ICEEI 2015

by Ardiaty Arief

Submission date: 27-Sep-2022 09:14AM (UTC-0400)
Submission ID: 1910352527
File name: arief2015.pdf (526.82K)
Word count: 4052
Character count: 21939

The 5th International Conference on Electrical Engineering and Informatics 2015
August 10-11, 2015, Bali, Indonesia

DG Placement and Size with Continuation Power Flow Method

Ardiaty Arief and Muhammad Bachtiar Nappu
Department of Electrical Engineering
Faculty of Engineering, Universitas Hasanuddin,
Makassar 90245, Indonesia
E-mail: ardiaty@eng.unhas.ac.id, ardiaty@engineer.com

***Abstract*—Optimum location and size of distributed generations (DGs) is important to maximize the system's stability. This paper presents a new simple but robust method based on the continuation power flow (CPF) method to determine the optimal location of DG units. The tangent vector in the CPF method provides the ratio of differential change in voltage to differential change in load. Size of DGs at each location is computed through an iteration process until the stable condition of the system is achieved. The proposed CPF method is tested on the IEEE 24-bus Reliability Test System (RTS) the results show the robustness of the method. Further relevant findings are also discussed in this paper.**

Keywords-Distributed generations (DG), continuation power flow, tanget vector, voltage stability.

I. INTRODUCTION

DGs have grown rapidly as means of exploitation of clean renewable energy resources, such as solar, wind, hydro, biomass, ocean and geothermal energy, for alternative generation in the electricity industry [1]. It is due to their fast technological development as well as their economic and environmental advantages regarding the exhaustion of fossil fuels caused by conventional electricity generations that lead to global warming problems [2-4].

The term DG refers to the electricity generations close to the demand. In the literature, various terminologies and definitions are used on the subject of distributed generation (DG). "Embedded generation" is usually used in Anglo-American countries. In North America, they use "dispersed generation" while Europe and a few countries in Asia apply "decentralized generation". In addition to various terminologies for distributed generation, several definitions for DG are also applicable. Reference [5] propose a general definition for DG as "an electric power source connected directly to the distribution network or on the customer site of the meter". Similar definition is also given in [6], where DG is defined as "the development of a set of sources of electric power connected to the distribution network or the customer side of the meter".

The addition of distributed generations into power system has brought many benefits. It improves the voltage profile of the system as well as power quality [7]. With sufficient generations, this can help in avoiding generators to implement market power that can increase electricity price [8-11]. However, these benefits depend on the location and the size of distributed generations. The appropriate location of DGs can improves voltage stability. Currently, the optimal placement of DG units is one of the major challenges for power system engineers [12]. The size of DG in a system should be determined correctly since high penetration of DG can also affect the stability during disturbance [13]. Therefore, investigation on the DGs' optimal allocation and size becomes important to optimize their benefits.

In this study, a new method to determine an optimal distributed generation allocation is presented. This method is based on the Continuation Power Flow (CPF) method. The CPF method is a quasi-static voltage stability analysis method. This method overcomes the problem of conventional power flow. Conventional power flow algorithms are prone to convergence problems at operating conditions near the voltage stability limit since Jacobian matrix becomes singular at stability limit. The CPF develops a predictor-corrector steps scheme to achieve a solution path of a reformulated power flow equations. In the prediction step, the tangent vector is computed. The tangent vector gives information about the weak bus, which is the bus that owes a large ratio of differential change in voltage to differential change in load. The IEEE 24-bus Reliability Test System (RTS) is used to verify the proposed method. This work only focuses on voltage stability enhancement. The proposed method is robust, straightforward and its computation is timely efficient. More interesting results are presented in this paper.

The structure of this paper is as follows. Section 2 describes about distributed generations. Section 3 elaborates about techniques in voltage stability analysis. Section 4 explains the proposed method. Results and analysis are presented in Section 5. Section 6 concludes the main findings of the research.

II. OVERVIEW ON DISTRIBUTED GENERATIONS

In general, based on their technologies, DGs can be classified into: traditional generators (combustion engines) and non-traditional generators [14]. Traditional generators are micro turbine whereas the non-traditional generators are fuel cells, batteries, flywheels, photovoltaic and wind turbine can be seen in Fig. 1. Table 1 shows the available sizes of power module of every DG technologies.

The integration of distributed generations into electric power system has brought many benefits, which can be listed as [15, 16]:

1. Reduce power flow inside the transmission system, hence improve the voltage profile,
2. Reduce power losses at distribution system,
3. Improve system's reliability and efficiency,

978-1-4673-7319-7/15/$31.00 ©2015 IEEE

4. Postpone infrastructure upgrades, since they can help to avoid bottleneck/congestion in transmission [11, 17-22],
5. Decrease expenses related to transmission and distribution,
6. Help in load management programs,
7. Provide local load reliability during emergency and system outages, hence can help to reduce amount of load shedding [13, 23-27],
8. Supply the required spinning reserve,
9. Reduce emission.

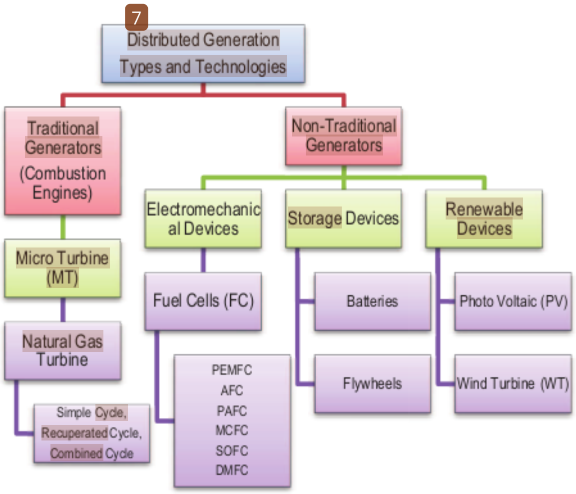


Figure 1 Types of DG and technologies [14]

TABLE I TECHNOLOGIES OF DG WITH ITS SIZE [28]

No	DG Technologies	Available size power module
1	Combined cycle gas turbine	35 – 400 MW
2	Internal combustion engines	5 kW – 10 MW
3	Combustion turbine	1 – 250 MW
4	Micro-turbines	35 kW – 1 MW
5	Fuel cells (phosphoric acid)	200 kW – 2 MW
6	Fuel cells (molten carbonate)	250 kW – 2 MW
7	Fuel cells (proton exchange)	1 – 250 kW
8	Fuel cells (solid oxide)	250 kW – 5 MW
9	Battery storage	500 kW – 5 MW
10	Small hydro	1 – 100 MW
11	Micro hydro	25 kW – 1 MW
12	Wind turbine	200 W – 3 MW
13	Photovoltaic arrays	20 W – 100 kW
14	Solar thermal, central receiver	1 – 10 MW
15	Solar thermal, Lutz system	10 – 80 MW
16	Biomass gasification	100 kW – 20 MW
17	Geothermal	5 – 100 MW
18	Ocean energy	0.1 – 1 MW

III. VOLTAGE STABILITY ANALYSIS METHODS

Voltage stability analysis holds a vital role for predicting potential voltage instability. As the power system become more complex and heavily stressed, voltage stability problems also become more severe. During planning and operation of power system, voltage problems now have become a great concern, because of significant amount of failures which is believed that have been caused by voltage instability. Voltage stability covers a wide range of phenomena. In recent years, much research works have been performed to investigate this phenomenon. Accordingly, good understanding of the physical nature of voltage stability as well as tools and techniques for voltage stability analysis have come into sight [29]. Voltage stability involves generation, transmission and distribution and also is affected by voltage control, reactive power compensation and management, rotor-angle stability, protective relaying and control center operations [30].

With the growing concern of voltage instability, much research has been performed to explore this phenomenon. As a result, a number of meaningful techniques have been developed to enhance voltage stability. Reference [31] classifies voltage stability analysis methods into 3 categories:

A. Static (Steady-State) Voltage Stability Analysis

Static voltage stability analysis involves the solution of algebraic equations and conventional power flow analysis. It utilizes a 'snapshot' of the system at a point in the time domain trajectory and provides a signal of the system stability on the whole and/or the closeness and margin to unstable operation at specific operating point.

The linearized model of steady-state power system is given by,

$$\begin{bmatrix}\Delta \boldsymbol{P}\\ \Delta \boldsymbol{Q}\end{bmatrix} = \begin{bmatrix}\frac{\partial P}{\partial \theta} & \frac{\partial P}{\partial V}\\ \frac{\partial Q}{\partial \theta} & \frac{\partial Q}{\partial V}\end{bmatrix}\begin{bmatrix}\Delta \boldsymbol{\theta}\\ \Delta \boldsymbol{V}\end{bmatrix} \qquad (1)$$

Where

ΔP = incremental change in bus real power
ΔQ = incremental change in bus reactive power injection
$\Delta\theta$ = incremental change in bus voltage angle
ΔV = incremental change in bus voltage magnitude
$\begin{bmatrix}\frac{\partial P}{\partial \theta} & \frac{\partial P}{\partial V}\\ \frac{\partial Q}{\partial \theta} & \frac{\partial Q}{\partial V}\end{bmatrix}$ = the *Jacobian* matrix of partial derivatives

B. Quasi-Steady-State Voltage Stability Analysis

One example of quasi-steady-state voltage stability analysis is continuation power flow [32]. Conventional power flow algorithms are prone to convergence problems at operating conditions near the voltage stability limit since Jacobian matrix becomes singular at stability limit. The continuation power flow overcomes this problem by reformulating the power-flow equations. The purpose of the continuation power flow is to find a continuum of power flow solution for a given load change scenario.

C. Dynamic Voltage Stability Analysis

Dynamic voltage stability analysis utilize time-domain simulations to provide solution to nonlinear system differential equations [33]. Time-domain simulation with appropriate power system modeling explains this phenomenon better by showing the time event and their chronology to the final phase of voltage collapse. Dynamic voltage stability analysis is useful for analyzing condition of specific voltage collapse and coordination of protection and time dependent action of controls [23, 25].

IV. THE PROPOSED METHOD

The Continuation Power Flow (CPF) method is one of the methods of quasi-static voltage stability analysis. The aim of CPF method is to get a continuing power flow solutions towards the change of specific load settings. CPF method described in this paper is the approach by Ajjarapu and Christy [32]. As shown in Fig. 2, the analysis procedure starts from a known outcome, then predict the next solution for different load parameter values.

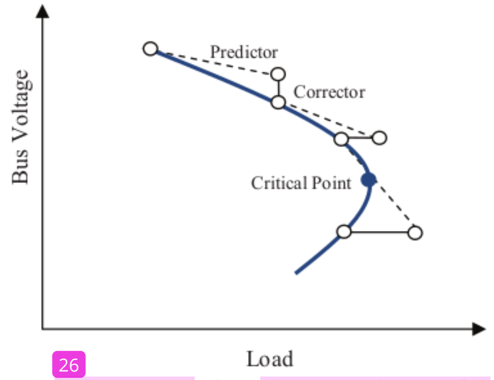


Figure 2 Predictor-corrector scheme of the continuation power flow [32]

Firstly, a load parameter, denoted by φ is defined by:

$$0 \leq \varphi \leq \varphi_{critical}$$

where $\varphi = 0$ corresponds to the base load and $\varphi = \varphi_{critical}$ corresponds to critical load. This load parameter is then incorporated into the active and reactive power to obtain:

$$0 = P_{Gi0}(1 + \lambda k_{Gi}) - P_{Li0} - \varphi\,(k_{Li}\, S_{\Delta base} \cos\theta_i) - P_{Ti} \quad (2)$$

$$0 = Q_{Gi0} - Q_{Li0} - \varphi\,(k_{Li}\, S_{\Delta base} \sin\theta_i) - Q_{Ti} \quad (3)$$

where,

P_{Li0}, Q_{Li0} are the original load at bus i, active and reactive
k_{Li} is the multiplier to designate the rate of load change at bus i as φ changes
θ_i is the power angle of load change at bus i
$S_{\Delta base}$ is a given quantity of apparent power which is chosen to provide appropriate scaling of φ
P_{Gi0} is the active generation at bus i in the base case
k_{Gi} is the constant used to specify the rate of change in generation as φ varies
P_{Ti}, Q_{Ti} are the injected active and reactive power.

Then a continuation algorithm is applied at the reformulated power flow equations. The above equations can be rewritten in a compact form such that:

$$F\,(\delta, V, \varphi) = 0 \quad (4)$$

where δ represents generator angle vector, V represents the bus voltage magnitude vector and φ is the loading parameter.

Continuation power flow method develops a predictor-corrector steps scheme to achieve a solution path of a reformulated power flow equations. In the prediction step, the tangent vector is calculated by deriving both sides of the power flow equations, so that:

$$[F_\delta \quad F_V \quad F_\varphi]\begin{bmatrix} d\delta \\ dV \\ d\varphi \end{bmatrix} = 0 \quad (5)$$

Then the prediction above is corrected by expanding the parameterization which identifies each solution along the path being traced. The tangent vector provides not only the direction of the solution path but also sensitivity analysis to determine the weak buses. A weak bus is the bus that owes a large ratio of differential change in voltage to differential change in load. This ratio is available from the tangent vector. Therefore, the tangent vector (TV) at bus j becomes:

$$TV_j = \left|\frac{dV_j}{dP_{total}}\right| = \left|\frac{dV_j}{Cd\varphi}\right| = \max\left[\left|\frac{dV_1}{Cd\varphi}\right|, \left|\frac{dV_2}{Cd\varphi}\right|, \dots \left|\frac{dV_n}{Cd\varphi}\right|\right] \quad (6)$$

Fig. 3 shows the flowchart of the proposed DG placement by using CPF method and tangent vector.

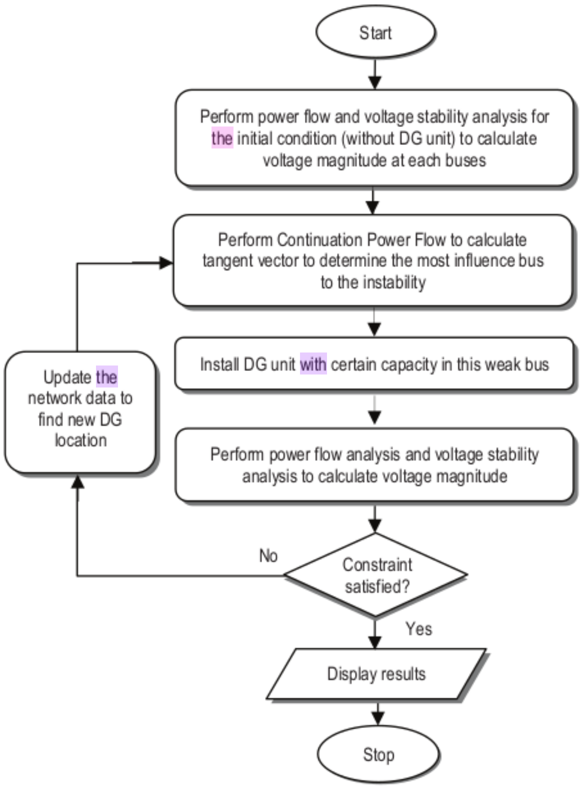


Figure 3 Flowchart of the proposed DG allocation methodology with CPF

V. TEST RESULTS AND ANALYSIS

The proposed method is tested on the IEEE 24-bus Reliability Test System (RTS) [34] which is illustrated in Fig.

4. Bus 13 is the slack bus. Table 2 informs the technical data of the generating units of the IEEE 24-bus RTS.

For the initial condition, the total power generation and demand are 3180.866 MW and 3105 MW, respectively. The voltage profile magnitude is demonstrated by Fig. 5. The red line is the voltage stability limit which is 0.95 pu.

As can be seen from Fig. 5, there are 4 buses which voltage drop below the stability limit, i.e.: buses 3, 4, 8 and 9. In this study, the tangent vector is calculated only to assess the impact of change in active power in the unstable buses. Previous research has proven that the unstable buses usually contribute the most to improve the stability compare to stable buses [1]. Therefore only tangent vectors at buses 3, 4, 8 and 9 are calculated.

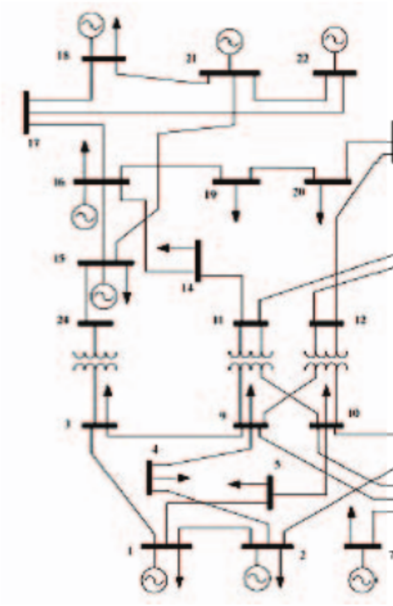


Figure 4 IEEE 24-bus Reliability Test Systems [34]

TABLE 2 TECHNICAL DATA OF GENERATING UNITS [34]

Unit	Node	P_{max} (MW)	P_{min} (MW)
Unit 18	18	400	100
Unit 21	21	400	100
Unit 1	1	152	30.4
Unit 2	2	152	30.4
Unit 15a	15	60	12
Unit 15b	15	155	54.25
Unit 16	16	155	54.25
Unit 23a	23	310	108.5
Unit 23b	23	350	140
Unit 7	7	350	75
Unit 13	13	591	206.85
Unit 22	22	300	

Fig. 6 shows the tangent vector to determine DG location for the first iteration. We can see that bus 4 has the highest TV 0.026. This bus has the biggest impact on improving the voltage profile all of the unstable buses. For each iteration, the generation size is set at 50 MW. But, after adding generation of 50 MW to the system at bus 4, the system's voltage still unstable, therefore, tangent vector is calculated again for the second iteration. This process is repeated 6 times until all the buses are stable. Table 3 shows the buses with the highest tangent vector for each step. Total DG generation based on the computation of the proposed method is 300 MW, approximately 9.5 % of the total power generation. Hence, total generation at bus 4 is 150 MW; while generation at bus 3, 8 and 9 is 50 MW each.

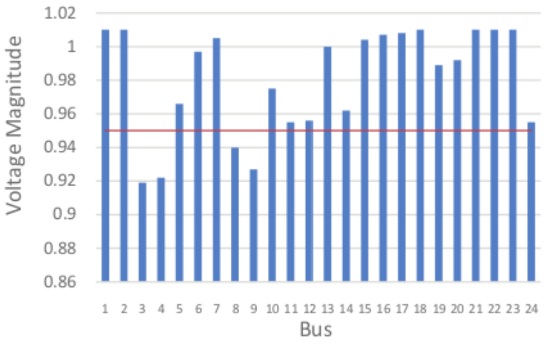


Figure 5 Voltage profile before DG installation

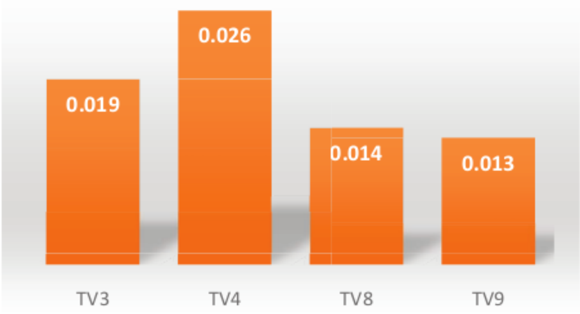


Figure 6 Tangent Vector to determine DG location

TABLE 3 BUS WITH HIGHEST TANGENT VECTOR

Iteration	Bus	Total Generations
1	4	50 MW
2	4	100 MW
3	4	150 MW
4	8	200 MW
5	3	250 MW
6	9	300 MW

Fig. 7 shows the voltage magnitude before and after the placement of DG at buses. After additional generation from DG with total of 300 MW, the voltage at all buses are stable.

Since there are 4 unstable buses, we simulate how the performance of the system if the DG size is distributed evenly between the four unstable buses. Fig. 8 illustrates the comparison of voltage magnitude for this scenario and based on the proposed method. It clearly shows that the voltage profile based on the recommendation of the proposed method is better compare to if the generations are divided evenly between the four buses. Even though with the same total generation, there are still several buses with voltage below the stability limit, if the DG sizes are spread evenly at buses 3, 4, 8 and 9.

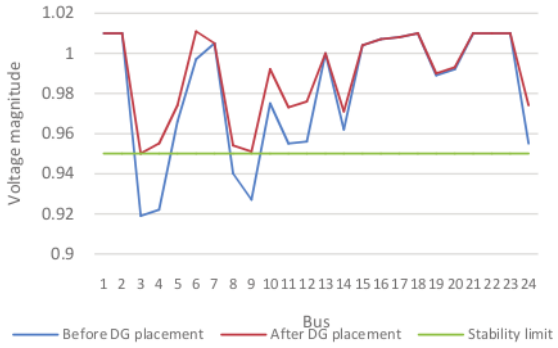
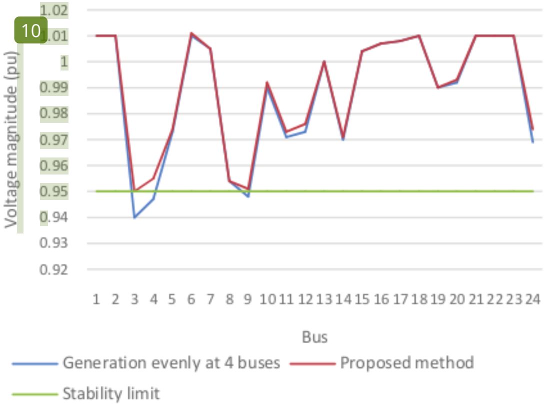


Figure 7 Voltage magnitude before and after DG placement



VI. CONCLUSION

The proper placement and size of DG units is important to maximize the benefits of DG. This paper proposes a new method based on the continuation power flow (CPF) method. The CPF method is a quasi-static voltage stability analysis method. This method employs a predictor-corrector steps scheme. In the prediction step, the tangent vector is computed. The tangent vector gives information about the weak bus, which is the bus that owes a large ratio of differential change in voltage to differential change in load. The IEEE 24-bus Reliability Test System (RTS) is used to verify the proposed method. This work only focuses on voltage stability enhancement. To evaluate the robustness of the proposed method, this work also observes the system's performance when DG sizes are even between the weak buses.

The results of applying this method to the IEEE 24-bus reliability test system clarify this method in finding optimal placement of DG units. The results show the efficiency of tangent vector in determining the optimal allocation, hence determining the optimal size for each location as well.

REFERENCES

[1] A. Arief, "Optimal placement of distributed generations with modified P-V Modal Analysis," in *2014 Makassar International Conference on Electrical Engineering and Informatics (MICEEI)* Makassar, Indonesia, 26-30 Nov 2014, 2014, pp. 200-204.

[2] T. Senjyu, Y. Miyazato, A. Yona, N. Urasaki, and T. Funabashi, "Optimal Distribution Voltage Control and Coordination with Distributed Generation," *IEEE Transactions on Power Delivery,* vol. 23, pp. 1236-1242, 2008.

[3] R. Caldon, A. Stocco, and R. Turri, "Feasibility of Adaptive Intentional Islanding Operation of Electric Utility Systems With Distributed Generation," *Electric Power Systems Research,* vol. 78, pp. 2017-2023, 2008.

[4] A. Keane, Q. Zhou, J. W. Bialek, and M. O'Malley, "Planning and operating non-firm distributed generation," *IET Renewable Power Generation,* vol. 3, pp. 455-464, 2009.

[5] T. Ackermann, G. Andersson, and L. Söder, "Distributed Generation: A Definition," *Electric Power Systems Research,* vol. 57, pp. 195-204, 2001.

[6] L. F. Ochoa, A. Padilha-Feltrin, and G. P. Harrison, "Evaluating Distributed Generation Impacts With a Multiobjective Index," *IEEE Transaction on Power Delivery,* vol. 21, pp. 1452-1458, 2006.

[7] A. Arief, M. B. Nappu, A. Nizar, and Z. Y. Dong, "Determination of DG Allocation with Modal Participation Factor to Enhance Voltage Stability," in *The 8th IET International Conference on Advances in Power System Control, Operation and Management (APSCOM)*, Hong Kong, China, 8-11 November, 2009.

[8] M. B. Nappu and R. C. Bansal, "Evaluation of GENCO's strategy in creating a congested system for exercising market power," in *2011 IEEE Power and Energy Society General Meeting (PES GM)*, Detroit, Michigan, USA, 24-28 July, 2011, pp. 1-7.

[9] M. B. Nappu, R. C. Bansal, and T. K. Saha, "Market power implication on congested power system: A case study of financial withheld strategy," *International Journal of Electrical Power & Energy Systems,* vol. 47, pp. 408-415, 2013.

[10] M. B. Nappu and T. K. Saha, "Financial withheld-based market power within congested power system," in *21st Australasian Universities Power Engineering Conference, AUPEC '11*, Brisbane, QLD Australia, 25-28 September, 2011, pp. 1-6, 2011.

[11] M. B. Nappu, T. K. Saha, and A. Arief, "Analysis of the influence of transmission congestion on power market based on LMP-lossless model " in *The 19th Australasian Universities Power Engineering Conference: Sustainable Energy Technologies and Systems* Adelaide, Australia, 27-30 September, 2009.

[12] Y. M. Atwa and E. F. El-Saadany, "Reliability Evaluation for Distribution System With Renewable Distributed

Generation During Islanded Mode of Operation," *IEEE Transactions on Power Systems,* vol. 24, pp. 572-581, 2009.

[13] A. Arief, Z. Dong, M. B. Nappu, and M. Gallagher, "Under voltage load shedding in power systems with wind turbine-driven doubly fed induction generators," *Electric Power Systems Research,* vol. 96, pp. 91-100, DOI:10.1016/j.epsr.2012.10.013, 2013.

[14] W. El-Khattam and M. M. A. Salama, "Distributed Generation Technologies, Definitions and Benefits," *Electric Power Systems Research,* vol. 71, pp. 119-128, 2004.

[15] A. Arief, M. B. Nappu, M. Gallagher, Z. Y. Dong, and J. Zhao, "Comparison of CPF and Modal Analysis Methods in Determining Effective DG Locations," in *The 9th International Power and Energy Conference (IPEC)*, Singapore, 27th – 29th October, 2010.

[16] A. Arief, "Advanced Computational Methods for System Voltage Stability Enhancement," School of Information Technology and Electrical Engineering, The University of Queensland, Australia, St. Lucia, Brisbane, 2012.

[17] M. Bachtiar Nappu, A. Arief, and R. C. Bansal, "Transmission management for congested power system: A review of concepts, technical challenges and development of a new methodology," *Renewable and Sustainable Energy Reviews,* vol. 38, pp. 572-580, DOI:10.1016/j.rser.2014.05.089, 2014.

[18] M. B. Nappu, "Locational Marginal Prices Scheme Considering Transmission Congestion and Network Losses," *Universal Journal of Electrical and Electronic Engineering,* vol. 2, pp. 132-136, DOI: 10.13189/ujeee.2014.020307, 2014.

[19] M. B. Nappu, "LMP-lossless for congested power system based on DC-OPF," in *2014 Makassar International Conference on Electrical Engineering and Informatics (MICEEI)*, Makassar, Indonesia, 26-30 November, 2014, pp. 194-199.

[20] M. B. Nappu, A. Arief, T. K. Saha, and R. C. Bansal, "Investigation of LMP forecasting for congested power systems," in *2012 22nd Australasian Universities Power Engineering Conference (AUPEC)*, Bali, Indonesia, 26-29 September, 2012, pp. 1-6.

[21] M. B. Nappu and T. K. Saha, "A comprehensive tool for congestion-based nodal price modelling," in *2009 IEEE Power & Energy Society General Meeting (PES GM)*, Calgary, Alberta, Canada, 26-30 July, 2009, pp. 1-8.

[22] M. B. Nappu, T. K. Saha, and P. A. J. Fonseka, "Investigation on congestion-based optimal energy price for competitive electricity market," in *Sustainable Energy Technologies, 2008. ICSET 2008. IEEE International Conference on*, 2008, pp. 860-865.

[23] A. Arief, "Under Voltage Load Shedding Using Trajectory Sensitivity Analysis Considering Dynamic Loads," *Universal Journal of Electrical and Electronic Engineering,* vol. 2, pp. 118-123, DOI: 10.13189/ujeee.2014.020304, 2014.

[24] A. Arief, M. B. Nappu, Z. Y. Dong, and M. Arief, "Under voltage load shedding incorporating bus participation factor," in *The 9th International Power and Energy Conference (IPEC)*, Singapore, 27-29 October, 2010, pp. 561-566.

[25] A. Arief, M. B. Nappu, M. Gallagher, and Z. Y. Dong, "Under voltage load shedding utilizing trajectory sensitivity to enhance voltage stability " in *The 21st Australasian Universities Power Engineering Conference, AUPEC*, Brisbane, Australia, 25-28 September, 2011.

[26] A. Arief, M. B. Nappu, X. Yin, X. Zhou, and Z. Y. Dong, "Under Voltage Load Shedding Design with Modal Analysis Approach," in *The 8th IET International Conference on Advances in Power System Control, Operation and Management (APSCOM)* Hong Kong, 8th-11th November, 2009.

[27] A. Arief, M. B. Nappu, D. Zhao Yang, and M. Arief, "Load curtailment strategy in distribution network with dispersed generations," in *The 21st Australasian Universities Power Engineering Conference (AUPEC)*, Brisbane, Australia, 25-28 September, 2011, pp. 1-6.

[28] S. N. Singh, J. ∅stergaard, and N. Jain, "Distributed generation in power systems: An overview and key issues," in *Indian Engineering Congress*, 2009.

[29] P. Kundur, B. Gao, and G. K. Morison, "Practical Application of Modal Analysis for Increasing Voltage Stability Margins," in *Proc. Joint International Power Conference "Athens Power Tech"*, Athens, Greece, 5-8 September, 1993, pp. 222-227.

[30] Z. Y. Dong, *Power System Dynamics and Stability, reference notes for ME course on Power System Dynamics and Stability*: UQ Publisher, 2007.

[31] D. Chen and R. R. Mohler, "Neural-Network-Based Load Modeling and Its Use in Voltage Stability Analysis," *IEEE Transactions on Control Systems Technology,* vol. 11, pp. 460-470, 2003.

[32] V. Ajjarapu and C. Christy, "The Continuation Power Flow: A Tool for Steady State Voltage Stability Analysis," *IEEE Transactions on Power Systems,* vol. 7, pp. 416-423, 1992.

[33] B. Gao, G. K. Morison, and P. Kundur, "Towards the Development of a Systematic Approach for Voltage Stability Assessment of Large-Scale Power Systems," *IEEE Transactions on Power Systems,* vol. 11, pp. 1314-1324, 1996.

[34] C. Grigg, P. Wong, P. Albrecht, R. Allan, M. Bhavaraju, R. Billiton, Q. Chen, C. Fong, S. Haddad, S. Kuruganty, W. Li, R. Mukerji, D. Patton, N. Rau, D. Reppen, A. Schneider, M. Shahidehpour, and C. Singh, "The IEEE Reliability Test System - 1996," *IEEE Transaction on Power Systems,* vol. 14, pp. 1010 - 1020, 1999.

ICEEI 2015

ORIGINALITY REPORT

18%	9%	13%	3%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	K.Y. Lee. "Static Voltage Stability Margin Enhancement Using STATCOM, TCSC and SSSC", 2005 IEEE/PES Transmission & Distribution Conference & Exposition Asia and Pacific, 2005 Publication	2%
2	Abdi, Sh., and K. Afshar. "Application of IPSO-Monte Carlo for optimal distributed generation allocation and sizing", International Journal of Electrical Power & Energy Systems, 2013. Publication	1%
3	Chandrabhan Sharma, Marcus G. Ganness. "Determination of the applicability of using modal analysis for the prediction of voltage stability", 2008 IEEE/PES Transmission and Distribution Conference and Exposition, 2008 Publication	1%
4	duepublico.uni-duisburg-essen.de Internet Source	1%
5	ro.scribd.com	

	Internet Source	1 %
6	B. Gao, G.K. Morison, P. Kundur. "Towards the development of a systematic approach for voltage stability assessment of large-scale power systems", IEEE Transactions on Power Systems, 1996 Publication	1 %
7	Submitted to University of Rwanda Student Paper	1 %
8	Dulau, Lucian Ioan, Mihail Abrudean, and Dorin Bica. "Distributed generation and virtual power plants", 2014 49th International Universities Power Engineering Conference (UPEC), 2014. Publication	1 %
9	Submitted to Universitas Hasanuddin Student Paper	1 %
10	theses.gla.ac.uk Internet Source	1 %
11	Taufik Widyanugraha, Rizal Rachmad, Wendhy, Suwarno. "DGA and tensile strength test on accelerated thermal aging of ester oil and kraft paper", 2015 International Conference on Electrical Engineering and Informatics (ICEEI), 2015 Publication	1 %

12	www.ijareeie.com Internet Source	1 %
13	www.transnav.eu Internet Source	1 %
14	vsip.info Internet Source	1 %
15	Submitted to University of Melbourne Student Paper	<1 %
16	YANG Zhichun. "Analytical method of the impact of distributed generation on static voltage stability of distribution network and its development", TELKOMNIKA Indonesian Journal of Electrical Engineering, 2013 Publication	<1 %
17	Al Abri, R. S., Ehab F. El-Saadany, and Yasser M. Atwa. "Optimal Placement and Sizing Method to Improve the Voltage Stability Margin in a Distribution System Using Distributed Generation", IEEE Transactions on Power Systems, 2012. Publication	<1 %
18	H. Hajian-Hoseinabadi, M. Fotuhi-Firuzabad, M. Hajian. "Optimal allocation of spinning reserve in a restructured power system using particle swarm optimization", 2008 Canadian Conference on Electrical and Computer Engineering, 2008	<1 %

	Publication	
19	Submitted to The University of Manchester Student Paper	<1 %
20	Antony, Neenu Rose, and Sarin Baby. "Optimal DG placement considering voltage stability enhancement using PSO", 2013 International Conference on Control Communication and Computing (ICCC), 2013. Publication	<1 %
21	d-nb.info Internet Source	<1 %
22	S. A. Al Dessi. "A comprehensive methodology for voltage stability assessment of power systems using modern analytical tools", 2011 2nd International Conference on Electric Power and Energy Conversion Systems (EPECS), 11/2011 Publication	<1 %
23	bradscholars.brad.ac.uk Internet Source	<1 %
24	hal.archives-ouvertes.fr Internet Source	<1 %
25	www.ijereee.com Internet Source	<1 %
26	certs.lbl.gov Internet Source	<1 %

27	dokumen.pub Internet Source	<1 %
28	epdf.pub Internet Source	<1 %
29	orbi.uliege.be Internet Source	<1 %
30	res.mdpi.com Internet Source	<1 %
31	tudr.thapar.edu:8080 Internet Source	<1 %
32	uwspace.uwaterloo.ca Internet Source	<1 %
33	Esmaeli, Abdolreza, Mohammad Abedini, and Mohammad H. Moradi. "A novel power flow analysis in an islanded renewable microgrid", Renewable Energy, 2016. Publication	<1 %

Exclude quotes	On	Exclude matches	< 5 words
Exclude bibliography	On		