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Research Article

THE EVALUATION OF THE EFFECTS OF STRATEGIC DISTRIBUTED GENERATORS ON THE FUNCTION OF INTELLIGENT POWER DISTRIBUTION NETWORK BY GENETIC ALGORITHM

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ABSTRACT
The use of reproducible energies has acquired higher significance in our time. A majority of the countries of the world tend to shift to production of electricity through reproducible sources. Among the different reproducible energies, the solar energy has always been studied thoroughly as the biggest energy source of the universe. DG sporadic generators sources have played an increasingly prominent role in a more sufficient distribution system and its certitude. The use of DG generators in the distribution system has a lot of interests for the producing companies, electricity consumers and the society in general. Reduction of lines casualty, the improvement of voltage profiles, reduction of the production of polluting gases, gradation of security and network certitude, improvement of potency quality, releasing the capacities of distribution and transmission systems, delaying the need of investment for expanding the network, gradation of profitability and improvement of security for sensitive and important loads of the distribution networks are among the positive results of using DG for producers and operators of the network. In this article, a method for optimizing the sporadic production in the distribution system has been presented and for a more desirable placement of the DG, mathematical calculations and evaluation factors have been used. The goal of this study is to minimize the casualties and to optimize voltage profile and the comparison of the casualties with and without the DG will be presented. The results will be done on a 20 bass IEEE network and the accuracy of our study will be demonstrated.

Keywords:*Strategic Distributed, Photo Voltaic Systems, Distribution Network, Genetic Algorithm*

INTRODUCTION
In the first years of producing and consuming electric energy, small scattered sources like rivers and small water turbines were used to produce electricity. In fact the idea of strategic distributed production is an old idea and dates back to the late nineteenth century (Philipson and Willis, 1999). Soon with the rapid development of the power industry and manufacturing massive producing and electricity receiving machines, small local energy generators tuned into multi hundred megawatt power plants that covered a great number of consumers, near and afar. Now after almost one century of human's utilization of electric energy in order to have a better life, this industry's designers and programmers all over the world are increasingly tending to the idea of strategic distributed production in an attempt to minimize the scale of production sites and the domain they have to cover. In this article the situation of the strategic distributed production sources as a productive method to produce the energy the consumers need is studied. Also the share of strategic distributed production technologies in the power production market will be analyzed and different strategic distributed production technologies (from the energy source point of view) alongside with the profits of producing energy through reproducible sources will be explained. Utilization of DG generators in interest distribution system will benefit producing companies, electricity consumers and the society in general. Reduction of lines casualty, the improvement of voltage profiles, reduction of the production of polluting gases, gradation of security and network certitude, improvement of potency quality, releasing the capacities of distribution and transmission systems, delaying the need of investment for expanding the network, gradation of profitability and improvement of security for sensitive and important loads of the distribution networks are among the positive results of using DG for producers and operators of the network. In this article, a method for optimizing the sporadic production in the

distribution system has been presented and for a more desirable placement of the DG, mathematical calculations and evaluation factors have been used. The goal of this study is to minimize the casualties and to optimize voltage profile and the comparison of the casualties with and without the DG will be presented. The results will be done on a 20 bass IEEE network and the accuracy of our study will be demonstrated.

Existent Networks

Economic, political, and geographical factors in each county have a great significance in the process of development and advancement of electricity networks. Yet still, it has been years since the basic primary structure of these networks remains as powerful as it was. The existent networks with their hierarchical structure, send the produced power from the power plants to the consumer. These networks in general act as one-way freeways through which all the produced power traverses and is sent to the consumer and there is no bilateral way for the electricity circulation of electricity and simultaneous exchange of information and deciding on the whole electricity system network (Khosravi, 2014).

Figure 1: Traditional production network **-** transmission and distribution of electricity

Available networks which often utilize electromechanical equipment and are operated and controlled with hand interaction, can no longer meet the needs of the new requirements and the electricity industry, especially in the distribution sector needs to utilize digital technology through the intelligent network in order to increase functionality. Some of the deficiencies of traditional electricity networks are as follows:

- Deficiency of the electricity network in managing maximum demand
- The network incapability in creating a secure transmission of information
- Limited capability of the network in using strategic distributed production sources
- Network deficiency with the expansion of electric machines (Khosravi, 2014).

Intelligent Networks

- Modern systems consist of major power plants, distribution and transmission posts, factories and residential areas. In order to send electricity to the consumers, power transmission from the power plant to the consumer is what we need. Here in order to do this transmission we use transmission posts. Also the existence of factories in this system and their need of electricity with exact certitude is an issue. The factories too in their turn most pay an additional price in peak consuming time for the electricity. The residential areas are located at the end of the line which brings about another issue which is the power drop in the end of the line and to make amends, some measures must be taken (Khosravi, 2014).

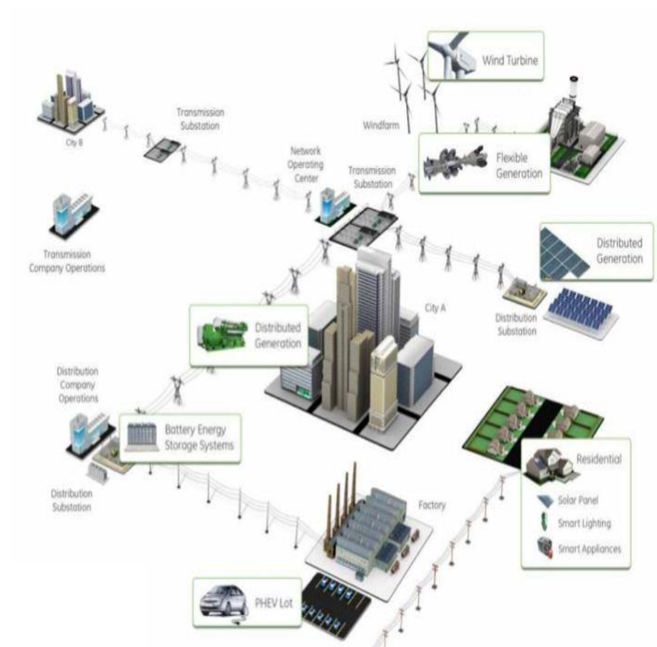

Figure 2: Modern network used to optimize the function of the power system

In intelligent networks of figure 2, however these problems are solved. No more do we need to use a power plant with high capacity, the transmitting power through the lines is reduces and also the reactive flow of the transmission line is reduced because a major part of the produced power is consumed in the place of the production. Industrial units not only do not pay a lot of money in peak time, but also have electricity with higher security and certitude because in case of power outs, battery systems can be utilized. The residential areas solve their problems of power drop that were caused by being located at the end of the line by using solar panels. Pollution is also reduced as the natural green resources have been used to produce energy.

Sporadic Production

In the mid twentieth century years and before the 1970s, the demand for electricity had a set growth rate of about 6-7 percent. The propounded environmental issues and the oil crisis that was caused by political events in the middle-east through the 1970s presented new problems to the world's electricity industry. These factors alongside with changes in global economy caused a drop in the growth rate of electricity consuming from 6-7 percent to 3-6.1 percent in the 1980's (Brown, 1999). At the same time the expenses of transmission and distribution of the energy witnessed a drastic shift of inflammation from 25 percent to 150 percent of the production expanses which was unprecedented. In fact this part of the industry consumed two third of the required investment budgets in the industry. Following the drop in the demand rates, the immethodical increase in the above-mentioned expenses, environmental concerns of the public for the welfare of the nature, reaching advanced technologies and the acceptance of changes in the networks, the massive central power plants were no longer the main concern of the energy producers. In other words the energy production pattern shifted from "looking for commercial profit in sizes and scales" to "decentralized efficient group production" (Lamarre, 1996). This strategic distributed production equipment is often used as tools that help reduce the casualties of power in the network. Strategic distributed production generators can be utilized to make amends for the active and reactive power, like specifying capacitors. In case the DG capacity raises higher than the desired amount, the system will have the same casualty rise as the previous condition which assumes these casualties as more than the minimum increased casualty's amount.

Therefore, the place and amount of DG is thoroughly examined through the stand point of casualty decrease and the optimized amount of strategic distributed production is different from one bass to the other.

The best place can be the bass in which DG transfuses the optimized capacity and is chosen to decrease the casualties. In fact it can be deducted that telling the desired and optimized DG capacity for each bass is the same as reaching an ultimate decision about the right place and the right amount of DG in the distribution system.

Benefits of using Strategic Distributed Production and Reproducible Energy Resources

The increase of utilization of reproducible energy resources instead of fusil fuels is connected to numerous factors, some of which are presented here (IpakchiandAlbuyeh, 2009).

- The well-being of human beings and the environment alike are highly endangered by the immethodical utilization of fusil fuels.
- The energy security of the countries is one of the most important issues related to each country's security. With the current political state of the world, diversity in energy resources is important for all countries.
- The potential to utilize the economic profits of using reproducible energies is a significant factor in investing in this sector.
- The oil and gasoline resources are reducing drastically and their prices rise year by year.
- The expenses for the extraction of oil resources are rising because of the fact that their amount is constantly decreasing and also because the prices of reproducible energy-related technologies are decreasing.

Other than the above-mentioned factors the casualties of the distribution are reduced, the flow of the power in the power networks is also decreased, the trust factor in the network is increased and also the need for investment for solving problems and making amends for the peak time issues is no longer there.

The Problems in the Advancement of Strategic Distributed Production and Reproducible Energies

Utilization of strategic distributed production and reproducible energies has some problems which have helped slowing down the process of their growth in some countries. Among the major problems that the expansive use of these energies faces are the following:

- Paying high subsides to the fusil and nuclear energies.
- A lack of interest in investors for investing in small industries because of their small profit.
- The preference of the government sector over the private sector in investing on massive power plants
- The scattered nature of these industries and the problems regarding their decentralization
- The lack of management experiences in reproducible energies and the high risks that are involved in investing on this sectors and the lack of certainty in their amount of productivity

Of course in less developed or developing countries other problems rise and impose barriers for these energies. These are the major issues:

a) Poor transportation system and difficulty in accessing these industries.
b) Poor telecommunication and correlation infrastructures.
c) Educated work force deficiency.
d) The lack of culture in terms of utilizing reproducible energies.

Also the risk of investing in these countries is very high due to a lack of constant reliable laws and regulation and the investors often do not tend to work in this sector.

The Suggested Algorithm

In this article and in order to reach an optimized solution, the genetic algorithm has been used. This method which is modeled with the consideration of the natural evolution of genes basis, is based on the better chance of choosing members with higher practice or goal dependent (Sedighizadeh and Rezazadeh, 2008). The genetic algorithm is preferred because of its flexibility, the fact that it can be applied on different networks, good convergence speed, reduction of side calculations, and its ability to find the

ultimate optimized and different encrypting methods. The genetic algorithms first start with a group of primary chromosomes. Then according to the limitations and the binds of the problem and with consideration of the goal dependent, each chromosome's propriety is evaluated. Then for producing further generations of the intertwined operators (a mixture of dual tracts) and shift (the random change of one or some bits of a tract) and new offspring's are born. This process is continued until a stop situation is reached and the optimized answer for the algorithm is at hand.
The presented following chart in optimized locating is given below.

The Distribution of the Studied Load

The position-recede method which has been used in the references is presenting an optimized method for distribution of the system's load with casualty estimation convergence criterion. This method consists of a group of load distribution equations of Pi, Qi and Vi that calculated the active, reactive and bass voltage powers. The best method for distributing the system's load is the radial distributions system which reaches convergence in the least amount of time and with the highest speed. In this method the network solution continues systematically from one line to another until all the lines in the network are counted (Khosravi, 2014).

Accurate Load Distribution Results through the Position-Recede Method

Optimized Capacity of DG Resources

This method is conducted based on mathematical equations for the calculation of the optimized capacity of the strategic distributed generator. This approach need a double timed power distribution, the first for the basic case without DG and other through the DG's desired capacity in the network and in a specific bass. This method is calculated through casualty factors and optimized capacity of DG is as what follows:
As it is shown in equation 1, in fact in the minimum level of casualty, the amount of changes in the powers casualty is zero (Acharya *et al.*, 2006).

$$\frac{\partial P_L}{\partial P_i} = 2\sum_{i=1}^{n}\left(\alpha_{ij} P_j - \beta_{ij} Q_j\right) = 0 \qquad (1)$$

In which case α_{ij} and β_{ij} casualty factors and P_j and Q_j are, respectively, the active and reactive streamed power in the branch.

The Calculation of the Desired Optimized DG

$$P_{dgi} = P_{ij} + \frac{1}{\alpha_{ij}}\left[-\sum_{i=1, j\neq i}^{n}\left(-\beta_{ij} Q_j\right)\right] \qquad (2)$$

In the equation above, P_{dgi} is the real DG power to the ith string and alsoP_{ij} is the existent power load in the ith string.
An algorithm for the desired optimized DG is analyzed in the following data:

1. The basic power distribution is done without considering the DG.
2. The amount of the optimized DG (P_{dgi}) is calculated for all basses.
3. The system's casualty for each bass is reached the desired amount of DG (P_{dgi}) and placing in the second stage for the wanted bass and it also determines it. In fact the DG capacity is the one that is injected in the bass.
4. The bass in which the minimum amount of casualty occurs is calculated as the place for locating DG and also as the optimized capacity of DG and is chosen for the wanted bass.

System Evaluation Indicators

Reliability EvaluationIndicator

Considering that every problem, based on its practical concepts, has an appropriate indicator to express system reliability, there are various evaluation methodsassociated with the appropriate indicator in different problems. Generally, there aretwo main methods to evaluate the reliability (El- Khattam and Salama, 2004).

- Analytical Method, and
- Simulation Method.

Calculating Reliability Indicators

Reliability is a probability which is defined as follows:

"Reliabilityof a device or a system is defined as the probability that the device or system, under certain conditions and at any given time(t), results in a successful performance without any errors". Normally, t is considered to be one year.

Reliability is defined as follows:

Failure Rate Function

Failure rate is defined as the rate of error occurrence in the time interval between t1 and t2, and is defined as follows: (Jaganathan, 2002).

$$\lambda(t) = \frac{1}{R(t)}\left[-\frac{d}{dt}R(t)\right] = \frac{f(t)}{R(t)} = \frac{R(t+h)-R(t)}{hR(t)}$$

The three parameters of reliability, namely average failure rate (λS), average outage time(rS), and average annual outage time (US), are as follows:

$$\gamma_s = \sum_i \gamma_i \quad (1\text{-}3)$$

$$U_s = \sum_i \gamma_i r_i \quad (2\text{-}3)$$

$$r_s = \frac{U_s}{\gamma_s} = \frac{\sum_i \gamma_i r_i}{\sum_i \gamma_i} \quad (3\text{-}3)$$

Indicator of Reduction of Power Loss

One of the main advantages offered by DG, is reduction in electrical loss of distribution system lines, which can have considerable losses under heavy load conditions. Using the DG system,it is possible to reduce line loss in the distribution systems. The suggested indicator has been defined as the ration of reduction of in-line losses with assigning DG in bus i, to the maximum reduction of in-line losses with the optimal size of DG in system, and is expressed by the following equation [4] :

$$PLossIn = \frac{(PLoss_0 - PLoss_{dgi})}{(PLoss_0 - PLoss_{dg})_{Opt}} \quad (4)$$

Indicator of Voltage Profile

Voltage Profile is one of the main indicators and factors for the introduction distributed generation sources. Distributed generation sourcesare used in order to improve system voltage profileand maintainterminal voltage in an acceptable range. Consideringthat DG can provide a part of the active and reactive to load power, it can also improveVoltage Profile. So much that it can also contribute to the current decline and thereby increase the voltage in the distribution system.

Voltage Profile Indicator for the i^th node is defined as follows (Iyer*et al.*, 2005):

$$VP_i = \frac{(V_i - V_{min}).(V_{max} - V_i)}{(V_{nom} - V_{min}).(V_{max} - V_{nom})} \quad (5)$$

WhereVP_i is Voltage Profile in the i^th bus, V_{min} and V_{max} are the maximum and minimum allowable voltagesof system nodes, and V_{nom} is nominal or desired bus voltage which is normally about 1pu.

Also, The Voltage Profile Improvement Indicator is defined as follows:

$$VPII_i = \frac{VPIn_{dgi}}{VPIn} \quad (6)$$

Where $VPIn_{dgi}$ and $VPIn$ are Voltage Profile Indicator considering DG and not considering DG in the i^th bus, respectively.

Actually,the value of this indicator is more than 1 and ultimately is changed as follows in order to improve the proper functioning of the distribution network and increase the amount of this indicator:

$$VPIIn_i = \frac{VPII_i - 1}{VPII_{max} - 1} \quad (7)$$

Reduction of Power Losses by DG Indicator Size

Research Article

The size of a network plays a crucial role in DG planning for a distribution network. In fact, discussion of size of the DGis directly related to economic issues. For maximum power loss, the size of DG must be smaller, such that the amount of reduced power loss in each size of DG unit can easily be calculated and named$redploss/pdg$. Therefore, this indicator, along with its specified parameters, is defined as follows: (Khosravi, 2014).

$$redPLoss = \frac{\left(\frac{PLoss_{\ D} - PLoss_{\ dgi}}{P_{dgi}}\right)}{\left(\frac{PLoss_{\ D} - PLoss_{\ dg}}{P_{dg}}\right)_{max}} \tag{8}$$

Where $PLoss_{dgi}$ and $PLoss_D$ are system power losses with considering the DG and without considering DG, respectively, and alsoP_{dgi} size of the distributed generation unit in the ith node.

The System Studied

To evaluate the proposed network method, the 20-bus distribution test was simulated. Figure 4 and 5 demonstrate the single-line diagram of this network. The baseline value, namely 20KV and 20MVA, are extracted from the system. This network consists of 20 distribution transformers with different buses. Transformers details are shown in Table 1.Distribution conductor detailsare shown in table 2, the length of each feederis shown in table 3, and table 4 represents the connected loads to the transformer.

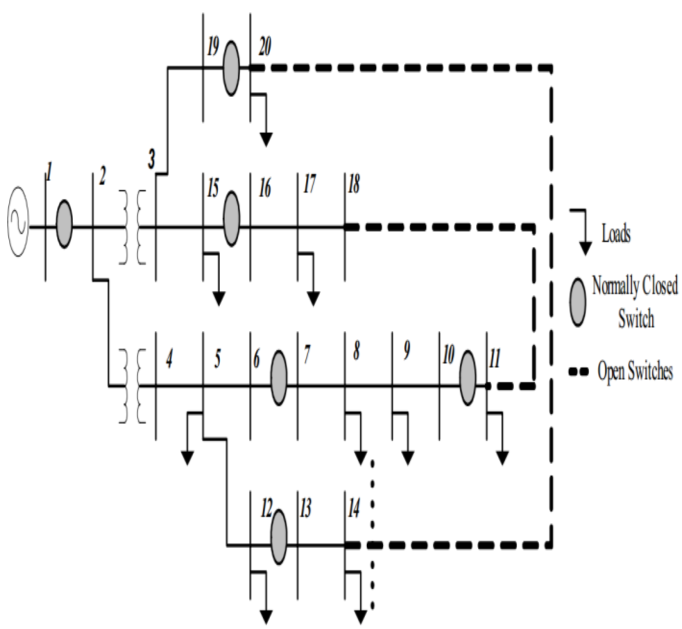

Figure 4: Sample test 20-bus network

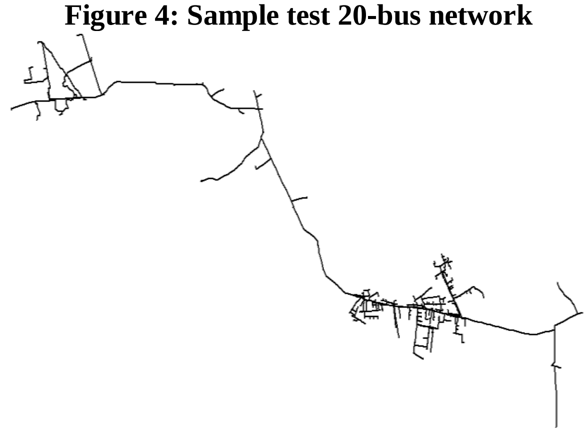

Figure 5: Single-line diagram

Table 1. Transformers details

Rating [KVA]	50	100	250
Number	5	9	6
No load losses [watts]	150	250	480
Impedance [%]	4.5	4.5	4.5

Table 2. Conductors' details

Type	R [Ω/Km]	X [Ω/Km]	Cmax [A]	A [Mm2]
Hyena	0.1576	0.2277	550	126
Dog	0.2712	0.2464	440	120
Mink	0.4545	0.2664	315	70

Table 3. Length of the feeders

From	To	Length (Meters)
1	2	80
2	3	80
3	4	80
4	5	60
5	6	60
6	7	60
7	8	60
8	9	60
9	10	60
10	11	60
11	12	60
12	13	60
13	14	60
14	15	60
14	16	60
16	17	60
17	18	60
18	19	60
19	20	60

Table 4. Connected loads to the transformer

Transformer No	Load [Kva]
1	35
2	245
3	85
4	165
5	50
6	85
7	180
8	35
9	35
10	90
11	85
12	75

13	200
14	73
15	35
16	85
17	98
18	230
19	220
20	85

Evaluation of the Generator Voltage Stability after Installation of Distributed Generation in Distribution System

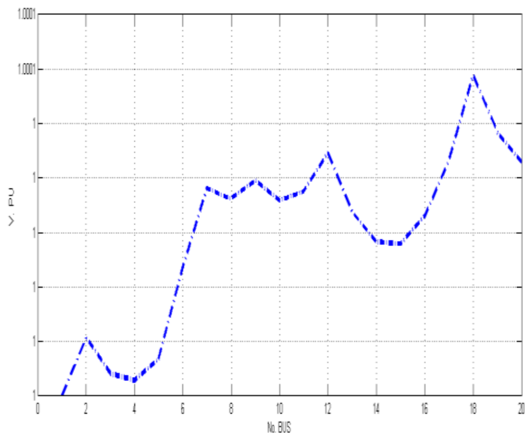

Figure 6. Improved voltage in the case of using DG

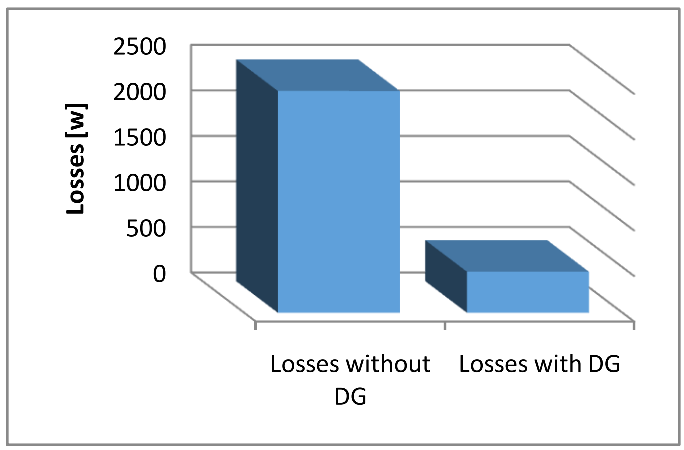

Figure 7. The amount of improved voltage with DG compared to the amount without DG in the study network

Comparison of Network Losses in the Case of using DG and without DG

In this case, total loss in the case of using DG compared to when DG is not inserted, will be reduced 13 times. The results of table 5 show that using DG generators plays an important role in the reduction of system loss which is much better and more cost-effective for the proper functioning of the system at various operating conditions.

Table 5: Comparison of losses in two cases with and without DG

Losses with DG (KW)	**Losses without DG (KW)**
84.4297	1.0736×3

Conclusion

In fact, reforms in the distribution of electrical energyhave significant implications for the operation and reduction of emissions.Distributed generation sources play akeyrole in load demand, reduction of losses, and overall improvement in network management. In this paper, a new approach to determine the optimum location of DGsis provided. First, improvement in network performanceis expressed through reliability-voltageprofile indicator, which is an appropriate indicator for the best possible choice in order to insert distributed generation sources. Also, section 13 shows the stability of the network voltageafter the installation of distributed generation which demonstrates a significant improvement in this profile. Finally, section 14 presents losses in two cases; with the insertion of DG and without the insertion of DG in which case the total loss in the case of using DG compared to when DG is not inserted, in the same bus, will be reduced 13 times.This number shows that the use of renewable sources plays an important role in reduction of pollution. By comparing both traditional and intelligent systems, we conclude that the use of renewable sources in power networks provides the following benefits:

1. Reducing the cost of power equipment (plants have become smaller –transition load from the transmission linehas been reduced and consequently cost of insulation and protection also reduces.
2. Reduction of transmission losses (a large part of the production is produced in the consumer area. Therefore, the transmission line reactive power flow is reduced).
3. Possibility of heat recoveryin distributed generation plants.
4. Installation and operation time of these plants.
5. Reduction of environmental and noise pollution in large power plants.
6. Postponing the construction of new lines.
7. Increases networks efficiency through generating and sending more power.
8. Filled feeders reduce the network load.
9. Reduce networks transmission routes.
10. Improve the voltage profile and network power.
11. Reduction of network peak load.

The obtained results suggest that the above-mentioned approach is a much better and cheaper solution for proper operation of the system at various operating conditions.

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