0.62 & 0.43 & 0.42 & 0.67 \\ 0.62 & 0.63 & 0.26 & 0.91 & 0.35 & 0.56 & 0.85 & 0.57 & 0.77 \\ 0.91 & 0.42 & 0.82 & 0.72 & 0.32 & 0.37 & 0.25 & 0.39 & 0.33 \\ 0.35 & 0.21 & 0.92 & 0.96 & 0.89 & 0.94 & 0.56 & 0.23 & 0.52 \\ 0.23 & 0.82 & 0.32 & 0.38 & 0.84 & 0.68 & 0.32 & 0.47 & 0.57 \\ 0.55 & 0.35 & 0.36 & 0.33 & 0.34 & 0.21 & 0.65 & 0.72 & 0.95 \\ 0.21 & 0.36 & 0.32 & 0.42 & 0.39 & 0.68 & 0.76 & 0.88 & 0.38 \\ 0.91 & 0.54 & 0.37 & 0.64 & 0.72 & 0.35 & 0.45 & 0.92 & 0.44 \\ 0.56 & 0.35 & 0.87 & 0.71 & 0.69 & 0.91 & 0.68 & 0.36 & 0.37 \\ 0.61 & 0.24 & 0.81 & 0.38 & 0.74 & 0.34 & 0.94 & 0.52 & 0.38 \end{bmatrix}$$

For instance, the value of feeder 2 is 0.92 since its feed the very critical loads (e.g. hospital) and 0.64 for feeder 3 as its feed the pump station and the other value as 0.35 for feeder 8 that its feed the non-critical load.

(A)



(B)

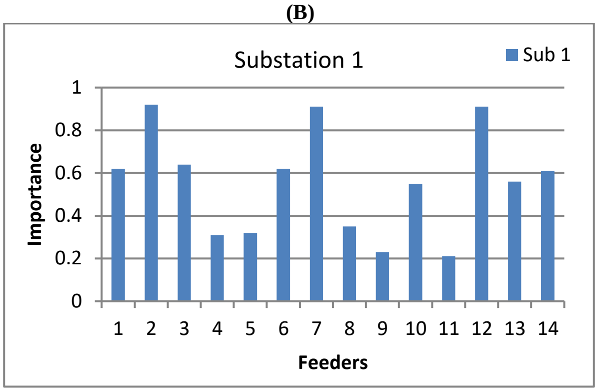


Fig. 3: A) Practical Loads of 14 Feeders Connected to the First Substation. B) Importance Factor for 14 Feeders Connected to the First Substation.

The obtained simulation results showed that the loads having the lowest priority at the instant of load shedding within each category are chosen for shedding as shown in the Fig.2. Therefore, those important loads in every category are kept in operation and loads which are not so important in each category are shed to zero in the new LM as shown:

$$LM = \begin{bmatrix} 3 & 5 & 4.3 & 4.5 & 2.7 & 0 & 3.7 & 0 & 4.2 \\ 4 & 3.5 & 0 & 2 & 0 & 4 & 3.6 & 3.7 & 0 \\ 2.7 & 0 & 4.5 & 2.5 & 5.2 & 4.7 & 3.1 & 4 & 0 \\ 0 & 1.7 & 2.8 & 0 & 4.2 & 2 & 3.8 & 3.8 & 3.8 \\ 0 & 2.3 & 0 & 3 & 0 & 4.8 & 2.8 & 3 & 3.3 \\ 2.2 & 2.5 & 0 & 2.5 & 5 & 3.4 & 2.3 & 4 & 3.7 \\ 3 & 1.8 & 2.3 & 3.3 & 0 & 2.5 & 0 & 3.7 & 0 \\ 2.5 & 0 & 1.8 & 2.3 & 3.7 & 3 & 2.3 & 0 & 4 \\ 0 & 2.3 & 0 & 3.3 & 2.5 & 3.8 & 0 & 2.3 & 3.5 \\ 2.5 & 3.5 & 5.2 & 0 & 0 & 0 & 2.9 & 3.7 & 4.6 \\ 0 & 5.2 & 0 & 5 & 5.2 & 5 & 4.6 & 4.5 & 4.5 \\ 4 & 2.8 & 4.3 & 3 & 2.8 & 4.3 & 2.6 & 3.5 & 2.2 \\ 2.8 & 3.8 & 4.2 & 3.7 & 3 & 5 & 0.3 & 3 & 4.2 \\ 2.5 & 0 & 3 & 2.3 & 2.7 & 2.5 & 3.2 & 3.3 & 4 \end{bmatrix}$$

For example, the residential load a_{41} in LM consumes 3 MW having $\propto_{41}$ is 0.31 importance in IM, so that under contingency condition over loading, a_{41} is shed to 0.0 MW that shown in Fig.4. Therefore, the total load of the grid after shedding will be 335.1 MW which is lower than the supply power that is 340 MW.

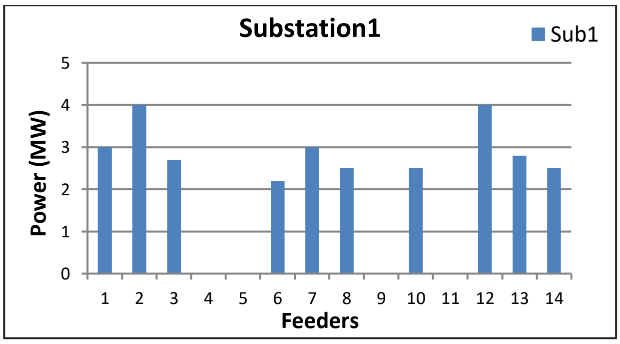


Fig. 4: Practical Loads after Shedding Feeders (4-5-9-11).

We can see that the feeders (4-5-9-11) are switching off (i.e. their values 0 MW) because they have a low importance factor. The aforementioned 4 feeders will be under shedding from the substation 1 in order to investigate the balance between the demands - supply power.

3.2. Load shedding based on importance with a reduction factor

Most of load shedding strategies based on importance are bounded by shedding a fixed amount of loads that may be shed lower or higher than the actual amount of loads as shown above in the section3.1. The reduction technique reduced the load slightly until the supply recovering loads and practical RM implement based on Eq.3 in section 2.2 as shown:

$$RM = \begin{bmatrix} 0.71 & 0.55 & 0.99 & 0.54 & 0.61 & 0.53 & 0.98 & 0.49 & 0.86 \\ 0.97 & 0.55 & 0.49 & 0.61 & 0.53 & 0.66 & 0.79 & 0.92 & 0.53 \\ 0.73 & 0.50 & 0.65 & 0.58 & 0.81 & 0.55 & 0.99 & 0.89 & 0.52 \\ 0.52 & 0.99 & 0.75 & 0.51 & 0.54 & 0.61 & 0.73 & 0.54 & 0.69 \\ 0.53 & 0.91 & 0.52 & 0.80 & 0.46 & 0.71 & 0.59 & 0.58 & 0.75 \\ 0.71 & 0.72 & 0.50 & 0.96 & 0.54 & 0.67 & 0.90 & 0.68 & 0.83 \\ 0.96 & 0.58 & 0.87 & 0.79 & 0.53 & 0.55 & 0.49 & 0.57 & 0.53 \\ 0.54 & 0.47 & 0.97 & 0.77 & 0.94 & 0.99 & 0.67 & 0.53 & 0.65 \\ 0.48 & 0.87 & 0.53 & 0.56 & 0.89 & 0.76 & 0.53 & 0.61 & 0.86 \\ 0.67 & 0.54 & 0.55 & 0.53 & 0.54 & 0.47 & 0.74 & 0.79 & 0.99 \\ 0.47 & 0.55 & 0.53 & 0.58 & 0.57 & 0.76 & 0.82 & 0.93 & 0.56 \\ 0.96 & 0.66 & 0.55 & 0.73 & 0.79 & 0.54 & 0.60 & 0.97 & 0.60 \\ 0.67 & 0.54 & 0.92 & 0.78 & 0.77 & 0.96 & 0.76 & 0.55 & 0.55 \\ 0.71 & 0.49 & 0.86 & 0.56 & 0.81 & 0.54 & 0.99 & 0.65 & 0.65 \end{bmatrix}$$

Each value in RM represents the reduced value for each load in the LM. Under disturbance condition such as overloading, the gap between supply and load is small value and the system will be operating without collapsing. Therefore, the exponent value (N) is equal to 1 in Eq.1 then loads within a particular category having low importance will be gradually reduced not totally from its value based on the Eq.5. Thus, the new LM is generated as shown below:

$$LM = \begin{bmatrix} 3 & 2.79 & 4.3 & 2.46 & 2.7 & 2.66 & 3.7 & 0.98 & 4.2 \\ 4 & 1.94 & 1.22 & 2 & 2.55 & 4 & 3.6 & 3.7 & 2.42 \\ 2.7 & 1.51 & 4.5 & 1.47 & 5.2 & 2.63 & 3.1 & 4 & 2.63 \\ 1.58 & 1.7 & 2.8 & 1.38 & 2.30 & 2 & 3.8 & 2.06 & 3.8 \\ 1.75 & 2.3 & 2.10 & 3 & 2.17 & 4.8 & 2.8 & 3 & 3.3 \\ 2.2 & 2.5 & 1.85 & 2.5 & 2.74 & 3.4 & 2.3 & 4 & 3.7 \\ 3 & 1.05 & 2.3 & 3.3 & 2.55 & 1.39 & 1.39 & 2.11 & 2.25 \\ 1.37 & 1.66 & 1.8 & 2.3 & 3.7 & 3 & 2.3 & 1.81 & 4 \\ 0.97 & 2.3 & 2.66 & 1.86 & 2.5 & 3.8 & 2.13 & 2.3 & 3.5 \\ 2.5 & 1.92 & 2.88 & 1.77 & 2.71 & 0.95 & 2.9 & 3.7 & 4.6 \\ 0.95 & 2.88 & 2.50 & 2.94 & 2.97 & 5 & 4.6 & 4.5 & 2.54 \\ 4 & 2.8 & 2.40 & 3 & 2.8 & 2.35 & 2.6 & 3.5 & 2.2 \\ 2.8 & 2.08 & 4.2 & 3.7 & 3 & 5 & 0.3 & 1.66 & 2.35 \\ 2.5 & 1.42 & 3 & 1.30 & 2.7 & 1.35 & 3.2 & 3.3 & 2.26 \end{bmatrix}$$

LM after reducing the load by RM does not have any zero value. For example a_{41} in LM consumes 3 MW that have $\propto_{41}$ is 0.31 in IM and also have β_{41} is 0.52 in RM. Thus, the a_{41} will consume 1.58 instead of 3 MW and which is none zero value after reduction as shown in Fig.5. The total load after reducing the loads with RM will be 339.7 instead of 335.1 MW and this value closed to the desired load shedding. Furthermore, the strategy has to reduce the load anywhere in the LM that has low priority in order to recover high priority loads with the continuous supply.

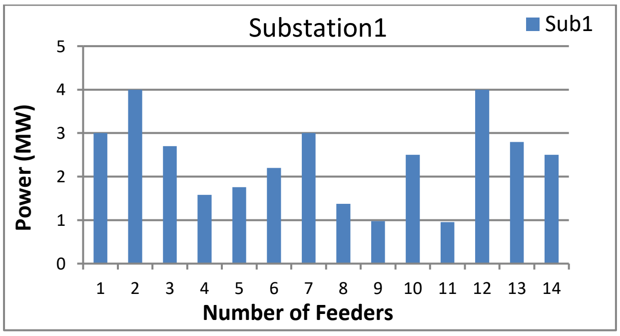


Fig. 5: Practical Loads after Reduction Feeders (4-5-8-9-11).

We can see from the Fig.5 that all feeders will be kept in operation and that means there is no shedding of loads but reduction only the feeder (4-5-8-9-11). In addition, from the Fig.4 the feeders (4-5-9-11) at first substation are switching off and their values will be 0 MW. But in Fig.5, the feeders (4-5-8-9-11) are being reduced their values from 12.8 MW to 6.62MW. To explain the variance of the LS scheme with and without β_{nm} , Fig.6.

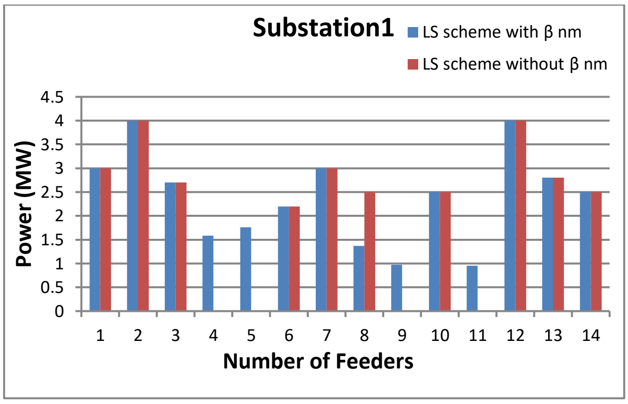


Fig. 6: Practical Loads after Reduction Feeders (4-5-8-9-11).

From the above figure, the red colure feeders (4-5-9-11) at first substation are switching off, but the blue colure feeders (4-5-8-9-11) will reduce its value from 12.8 MW to 6.62MW.

4. Conclusion

We first presented a LS process that takes place at the feeder's level based on their importance. Feeders will be disconnected according to the criticality of the demands. Consequently, low priority feeders are switched off along with all the attached loads. We find these loads are over-shed and therefore the process is impractical.

We suggested a reduction strategy to reduce the shedding impact on the critical and non-critical loads by reducing the later gradually based on a logarithmic reduction factor.

Processes of the multiplication RM according to implementing IM and LM, resulting in new LM is represented the practical new loads with a lower reduction to investigate supply-demand balancing. In addition, all the loads will operate, but with the different relativity of reduction.

In this case, the critical loads such as health care and security installation are kept intact without any interruption as possible. The result of the implementation shows the effectiveness of the proposed load reducing scheme, as well as the logarithmic RM. Moreover, in order to determine the LS capacity of each feeder, the reduction can be distributed between all the non-critical loads to achieve an effective process and improve the reliability of essential and unessential loads.

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