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Deliverables of Re-configuration in Autonomous Micro-grids

Venkata Kirthiga M* and Arul Daniel S*

Distribution Systems with optimally sized Distributed Generators(DGs) placed at optimal locations would become Micro-grids. These micro-grids operate either in non-autonomous mode (in conjunction with the utility grid) or in autonomous mode (in the absence of the utility grid) depending on the penetration level and sustainability of the DGs connected. This paper has suggested an optimal structure for autonomously operated micro-grids by re-configuring the radial system into a weakly meshed system. The deliverables of the proposed reconfiguration strategy in autonomous micro-grids are discussed in detail in this paper. The proposed reconfiguration strategy is found to ensure continuous power supply to the select customers of the micro-grid by enhancing a stable operation of the generators to avoid formation of accidental islands on line outages and minimizing the distribution losses. MATLAB code has been developed for the proposed methodology of reconfiguration and the standard 33 bus distribution system has been used to validate the proposed algorithm.

Keywords: *Distributed Generation, Autonomous Micro-grids, Re-configuration, Weakly Meshed Systems, Particle Swarm Optimization*

1.0 INTRODUCTION

Modern power distribution systems are experiencing a paradigm shift into de-regulated environment owing to the increased addition of small non-conventional generation sources into the existing systems. The rating of these generators ranges between few kW to few MW and are commonly connected at the consumer end of the low and medium voltage level systems. The development of DGs in low and medium voltage networks causes a structural change in the traditional centralized power system, resulting in de-regulated environment. The key objective of any electricity utility company in current deregulating environment is to maximize the quality of services with acceptable level of voltage and reliability, to reduce the electricity cost for customers, lowering the investment, operation and maintenance costs [1].

Distributed generation encompasses a wide range of primemover technologies, such as Internal Combustion(IC) engines, gas turbines, micro-turbines, photovoltaic, fuel cells and windpower. These emerging technologies have lower emissions and the potential to have lower cost negating traditional economies of scale.The applications include power support at substations, deferral of T&D upgrades and onsite generation[2]. In early days, conventional fossil fuels such as gasoline, diesel, natural gas, propane, methane, gasified coal, etc., were used. But gradually installation of renewable energy power generation started to gain increasing importance and the DG technologies have started to explore the possibilities of generating power using natural resources[3].Indiscriminant application of individual distributed generator scan cause as many problems as it may solve. A better way to realize the emerging potential

*National Institute of Technology Tiruchirappalli, Tirucirappalli-620015, Tamil Nadu. E-mail: mvkirthiga@nitt.edu

of distributed generation is to take a system approach which views generation and associated loads as a subsystem or a “micro-grid”[2]. Such micro-grids are operated in non-autonomous and autonomous modes.

Further, to satisfy today’s increasing energy demand, power sector is concentrating on developing robust, reliable and sustainable autonomous micro-grids, to satisfy the real and reactive power demand of the connected customers.

In this scenario, to exploit the complete potential of distributed generation, proper siting and sizing of DGs become important. A number of algorithms had been developed for optimal siting and sizing of the DGs in micro-grids in literature[4-10]. The authors have also attempted an optimal siting and sizing algorithm which involves minimization of the installation cost of the generators and the distribution losses without violation of voltage limits (±5%), for an autonomous micro-grid.

On completion of the generation planning of an autonomous micro-grid, it becomes a great deal of importance to look into its reliability aspects. In view of improving the technical performance of the planned sustainable autonomous micro-grid, it is desired that an optimal structure should be decided to improve the stability of the autonomous micro-grid. There are many alternatives available for reducing losses at the distribution level: reconfiguration, capacitor installation, load balancing, and introduction of higher voltage levels[11-13]. Re-configuration of the radial distribution systems is applied in view of both protection [14] and configuration management issues for cost minimization [15].

Network reconfiguration is the process of changing the topology of distribution systems by altering the OPEN/CLOSED status of the sectionalizing and tie switches. As there are many candidate-switching combinations in the distribution system, network reconfiguration becomes a complicated combinatorial problem to be solved logically[15]. Many computational and heuristic approaches have been proposed in literature towards reconfiguration of distribution systems[16-18]. But most of these works either concentrate on converting a mesh system into radial system or suggest reconfiguration methodologies for non-autonomous micro-grids where the system stability is guaranteed by the utility grid.

In this context, reconfiguration of a sustainable autonomous micro-grid has been attempted for performance improvement of the micro-grid after addressing the planning issues. Ranking of the buses based on maximum loadable limits (beyond which the voltage limits violation of buses was observed) has been employed to identify the candidate nodes, between which the additional tie branches are to be connected. Also the rotor angle stability of the DGs in the system is also considered as the main issue to be focused during line outages. The optimal structure for the autonomous micro-grid formed by transformation of an existing radial distribution system has been attempted taking into consideration the stability issues of the system to avoid formation of accidental islands. The deliverables of such reconfiguration strategy in an autonomous micro-grid have been discussed in detail in this paper. MATLAB coding has been developed for implementing the proposed strategy and the standard 33 bus radial distribution system has been employed for validation.

The paper is organized with introduction in section I, followed by the description of the autonomous micro-grid adopted in section II. Section III focuses on the proposed reconfiguration strategy and its deliverables in autonomous micro-grids. Section IV explains a case study for validation of the proposed reconfiguration strategy and its deliverables. The paper concludes with section V.

2.0 AUTONOMOUS MICRO-GRIDS

In conventional radial distribution systems, every segment of the system gets its power from only one sub station. This path involves feeders, switches, transformers, etc. The R/X ratio of branches in a distribution system is relatively high which in turn makes the system ill conditioned. A micro-grid is a system that encourage the coexistence of conventional utility grid and distributed generation. To the utility, the Micro-Grid can be thought of as a controlled cell of the power system, controlled as a single dispatchable load, which responds in seconds to meet the needs of the transmission system. To the customer, Micro-Grid can be designed to meet their special needs; such as, enhance local reliability, reduce feeder losses, support local voltages, provide increased efficiency through use waste heat, voltage sag correction or provide uninterruptible power supply functions to name a few[2].

The Point of Common Coupling (PCC) which connects the micro-grid to the main utility grid remains CLOSED in Non-Autonomous mode of operation enabling power exchange with the utility grid. Whereas this PCC is OPENED in Autonomous mode of operation, there by supporting all the loads connected and contributing towards the system distribution losses locally. Such autonomous micro-grids possess the following significant applications:

1. Electrification of remote rural areas where no utility is available.
2. Assurance for a continuous un-interrupted power supply when appropriately switched between autonomous and non-autonomous modes of operation.
3. Reduction of the stress upon the utility grid when the micro-grids are fed majorly by renewable energy based resources and also ensures a sustainable power supply to select customers even when the utility grid fails.
4. A considerable reduction in the distribution losses without compromising any of the power quality issues.

In this regard, autonomous operation of micro-grids alone is given emphasis in this work, in view of ensuring reliable and continuous power supply to select customers even in the absence of the utility grid. This research work mainly aims at suggesting an optimal structure for an autonomous micro-grid through the proposed reconfiguration strategy with a view of improving the voltage profile of the system, reducing the distribution losses and enhancing the reliability of power service.

2.1 Optimal location and sizing of DG units

A presumed number of DGs is decided from literature for the autonomous micro-grid adopted. Particle Swarm Optimization (PSO) technique has been used to solve the objective function shown in eqn. (1) iteratively to determine the optimal location and sizing of the DGs in this work.

$$F_x = \sum_{j=1}^{r} C_j P_{g_j} + \sum_{i=1}^{N}\sum_{k=1}^{N} P_{loss_{ik}} + \left(\sum_{i=1}^{r} P_{g_i} - P_d\right)^2 + \left(\sum_{i=1}^{r} Q_{g_i} - Q_d\right)^2 + \left(V_{i\max} - V_{\max}\right)^2 + \left(V_{i\min} - V_{\min}\right)^2 + \left(0.0001 - I_{(1,2)}\right)^2 \quad ....(1)$$

Subject to

(i) Generator rating constraint: Based on cost per unit peak power generation and modularity, the minimum and maximum limits have been imposed on the generation capacity as:-

$$P_{gi\min} \le P_{gi} \le P_{gi\max} \quad ....(2)$$

(ii) Voltage constraint: The optimal sizing has to be obtained such that there are no bus voltages limits violations, as shown in (3)

$$V_{\min} \le V_i \le V_{\max} \quad ....(3)$$

(iii) Power balance constraint: The following power mismatch constraints are considered:

$$\sum_{i=1}^{r} P_{g_i} \ge P_d \quad ....(4)$$

$$\sum_{i=1}^{r} Q_{g_i} \ge Q_d \quad ....(5)$$

(iv) Feeder current constraint: To ensure autonomous operation, the feeder current constraint shown in (6) is to be satisfied (i.e. current drawn from the feeder should be close to zero).

$$I_{(1,2)} \le 0.0001 \quad ....(6)$$

where

c_j	Cost coefficient of the DG at the j[th] bus
$I(1,2)$	Current drawn from the substation feeder
N	Total number of buses in the system
ΣP_d	Total real power demand in the system
Pg_j	Size of the DG unit connected to the j[th] bus
$\sum_{i=1}^{r} P_{gi}$	Total real power generated in the system
P_{gimax}	Maximum generation limit on i[th] generator
P_{gimax}	Minimum generation limit on i[th] generator
$P_{loss\ ik}$	Real power loss in line between buses i & k
ΣQ_d	Total reactive power demand in the system
$\sum_{i=1}^{r} Q_{gi}$	Total reactive power generated in the system
r	Total number of generators in the system
V_{imax}	Maximum bus voltage magnitude
V_{imin}	Minimum bus voltage magnitude
V_{max}	Maximum limit on bus voltage magnitude
V_{min}	Minimumlimit on bus voltage magnitude

2.2 Choice of the type of the DG units

DGs are considered to be capable of supplying both real and reactive powers(preferably synchronous generators) and the buses to which DGs are connected are modeled as PQ buses. The power factor controller capable of maintaining a constant power factor within ±1% at any set point is assumed to be present at the PQ buses. Hence the real power sizing of the generators alone is considered as the variables in the optimization of the objective function and the reactive power rating of the generators are determined as shown in eqn. (7).

$$Q_{g_i} = aP_{g_i} \qquad ....(7)$$

where $a = (\text{sign}) \tan(\cos^{-1}(PF_{DG}))$and $\mathbf{PF_{DG}}$ is the power factor to be maintained at the generator connected buses in the system.

2.3 Load flow analysis

Several algorithms have been proposed in literature for distribution load flow analysis, which are classified into three categories: direct methods, backward / forward sweep methods and Newton-Raphson based methods[19-26]. In this work, basic Backward and Forward Sweep technique has been modified to suit the load flow analysis of an autonomous micro-grid with DGs. Largest generator is considered to act as the Slack and all other generator connected buses are modeled as PQ injecting buses. After reconfiguring the micro-grid as per the proposed strategy, the system changes to a weakly meshed system and hence the standard Newton Raphson method of load flow analysis is adopted for the reconfigured micro-grid.

3.0 RECONFIGURATION STRATEGY AND ITS DELIVERABLES

Distribution systems are provided with two types of switches namely sectionalizing and tie switches which are initially in CLOSE and OPEN positions respectively, and changed on reconfiguration. Reconfiguration significantly alters the distribution of loads and also the real and reactive power losses in the system. This reallocation of the loads and losses among different buses and branches would be beneficial only if attempted by redirecting the power flows from strong buses to weak buses of the system. Hence in this work a reconfiguration strategy has been attempted for the autonomous micro-grids by identifying the strong and weak buses with respect to their loading capabilities.

3.1 Ranking of buses based of maximum loadable level of real power demand

The proposed algorithm has been followed to identify the buses between which new meshes are to be formed through installation of tie switches. The candidate locations for placing the tie switches have been identified by ranking the buses based on their capability to withstand maximum real power demands without violating the voltage limits. Since the distribution systems possess high R/X ratio, this is found suitable to identify the strong and weak buses with respect to the real power loading. The ranking algorithm has been depicted in the flowchart shown in Figure 1.

3.2 Re-configuration of micro-grids

In the proposed reconfiguration strategy, TIE switches are placed near the locations identified as the strong and weak buses. The operation of the sectionalizing switches in the event of faults may result in islanding of a section of the micro-grid. However, the proposed reconfiguration can avoid the formation of such larger islands and thereby improves the reliability of supply to major section of the micro-grid. A detailed study of the switching of such sectionalizers in the operation of an autonomous micro-grid has not been taken up in this work. The tie switches are normally open and are modified to close position for reconfiguration. Additional tie lines are introduced in the radial micro-grid formed, linking strong and weak buses.

All possible combinations of reconfiguration are identified for deciding the best reconfigured option and for each of the possible configurations, load flow analysis is performed using Newton Raphson method and the total real power distribution losses are determined. After reconfiguration, the micro grid structure resembles a weakly meshed system. The possible configurations are ranked based on distribution losses. Consequent to this ranking, voltage limit violations are checked for each configuration. Hence the best reconfigured architecture for transforming an existing radial distribution system into a weakly meshed autonomous micro-grid is chosen as that structure which has minimal losses as well as the one which does not violate the voltage limits. In addition, the length of the tie lines (for bringing down the cost of the tie lines) and the rotor angle stability of the generators (for ensuring anti-islanding) are also taken into account for deciding the final configuration of the micro-grid. The proposed reconfiguration algorithm has been depicted in the flowchart shown in Figure 2.

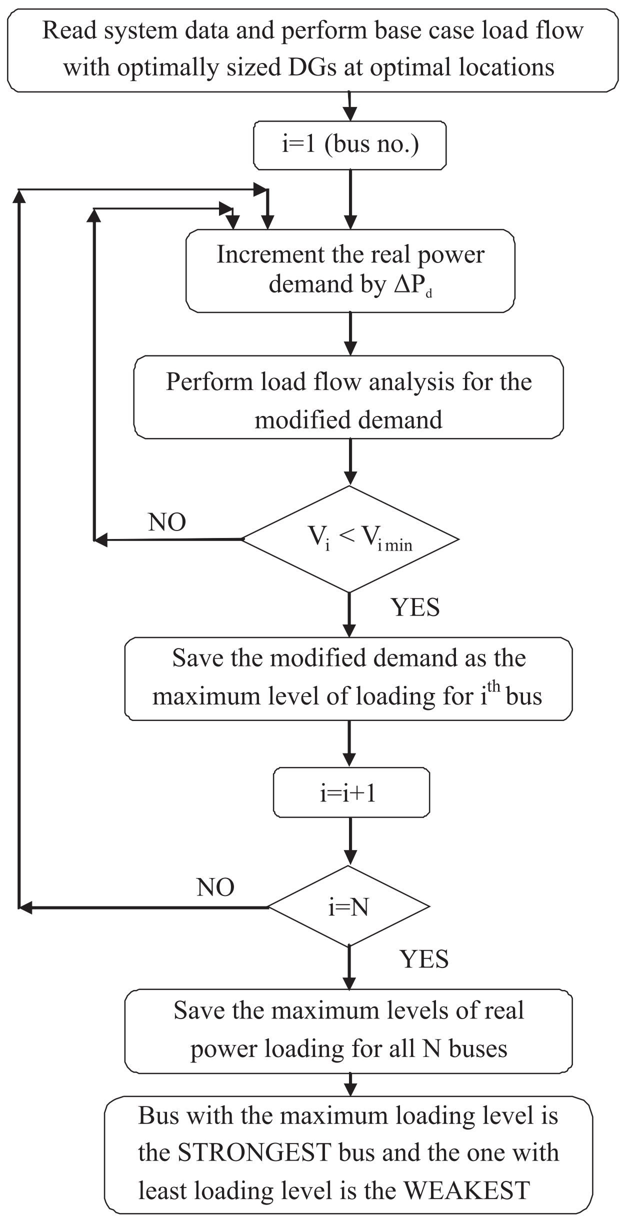

FIG. 1 ALGORITHM FOR RANKING OF BUSES

3.3 Deliverables of reconfiguration in autonomous micro-grids

The main significance of reconfiguration and the suggested weakly mesh structure for an autonomous micro-grid is realized by:

1. Improvement in voltage profile
2. Drastic reduction in the distribution losses
3. Enhanced anti-islanding behavior assuring continuous and reliable power supply

These deliverables are validated in the case study and discussed in detail.

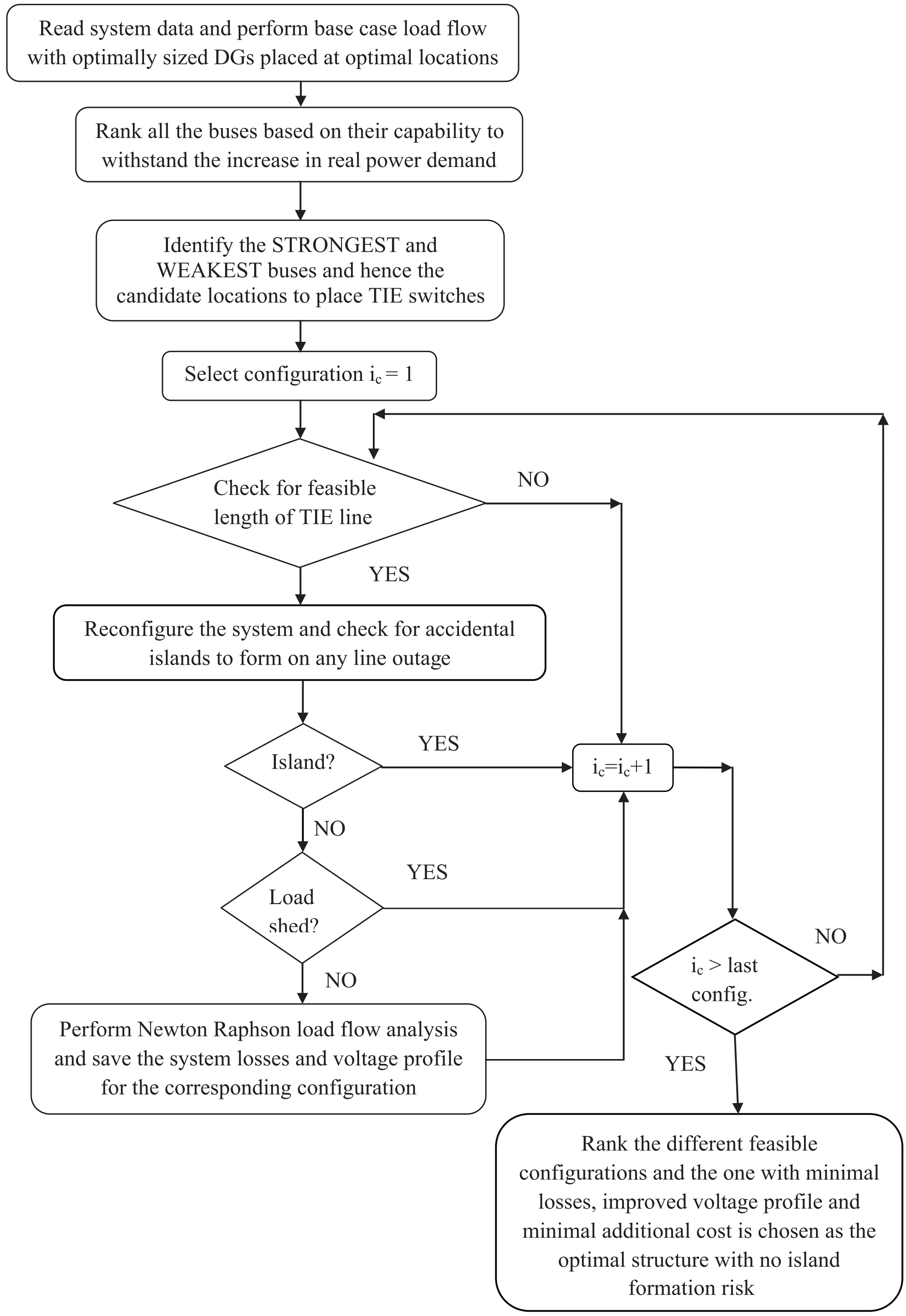

FIG. 2 ALGORITHM FOR RECONFIGURATION OF AUTONOMOUS MICRO-GRIDS

4.0 CASE STUDY

The standard 33 bus distribution system with a demand of 3.715MW and 4.456 MW respectively in summer & winter has been used for validating the proposed strategy and the deliverables of reconfiguration are demonstrated for this system.

4.1 Optimal siting and sizing of DGs

It is determined that for three numbers of DGs the optimal location is viz., **3rd bus, 9th bus & 31stbus** to attain minimal distribution losses without violating the voltage constraints, in the autonomous micro-grid under consideration. The power factor at each DG bus has been considered 0.85 lagging. The base MVA and voltage adopted for the load flow analysis are 100 MVA & 12.66 kV respectively. The objective function shown in eqn.(1) has been solved using PSO. Since winter demand is larger than the summer demand, the analysis is done for satisfying winter demand which satisfies summer demand also. Forward & Backward sweep based load flow analysis has been adopted. The optimal location and size/ rating of the DGs are shown in Table 1.

TABLE 1

OPTIMAL SITING AND SIZING OF DGS

Bus No.	**Optimal sizing / rating of DGs**	
	Real power rating in MW	**Reactive power rating in MVAr**
3	1.9	1.18
9	0.95	0.59
31	1.69	1.04

On placing the DGs at specified locations with the specified sizing, radial distribution system becomes radial autonomous micro-grid as shown in Figure 3.

4.2 Ranking of buses based on maximum loadable limits

Following the flowchart shown in Figure 1, all buses of the system under investigation have been ranked based on their individual capabilities to with stand increase in the real power demands. The strongest bus and the weakest bus are thus determined and are shown in Table 2 for the autonomous micro-grid.

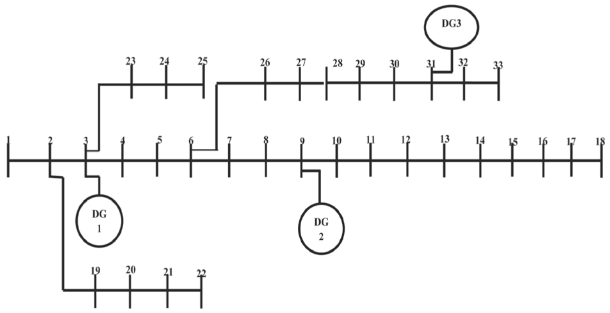

FIG. 3 ONE LINE DIAGRAM OF THE RADIAL AUTONOMOUS MICRO-GRID

TABLE 2

RANKING OF BUSES

Bus No.	**Loadable limit in pu**	**Bus No.**	**Loadable limit in pu**	**Bus No.**	**Loadable limit in pu**
31	0.916	26	0.898	21	0.875
32	0.914	5	0.896	24	0.875
33	0.914	4	0.895	13	0.871
30	0.909	3	0.893	22	0.869
29	0.907	10	0.891	25	0.867
09	0.905	11	0.890	14	0.866
28	0.905	2	0.889	15	0.861
06	0.902	19	0.888	16	0.838
08	0.902	23	0.886	17	0.723
27	0.902	12	0.901	18	0.673
7	0.901	20	0.877		

Table 2 depicts that **31st bus** has the maximum loadable real power demand due to the presence of a generator. But all the top three strong buses are found to be closely present on a sub lateral. However, due to geographical distances between the buses, adding a tie-line connecting the strongest and weakest buses does not guarantee reduction in losses. Hence based on the geographic considerations, **33rd bus** is ranked the ***strongest*** bus.

The other consecutive strong buses are chosen similarly as **30th** and **27th** respectively and the weak buses are also chosen as **12th, 25th and 17th** buses respectively (considering the proximity towards the strong buses). Thus a heuristic alteration of the ranking in the top and bottom three ranks of Table 2 is carried out for reducing the length of the tie branches. As a result ***six*** locations have been chosen (three for strong and three for weak buses respectively), for placing the tie switches to enable additional distribution lines between these locations for different possible reconfigurations. Choice of the optimal locations for the tie switches by including geographical proximity helps to compensate the additional cost incurred on including the tie lines. The optimal locations chosen for placing tie switches are shown in the Figure 4.

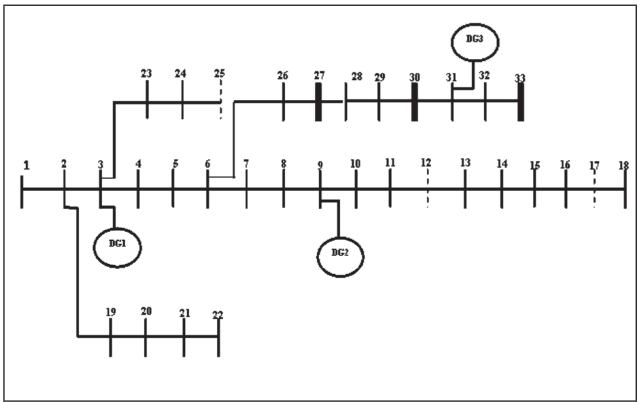

FIG. 4 ONE LINE DIAGRAM OF THE AUTONOMOUS MICRO-GRID WITH OPTIMAL TIE LOCATIONS

4.3 Reconfiguration based on loadable limits

After determining the optimal locations for placing tie switches, it becomes inevitable to identify the geographical feasibility of connecting a strong and weak bus based on the length of the tie line. A total of 27 combinations have been identified as geographically feasible for placing additional tie branches (between a ***strong*** and a ***weak*** bus) as tabulated in Table 3.

TABLE 3

CHOICE OF ALL POSSIBLE COMBINATIONS OF CONFIGURATIONS

From positions	To positions	From positions	To positions
33,33,33	17,25,12	27,27,27	17,25,12
33,33,27	17,25,12	27,27,30	17,25,12
33,33,30	17,25,12	27,30,33	17,25,12
33,27,33	17,25,12	27,30,27	17,25,12
33,27,27	17,25,12	27,30,30	17,25,12
33,27,30	17,25,12	30,33,33	17,25,12
33,30,33	17,25,12	30,33,27	17,25,12
33,30,27	17,25,12	30,33,30	17,25,12
33,30,30	17,25,12	30,27,33	17,25,12
27,33,33	17,25,12	30,27,27	17,25,12
27,33,27	17,25,12	30,27,30	17,25,12
27,33,30	17,25,12	30,30,33	17,25,12
27,27,33	17,25,12	30,30,27	17,25,12
		30,30,30	17,25,12

Reconfiguration based on appropriate switching of tie switches is effected and the total real power distribution losses have been evaluated for each of the possible combinations. These configurations are ranked based on the losses and the best configuration offering minimal losses and additional cost for installation of the tie lines is considered as the optimal structure for the autonomous micro-grid. A comparison of the configurations based on the distribution losses attained and the additional cost incurred for laying the tie lines are tabulated in Table 4. The rate of the additional tie lines has been taken as \$32/km [27-28]. It is evident that such a re-configuration transforms a radial network into a weakly meshed network, thereby improving the reliability of service to customers.

TABLE 4

RANKING OF RE-CONFIGURATION OPTIONS

Rank	Tie switch position	Real power losses in MW	Reactive power losses in MVAr	Additional cost in \$
1	**33-17, 33-25, 33-12**	**0.0237**	**0.0183**	**2976.00**
2	**33-17, 33-25, 27-12**	**0.0237**	**0.0181**	**3303.04**
3	27-17, 33-25, 33-12	0.0237	0.0174	3800.00
4	33-17, 33-25, 30-12	0.0238	0.0183	3100.00
5	33-17, 27-25, 30-12	0.0245	0.0194	2750.00

4.4 Optimal structure for the autonomous micro-grid

Table 4 depicts that the configuration which gives minimal losses needs slightly more additional cost to be invested for laying the tie lines. Hence the final decision on the optimal structure of the autonomous micro-grid under consideration is taken after considering the reliability issues. A radial micro-grid operated in autonomous mode has the possibility of formation of accidental islands due to the occurrence of any electrical disturbances viz., line contingency or line outage. In such an eventuality, a reconfigured weakly meshed network will prevent black-out of major section of the network. In addition, such a re-configuration also improves the voltage profile and hence will bring down the distribution losses, ensuring anti-island formation.

It is seen in the Table 4 that for both the configurations highlighted, three of the terminal buses are connected to the main distributor whereas the terminal bus 22 alone remains open. To check the validity of the two suggested configurations, a reliability test is performed on the system for various line outages to happen(one outage at a time). It is found that a line contingency at line 2(between buses 2 & 3) would result in shedding of the buses 2, 19, 20, 21 and 22, and hence the loads connected to these buses, thereby disturbing the stability of all the generators owing to mismatch between the total generation and demand. Hence it is decided to connect the terminal bus 22 to its nearby bus on the main distributor, 8. Hence the optimal structure for the autonomous micro-grid under consideration is the weakly meshed structure as shown in the Figure 5.

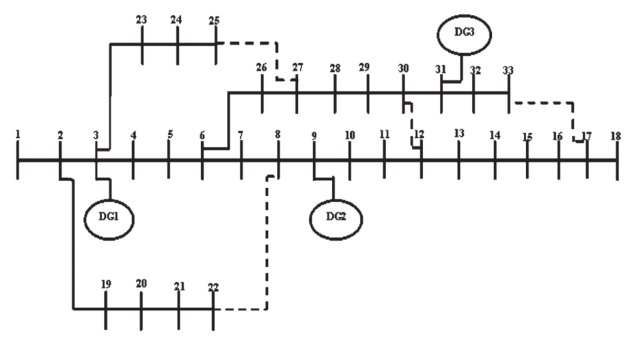

FIG. 5 OPTIMAL STRUCTURE FOR THE 33 BUS AUTONOMOUS MICRO-GRID

4.5 Deliverables of the re-configuration

As a measure of justification of the proposed configuration for the 33 bus autonomous micro-grid, the various issues viz., voltage profile, distribution losses, additional cost of installation and the rotor angle stability of the generators in the system, are discussed.

Voltage profile improvement:

The proposed reconfigured structure is found to contribute an approximately flat voltage profile for the system when compared to the structure before re-configuration, as shown in Figure 6. A detailed comparison of the voltage variations for different architectures is depicted in the Table 5. It shows clearly that all the terminal buses of the system are found to experience an improvement in their respective voltages. Also the generator bus voltages do not ascend beyond unity due to redirection of power flow on reconfiguration. This is clearly viewed in the Figure 6.

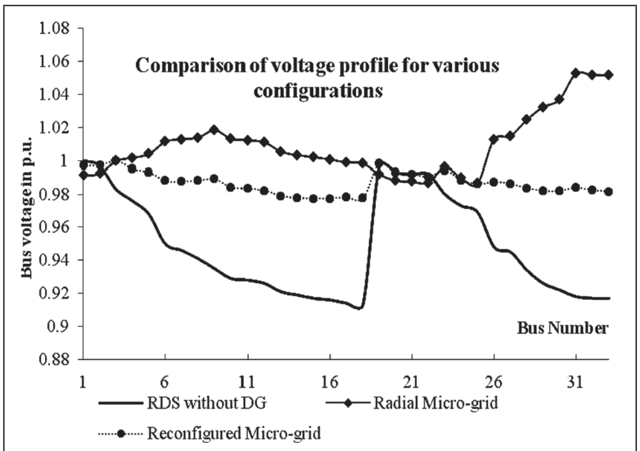

FIG. 6 COMPARISON OF VOLTAGE PROFILE FOR DIFFERENT CONFIGURATIONS

Distribution loss reduction:

As compared to the distribution system fed from the substation, the total real power loss is found to reduce by 67% and further reduced by 9% on reconfiguring based on the proposed strategy. This comparison of the distribution losses is shown in Table 6 as well as in Figure 7.

TABLE 5

VOLTAGE PROFILE FOR VARIOUS CONFIGURATIONS

Bus No.	V in pu For radial distribu-tion system without DG Units	V in pu before reconfigura-tion	V in pu after reconfiguration (final configuration)
1	1.000	0.9915	0.997281
2	0.997	0.9926	0.997281
3	**0.983**	**1**	**1**
4	0.976	1.0019	0.995212
5	0.968	1.0042	0.993112
6	0.950	1.0117	0.988264
7	0.946	1.0131	0.987795
8	0.941	1.0141	0.98835

9	**0.935**	**1.0186**	**0.989343**
10	0.929	1.0133	0.98422
11	0.928	1.0125	0.983539
12	0.926	1.0112	0.982372
13	0.921	1.0056	0.979091
14	0.919	1.0035	0.978005
15	0.917	1.0022	0.977675
16	0.916	1.0009	0.977619
17	0.914	0.9991	0.978238
18	0.913	0.9985	0.977684
19	0.997	0.9921	0.998574
20	0.993	0.9885	0.993406
21	0.992	0.9878	0.992192
22	0.992	0.9871	0.990595
23	0.980	0.9965	0.99448
24	0.973	0.9899	0.988708
25	0.969	0.9867	0.98619
26	0.948	1.013	0.987522
27	0.945	1.015	0.986612
28	0.934	1.0248	0.983916
29	0.926	1.0326	0.982273
30	0.922	1.0371	0.982031
31	**0.918**	**1.0528**	**0.984152**
32	0.917	1.052	0.982745
33	0.917	1.0518	0.981792

Though the voltage profile of the system and the distribution losses are improved drastically in a reconfigured autonomous micro-grid, there needs an additional investment of $3250 [27-28] which is worth compared to the improvement in the technical performance of the system.

TABLE 6

COMPARISON OF DISTRIBUTION LOSSES

Configuration of the system	Real power loss (kW)	Reactive power loss (kVAr)
No DG Unit	202.7	135.1
Losses before reconfiguration	56.1	43.7
Losses after reconfiguration	51.1	42.8

Rotor angle stability of the generators:

Apart from the improvement in the voltage profile and distribution losses, the rotor angle oscillations are found to be on the safe margin for all the line outages since no accidental islands are formed. This is validated by simulating one line outage at a time and evaluating the system for every line outage. The rotor angle oscillations of all the generators are found to be stable as visualized in Figure 8.

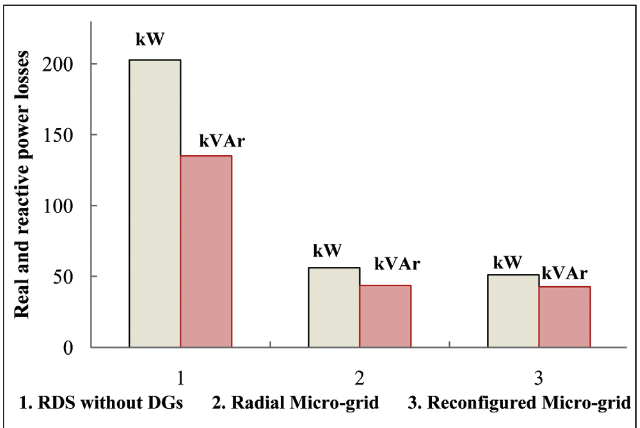

FIG. 7 COMPARISON OF DISTRIBUTION LOSSES FOR DIFFERENT CONFIGURATIONS

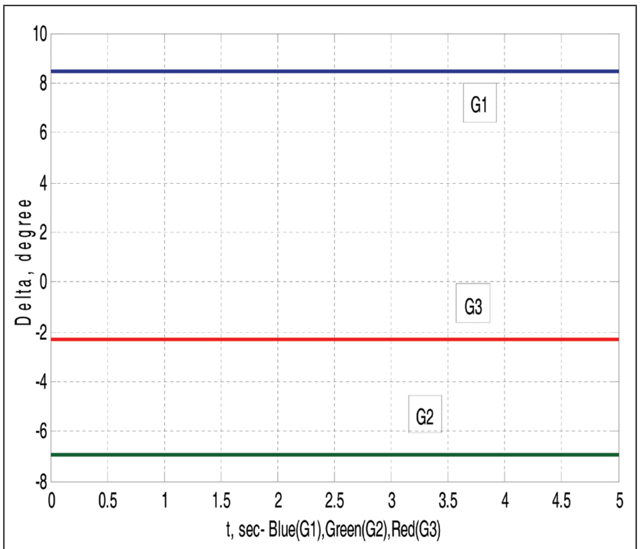

FIG. 8 ROTOR ANGLE VARIATIONS OF DGS IN THE MICRO-GRID

5.0 CONCLUSION

In this paper a methodology for reconfiguring an autonomous micro-grid has been proposed based on ranking of the buses. A ranking algorithm has also been proposed depending upon the capability of the buses to with stand maximum real power loadable limits. Based on the ranking of the buses, the candidate locations for placing TIE switches have been identified. Sectionalizing switches are not considered in this work. A partially heuristic algorithm is followed to determine the best configuration for an autonomous micro-grid which results in an improved (almost flat) voltage profile, reduced distribution losses and a robust reliable system with stable rotor angle behaviour of the generators connected in the system. This methodology suggests that the weakly meshed system is suitable for an autonomous micro-grid for better performance when compared to a radial structure.

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