International Journal of
Intelligent Systems and Applications in Engineering

ISSN:2147-6799 www.ijisae.org Original Research Paper

Vulnerability Analysis of Multiple Critical Fault Outages and Adaptive Under Voltage Load Shedding Scenarios in Marmara Region Electrical Power Grid

Nihat Pamuk*[1]

Accepted : 11/03/2017 Published: 30/03/2017

Abstract:The utilization of electrical power system has been rising frequently from past to now and there is a need of dependable electrical transmission and distribution networks so as to ensure continuous and balanced energy. Besides, conventional energy governance systems have been forced to change as a result of rises in the usage of renewable energy resources and the efficiency of demand-side on the market. In this regard, electrical power systems should be planned and operated, appropriately and the balance of production and consumption demand should be provided within the nominal voltage limits. In this study, firstly, the current status of Marmara region interconnected power grid in Turkey is evaluated. Afterwards, the multiple cascading failure outages scenarios are modelled by "DIgSILENT Power Factory V14" software. The critical transmission line scenarios are implemented on the high voltage power grid model improved. These scenarios are based on the period of maximum and minimum production and consumption demand and the effects of demand response in this period. As a result of grid vulnerability analyses performed, several findings has been obtained about the impacts of different line scenarios on the high voltage transmission system, the optimization of power grid voltage profile and the role of production and consumption demand response on voltage regulation.

Keywords:*Power flow, Electrical power grid, Cascading outages scenarios, Voltage regulation, Dig-silent power factory V14 software.*

1. Introduction

Electrical power system which is one of the most fundamental necessities of human life is currently used in every field from transportation to health. Despite the electricity production and consumption demand increases day by day, conventional energy production sources are depleted and it becomes more difficult to supply of electricity energy. On the other hand, even though the use of renewable energy generation resources like wind, solar, etc. is a solution on the generation side, it causes several problems for a dependable and sustainable electrical power system [1]. For these reasons, new solutions are being sought to provide security of supply in electricity energy. Contrary to the past, electrical power system can be produced not only in great powerful plants but also in medium and low voltage levels though new generation technologies of production and storage. It ensures efficiency to customers by means of producing their own energy needed and they can sell more electrical power system. In addition to these, customers are able to save their money by controlling electrical power consumption demand according to the market price or to shift electrical power consumption demand to cheaper tariff time [2]. However, numerous generation-consumption integrations and two-way power flows causes complex grid structure and energy management becomes more difficult [3]. Therefore, the process of planning and operating of power systems gain more significance for meeting growing needs of electrical energy reliably along with constantly expanding power grid substructure.

[1] Turkish Electricity Transmission Company, Maltepe District, Orhangazi Street, No: 74, 54100, Adapazarı–SAKARYA,TURKEY
** Corresponding Author:Email: nihatpamuk@gmail.com*

The design of the power systems takes a long time and investment costs of them are high. For this reason, power flow, restriction and short-circuit analyses are performed before the design of a power plant so as to determine the capacity of new transmission lines and the effects of existing grid [4-5]. In the literature, the determination of connection points of distributed generation plants and its effects on voltage profile and grid losses were examined [6-7]. In addition, several analyses were done for previously assessing the reaction of grid in the cases of failures, outages etc. occurred in transmission and distribution grids [8-9]. As a result of these analyses, possible future problems and system reliability were examined [10].

There are many studies that examine the effects of renewable energy integration into the electrical power system without immediate load variation on the source-based load flow stability in the literature. Panagis et al. and Tomonobu et al. studied the additively and the impacts of discontinuous distributed generation sources on the basis of daily and hourly [11-12]. The other one are compared the optimal power flow in a normal condition of 39-bus station power system with the optimal power flow in wind-based generation [13]. The impacts of wind based generation on voltage limits, reactive power variations and active power losses were investigated and voltage safety of the grid was reviewed [14]. Dobson et al. carried out risk assessments of a wind-based power system that was affected by variable weather conditions. In different weather conditions, overloading situations of transmission lines were analyzed and grid conditions were evaluated on the basis of daily and hourly [15].

Andersson et al. for North West America [16], Nedic et al. for New Zealand [17] and Wierzbowski et al. for Denmark [18] made grid models of their power systems and surveyed the integration impacts of wind and solar energy-based generation, their voltage profile and power quality. Weber et al. realized the optimal power flow analysis of the transmission system in Switzerland for a long-term capacity planning [19]. The regional availability of wind power and its effects on transmission lines were examined and grid constraints were determined for 2020 [20]. Benedettini et al. foresaw the status of generation and consumption cases in 2030 by making the continuous state analysis of the power transmission grid of Sardinian in Italy [21]. In addition, power flow analyses of the related grid were evaluated according to the regional generation estimates of wind and solar energy [22]. Furthermore these studies in literature, the effects of demand response cannot be ignored in modern electrical power grid management. Since, the demand response increases the consumer's activities, directs the grid profile to the point where energy is consumed enhances the voltage control and reduces the grid losses. In this way, the flexibility structure can be achieved for the supply-demand balance of electricity system through micro-grid generation or direct load control on consumer side. There are works about demand response and its grid effects in literature. Zhao et al. and Chen et al. implemented the demand side management that includes direct load control and energy storage systems along with real-time pricing and measuring systems [23-24].

Gonzalez et al. monitored the instant electricity prices by means of the developed micro-grid management system and implemented smart load management systems [25]. Jalilzadeh et al. and Zhou et al. controlled the voltage levels and optimized the power losses by means of the demand response modelled for a distribution system [26-27]. Besides, the working performance, lifetime, power flow analysis and risk assessment of devices such as transformers, circuit breakers etc. in a electrical power grid were surveyed through smart grid management approaches used in power transmission and distribution systems [28-29]. Unlike the existing studies in literature, in this study, the electrical power grid of Marmara region that is an important part of the interconnected transmission system in Turkey is initially modelled. Afterwards, the critical line scenarios are implemented on the electricity transmission model developed. Maximum and minimum demand situations in 2015, the effects of demand response on the grid and the comparison of voltage levels are made efficiently.

2. Describing of Interconnected Marmara Region Electrical Power Grid

Interconnected electrical power grid has the installed power of 71429 MW as of May 2015 in Turkey. 60% of electricity demand is provided by thermal energy resources such as natural gas, coal, etc., while 40% of it is supplied from renewable energy resources such as hydraulic, wind, solar, geothermal, etc. [30]. The existing installed power is able to meet the need of annual average electricity energy, but the grid capacity is inadequate in the time of instant peak demand. In this case, the required electricity is imported from neighboring countries. In opposite cases, the more electricity can be sold to neighboring countries. The electrical power transmission system represents the third largest grid of Europe and it consists of the line length of exceeding 53000 km and the total substations of 686 [31]. Hence, the energy losses and the energy quality have a great importance in such a large grid. Therefore, all power system is monitored in real time by National Power Quality Monitoring Centre of Turkey and the problems occurred are resolved [32]. The electrical power transmission system is managed by the national and regional load dispatch centers. The existing electrical power transmission system consists of 66 kV, 154 kV and 400 kV grids, while the existing power distribution system consists of 34.5 kV and lower voltage levels. Power transmission and distribution systems are governed and operated by different companies [30-31].

Other analyses are done in the existing electrical power system for the design of novel power transmission lines and substations, the integration of new generation stations and the synchronization of protection-control devices. These analyses are based on the power flow analysis so as to determine active-reactive power cases of the related power system and loading capacity of the related power transmission lines and transformers. Short circuit; harmonic, stability, constraint and coordination analyses are used for deciding the limit values of switching equipment on a power grid [32]. On the other hand, power transmission system operators situated in the international synchronization area should ensure the national and international standards in order to carry out their electricity market activities taking into consideration of supply-demand balance. For these reasons, primer and secondary frequency control, tertiary control, active-reactive power control and voltage control are realized for controlling the active power and the load frequency in electrical power system [33, 34].

The electrical power consumption is met from great powerful plants which are generally situated away from residential areas in interconnected electrical power systems. The transportation of electricity energy for a long distance causes voltage dropping in power transmission lines and so, different voltage levels occur in the power system according to the different usage cases. Moreover, voltage variations also arise depending on the load demand in an electrical power system. While the voltage value drops in the time of high electricity consumption, it is high in the time of low electrical power consumption. However, it is required that the grid should be within the voltage limits in its nominal operating state [28, 33]. On the other hand, the voltage is also affected by the active and reactive energy consumption. Inductive and capacitive reactance is equal in the nominal load capacity of power transmission lines. If the power transmission line is loaded below the nominal transportation capacity, the voltage value increases, otherwise it decreases above the nominal transportation capacity. Generally, inductive consumers reduce the voltage value, while capacitive consumers enhance the voltage [35].

3. Vulnerability Analysis of Marmara Region Electrical Power Grid

In an interconnected electrical power system, it will be enough to know the substation capacities and the grid parameters for a regional analysis [36]. In this study, the grid modelling of 380 kV and 154 kV interconnected electrical power transmission system in Marmara region is made in a region wide manner. The electrical power transmission system modelled consists of 126 substations and 217 electrical power transmission lines between these substations. In addition, there are 30 generation plants. 12 of them are medium and large sized (the installed power > 30 MV) and the other ones are small sized. The small sized plants are the mini grids which are generally established by costumers. The single transmission line diagram of the electrical power system of Marmara region is shown in (Figure.1).

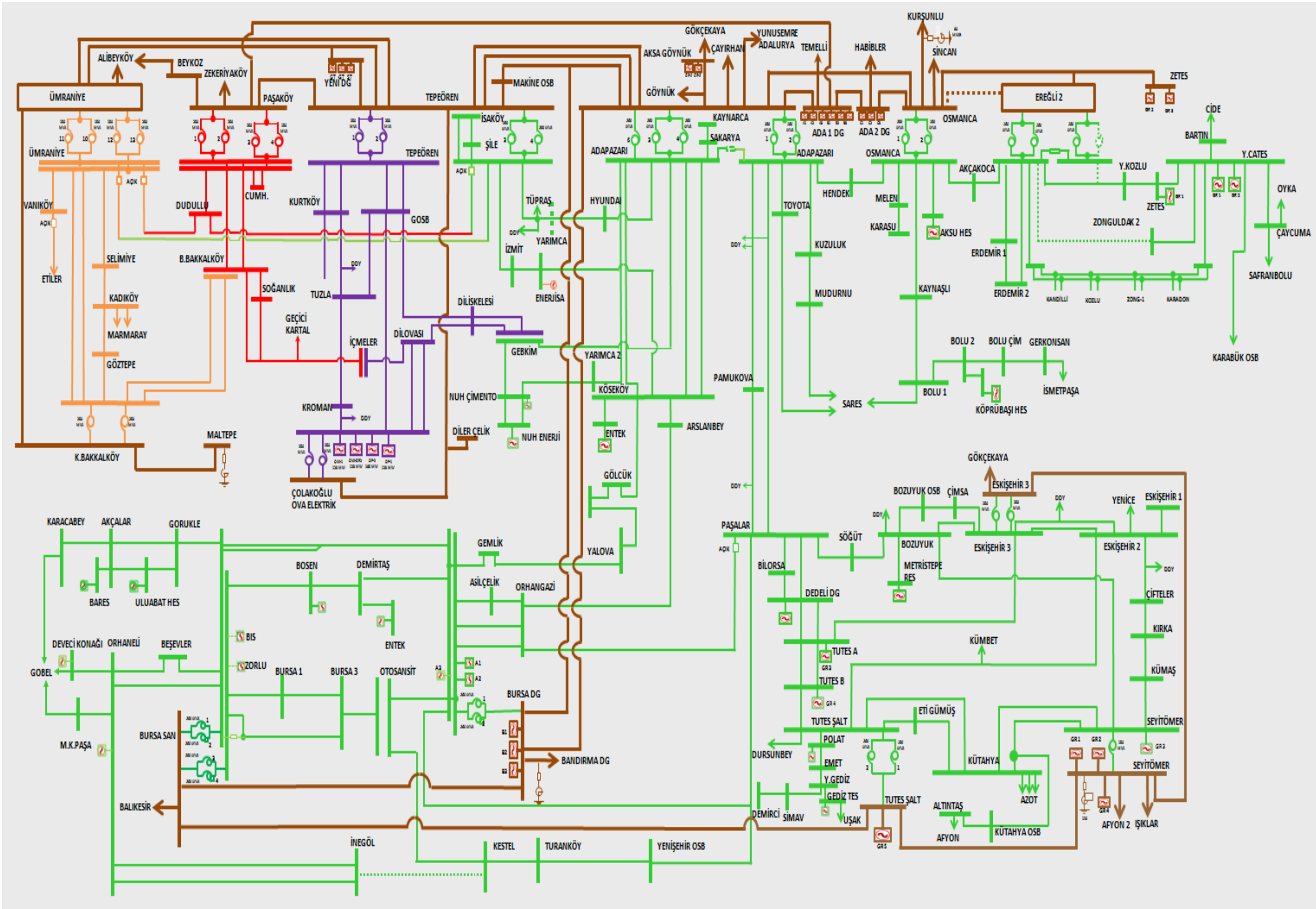

Figure 1. The single transmission line diagram of the Marmara region electrical power system.

It is performed by means of using real Marmara region electrical power grid, power transmission line, power transformer and power plant data in "DIgSILENT power factory V14 software" program. Electrical power transmission lines have physically single or double circuit structure. However, they are modelled as separate power transmission lines in the single line diagram because of the different bus connections. In addition, the tie transmission lines with outer regions are defined as external power grids.

Ada DGKCS-I, Ada DGKCS-II, Bursa DGKCS, Zetes-I, Zetes-II, Çolakoğlu, Seyitömer, Tutes-Şalt, Yeni-Çates, Köprübaşı-Hes, Aksu-Hes and Polat-Tes among generation plants are medium and large sized power plants. Through the electrical power transmission system model developed, voltage value, phase angle value, directions of active and reactive power flow, electrical power transmission line loading are examined according to the power generation, load and electrical power transmission line situations in maximum and minimum demand periods in 2015. Particularly, the effect of demand response on the electrical power grid voltage profile is focused with different scenarios in both periods. In 380 kV electrical power transmission systems, the maximum and the minimum operating voltage limit values should be 420 kV and 340 kV, respectively. In 154 kV electrical power transmission systems, the maximum and the minimum operating voltage limit values should be 170 kV and 140 kV, respectively. However, it is required that the voltage limit value should be in the range of ±5% at substations [31, 34].

In addition, base values are generally used instead of actual values belong to electrical power system components such as voltage, current and active reactive power. Therefore, the base voltage values have been defined as 154 kV and 380 kV in the performed analyses in this study. In this respect, the voltage limits are assigned as follows;

- The operating voltage limits: $0.90 < U < 1.1$ Per-Unit (Pu).
- The bus station voltage limits: $0.95 < U < 1.05$ Per-Unit (Pu).

4. Evaluation of Multiple Critical Fault Outages and Adaptive Under Voltage Load Shedding Scenarios

In this study, four different power transmission line scenarios are created in order to evaluate the Marmara region electrical power system in Turkey. Scenarios 1 and scenarios 2 investigate the electrical power grid constraints in the cases of maximum and minimum electricity generation demand respectively. The impacts of demand side participation in the cases of maximum and minimum electricity generation demand are also analyzed in scenarios 3. Finally, scenario 4 reduces the contribution of large-scale electrical power plants in the case of minimum electricity generation demand. Many detailed comparisons and assessments about all scenarios are made in the following subsections.

4.1. Analysis of Scenario 1

In the scheme of (Figure 2) is shown the single transmission line diagram of the Marmara region electrical power system for scenario 1. The quantity of power generation and load value for scenario 1 is given in table 1. Scenario 1 represents the periods of maximum and minimum generation and load demands in Marmara region interconnected electrical power grid.

In the analysis of these two periods, the power transmission system includes only medium and large sized generation plants. The bus station voltage values, the voltage variations and phase angles in scenario 1 are shown in (Figure 3). The most important issues in this scenario are the variation in generation and consumption values. In addition, there are physical differences on the electrical power grid at the time of analysis performed.

The average value of voltages in Scenario 1 is found as 0.97 Per-Unit (Pu). Besides, the voltage values of Yenidağ, Adapazarı and Tuzla bus stations are below the lower limit in scenario 1. It should be noticed that the system voltage is more stable in peak demand period. Furthermore, the direction of power flow depends on the voltage magnitude and the phase angle of bus stations in power flow analysis. While the larger positive phase angles represent the injection of production to the system, the negative phase angles or lower phase angles represent the consumption bus stations. Also, the active power flow towards from the bus having larger voltage phase angle to the one having lower voltage phase angle.

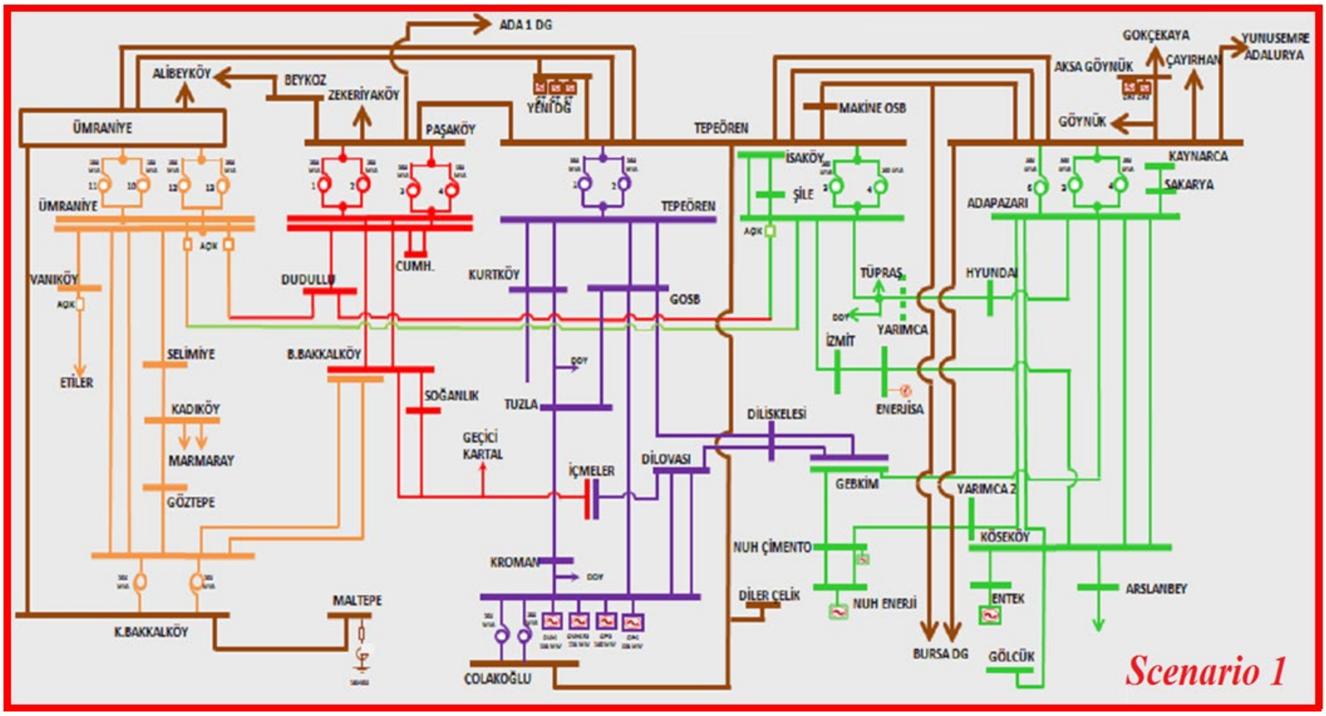

Figure 2. The single transmission line diagram of the Marmara region electrical power system for scenario 1.

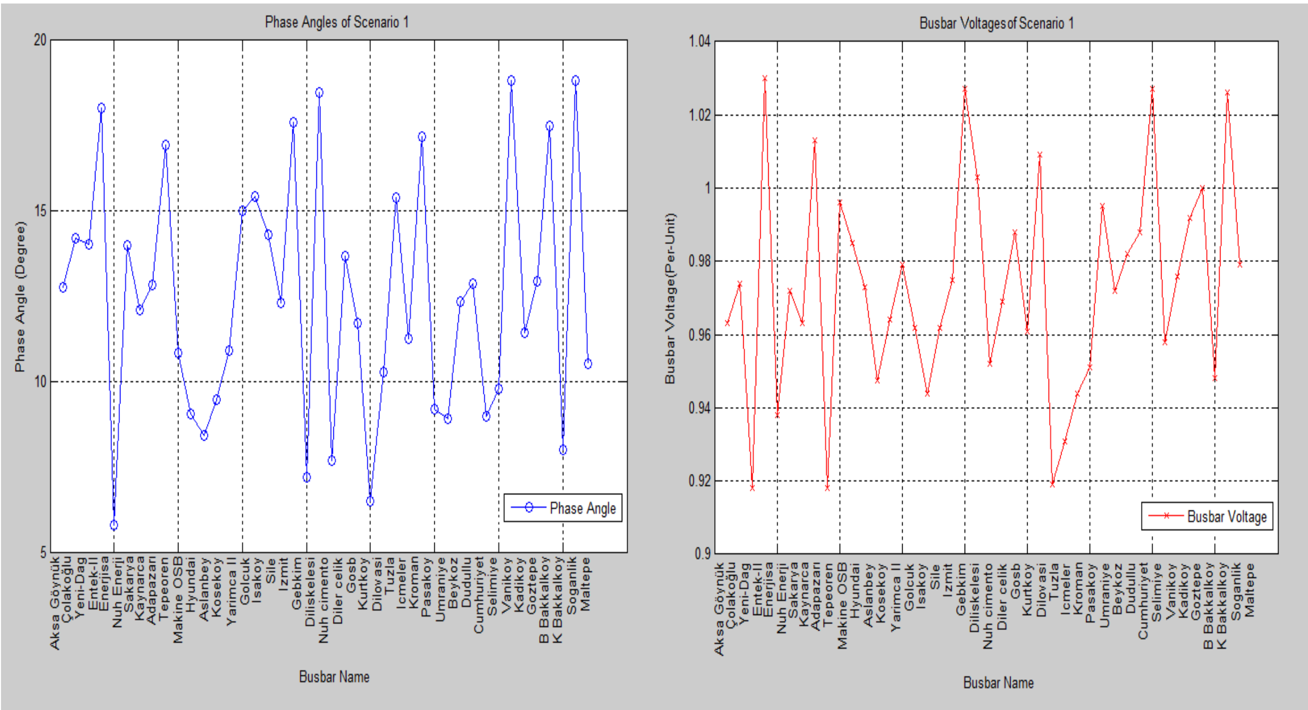

Figure 3. The bus station voltages and phase angles of the Marmara region electrical power system for scenario 1.

Table 1. The quantity of power generation and load value for scenario 1.

	Scenario 1		
	Bus Station Name	Active Power	Reactive Power
Generation Bus Station	**Aksa Göynük**	**50.5**	**11.7**
	Çolakoğlu	**474.6**	**116.3**
	Yeni Dağ	**28.9**	**7.1**
	Entek II	**97.3**	**30.1**
	Enerjisa	**41.6**	**4.2**
	Nuh Enerji	**58.9**	**14.3**
Load Bus Station	Sakarya	50.1	10.7
	Kaynarca	13.6	3.2
	Adapazarı	600.2	195.4
	Tepeören	1537.5	274.7
	Makine OSB	810.6	129.5
	Hyundai	61.6	9.1
	Aslanbey	87.8	14.9
	Köseköy	135.6	24.9
	Yarımca II	47.3	15.4
	Gölcük	16.7	4.6
	İsaköy	35.0	8.9
	Şile	50.1	10.9
	İzmit	71.0	22.5
	Gebkim	116.1	15.6
	Diliskelesi	310.4	103.6
	Nuh Çimento	58.0	7.8
	Dilerçelik	81.2	22.2
	Gosb	134.0	27.7
	Kurtköy	95.0	10.8
	Dilovası	50.8	9.9
	Tuzla	104.0	28.6
	İçmeler	179.1	35.6
	Kroman	134.1	41.4
	Paşaköy	945.6	152.6
	Ümraniye	818.2	128.3
	Beykoz	51.9	12.2
	Dudullu	206.0	47.0
	Cumhuriyet	23.4	4.6
	Selimiye	193.1	33.3
	Vaniköy	50.0	17.0
	Kadıköy	16.7	3.1
	Göztepe	105.0	24.1
	Büyük Bakkalköy	260.0	81.8
	Küçük Bakkalköy	237.0	33.2
	Soğanlık	149.0	50.7
	Maltepe	80.4	15.0

On the other hand, the reactive power flows from the bus station having higher voltage to the bus station having lower voltage profile. In case of giving an instance for (Figure 3); Entek-II, Nuh çimento, Vaniköy and Soğanlık have a high positive phase angle owing to the injection of production to electrical power system in scenario 1.

4.2. Analysis of Scenario 2

In the scheme of (Figure 4) is shown the single transmission line diagram of the Marmara region electrical power system for scenario 2. The quantity of power generation and load value for scenario 2 is given in table 2.

In scenario 2, the effects of small-sized micro generation power plants on the Marmara region interconnected power grid are analyzed in the period of maximum demand. The bus stations as Aksu Hes, Köprübaşı Hes, Pamukova, Erdemir-I, and Erdemir-II are included for the micro grid power generation. The active power participation is increased approximately 9% in the electrical power system. The bus station voltage values, the voltage variations and phase angles for scenario 2 are shown in (Figure 5). The average value of voltage is 0.99 Per-Unit value in scenario 2. Hence, the Marmara region interconnected electrical power system voltage value has become more stable in the peak demand period. As seen in (Figure 5), the voltage phase angles variations of bus stations that increase their electricity generation demand have risen in scenario 2.

Table 2. The quantity of power generation and load value for scenario 2.

	Scenario 2		
	Bus Station Name	Active Power	Reactive Power
Generation Bus Station	**Ada DGKÇS-I**	**1660.0**	**421.1**
	Ada DGKÇS-II	**722.0**	**200.1**
	Zetes-I	**746.6**	**152.6**
	Zetes-II	**1237.6**	**220.7**
	Aksu Hes	**37.0**	**8.6**
	Yeni Çates	**228.0**	**80.4**
	Köprübaşı Hes	**65.1**	**16.7**
Load Bus Station	Osmanca	145.4	35.7
	Ereğli	151.3	46.2
	Adapazarı	287.6	49.8
	Toyota	63.6	12.3
	Pamukova	44.0	10.8
	Hendek	37.0	8.6
	Kuzuluk	41.0	9.3
	Mudurnu	68.5	18.1
	Melen	28.0	5.6
	Karasu	47.0	9.1
	Kaynaşlı	44.9	10.6
	Bolu-I	65.1	15.7
	Bolu-II	35.4	9.7
	Bolu Çimento	36.5	6.3
	Gerkonsan	27.6	7.2
	Akçakoca	21.9	3.9
	Erdemir-I	57.2	11.9
	Erdemir-II	35.2	8.5
	Yeni Kozlu	35.5	6.3
	Bartın	49.5	11.2
	Zonguldak-II	46.9	16.3
	Çaycuma	69.7	18.3

4.3. Analysis of Scenario 3

In the scheme of (Figure 6) is shown the single transmission line diagram of the Marmara region electrical power system for scenario 3. The quantity of power generation and load value for scenario 3 is given in table 3. The effects of small-sized micro generation plants on the Marmara region interconnected power grid are analysed in the period of minimum demand in scenario 3. The bus stations as Aksa, Bis, Entek, Bares, Ulubat Hes, Asil Çelik and Yenişehir are included for the micro grid power generation. The active power participation is increased about 13% in the electrical power system.

Bus station voltage values and phase angles for scenario 3 are shown in (Figure 7). As seen in (Figure 7), voltage phase angles of bus stations that increase their power generation have risen in scenario 3. The voltage in 16% of bus stations has remained above the upper limit in scenario 3. This rate is increased to 8% through the demand response implemented. In addition, the average voltage value of electrical power grid has risen to 1.02 Per-Unit in scenario 3 and the voltage profile has become more stable according to other scenarios.

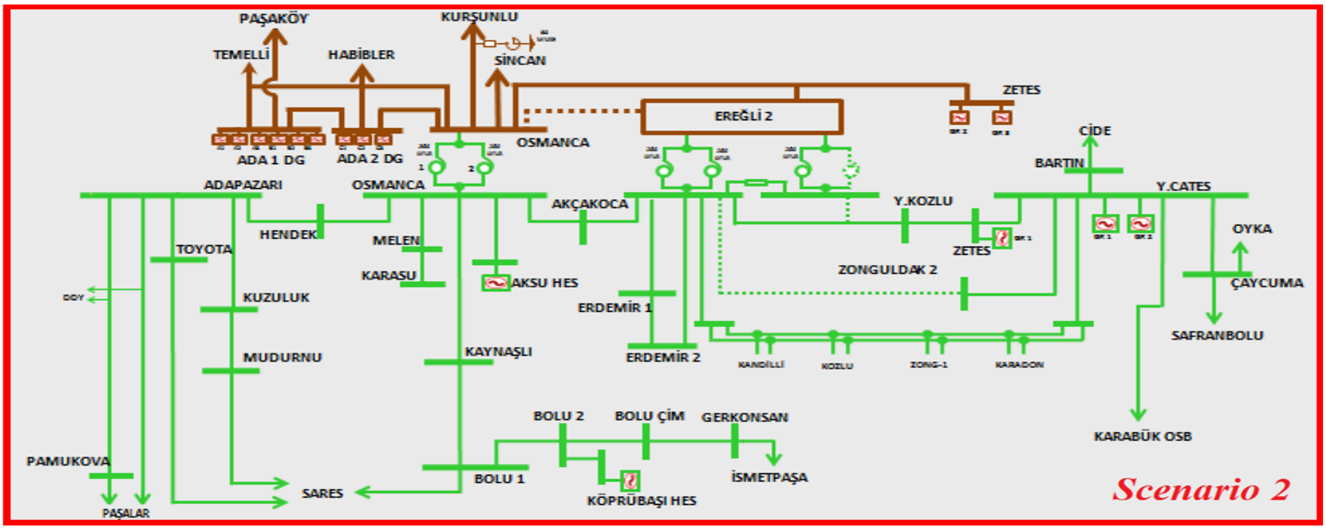

Figure 4. The single transmission line diagram of the Marmara region electrical power system for scenario 2.

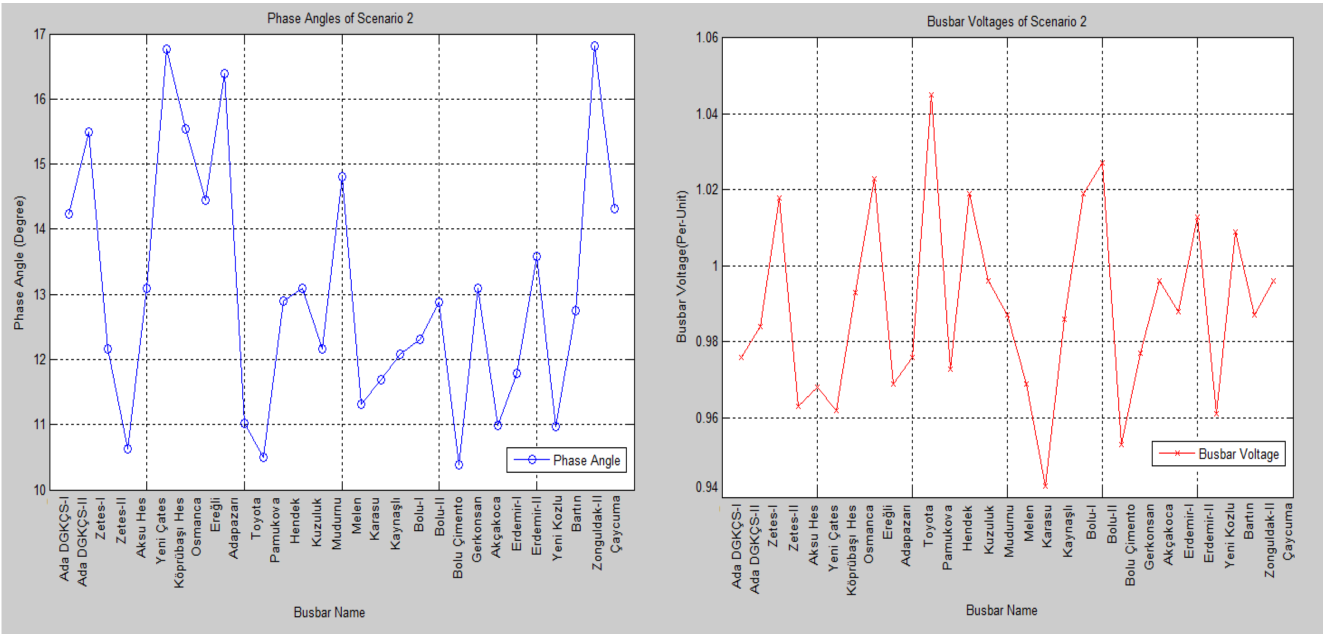

Figure 5. The bus station voltages and phase angles of the Marmara region electrical power system for scenario 2.

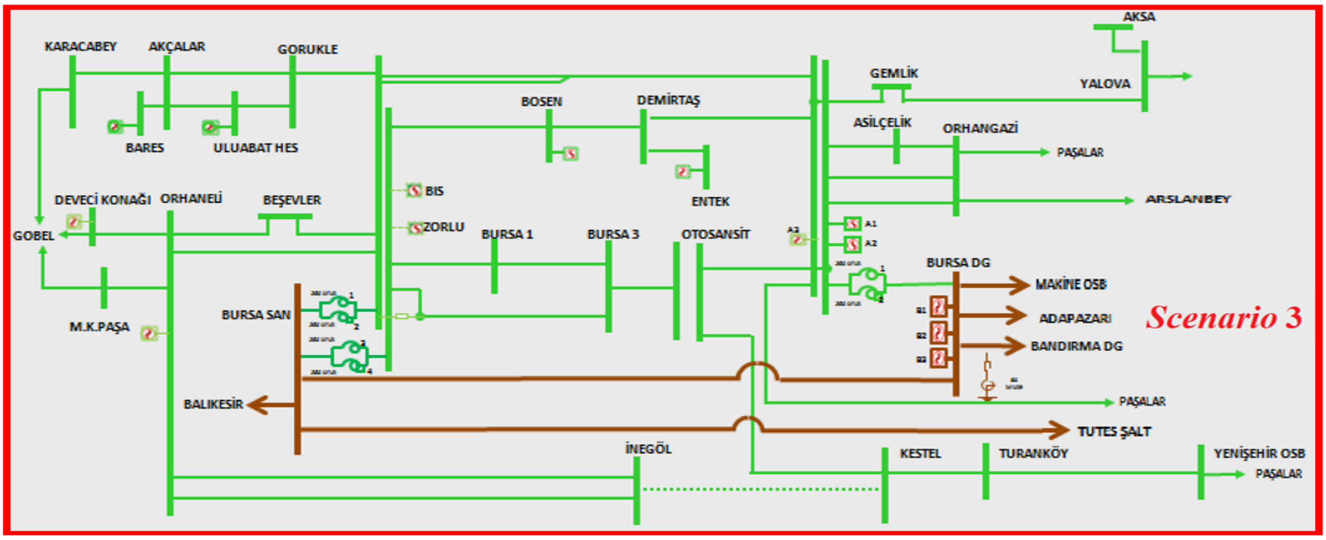

Figure 6. The single transmission line diagram of the Marmara region electrical power system for scenario 3.

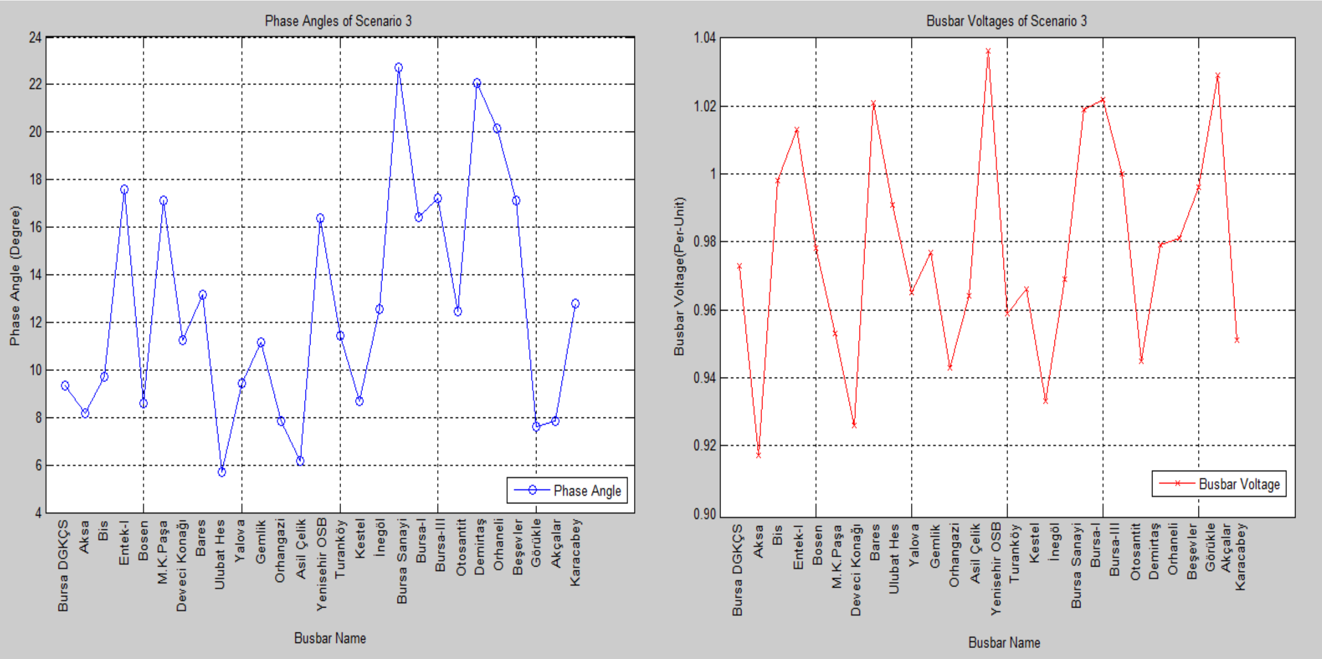

Figure 7. The bus station voltages and phase angles of the Marmara region electrical power system for scenario 3.

Table 3. The quantity of power generation and load value for scenario 3.

	Scenario 3		
	Bus Station Name	Active Power	Reactive Power
Generation Bus Station	**Bursa DGKÇS**	**799.2**	**131.4**
	Aksa	**140.6**	**21.7**
	Bis	**76.4**	**12.3**
	Entek-I	**137.0**	**43.4**
	Bosen	**31.6**	**5.4**
	M.K. Paşa	**25.0**	**7.7**
	Deveci Konağı	**39.0**	**7.6**
	Bares	**29.0**	**5.3**
	Ulubat Hes	**13.0**	**2.6**
Load Bus Station	Yalova	87.3	14.6
	Gemlik	130.0	25.6
	Orhangazi	182.5	25.1
	Asil Çelik	102.1	11.0
	Yenişehir OSB	34.0	10.0
	Turanköy	58.0	16.2
	Kestel	142.9	21.8
	İnegöl	97.0	21.6
	Bursa Sanayi	610.2	268.1
	Bursa-I	198.3	51.6
	Bursa-III	80.0	24.8
	Otosantit	231.9	51.3
	Demirtaş	108.9	44.1
	Orhaneli	175.8	64.5
	Beşevler	72.3	22.3
	Görükle	47.0	6.3
	Akçalar	8.0	1.1
	Karacabey	26.0	5.9

4.4. Analysis of Scenario 4

In the scheme of figure 8 is shown the single transmission line diagram of the Marmara region electrical power system for scenario 4. The quantity of power generation and load value for scenario 4 is given in table 4. In scenario 4, the voltage levels have remained below the lower limit in the bus stations of Polat Tes, Söğüt, Kütahya, Kütahya OSB and Eskişehir-I. For this reason, in scenario 4, the voltage variations in the mentioned bus stations are analysed by changing the consumption and the reactive power rates of these bus stations. The power consumption values in these bus stations are decreased in the rate of 4%. Voltages in the bus stations of Dedeli DG, Tutes Şalt, Metristepe Res, Altıntaş and Kırka have increased and the average voltage of electrical power system has risen to 1.00 Pu.

Table 4. The quantity of power generation and load value for scenario 4.

	Scenario 4		
	Bus Station Name	Active Power	Reactive Power
Generation Bus Station	**Dedeli DG**	**21.3**	**4.1**
	Tutes-A	**125.0**	**10.3**
	Tutes-B	**130.0**	**10.9**
	Tutes Şalt	**213.3**	**39.8**
	Polat Tes	**134.6**	**33.9**
	Gediz Tes	**76.5**	**11.9**
	Seyitömer	**324.1**	**93.1**
	Metristepe Res	**16.6**	**4.2**
Load Bus Station	Paşalar	53.5	13.9
	Bilorsa	50.1	10.9
	Söğüt	43.1	12.6
	Emet	84.5	22.2
	Yeni Gediz	76.5	11.9
	Simav	47.0	6.3
	Demirci	97.0	21.6
	Eti Gümüş	80.3	20.8
	Kütahya	147.0	39.6
	Kütahya OSB	51.1	13.8
	Altıntaş	28.3	7.4
	Kümaş	19.4	4.3
	Kırka	24.0	3.3
	Çifteler	69.7	19.3
	Eskişehir-I	46.1	12.6
	Eskişehir-II	76.5	11.9
	Eskişehir-III	182.5	25.1
	Çimsa	34.2	8.5
	Bozuyuk OSB	61.6	9.1
	Bozuyuk	71.0	18.5

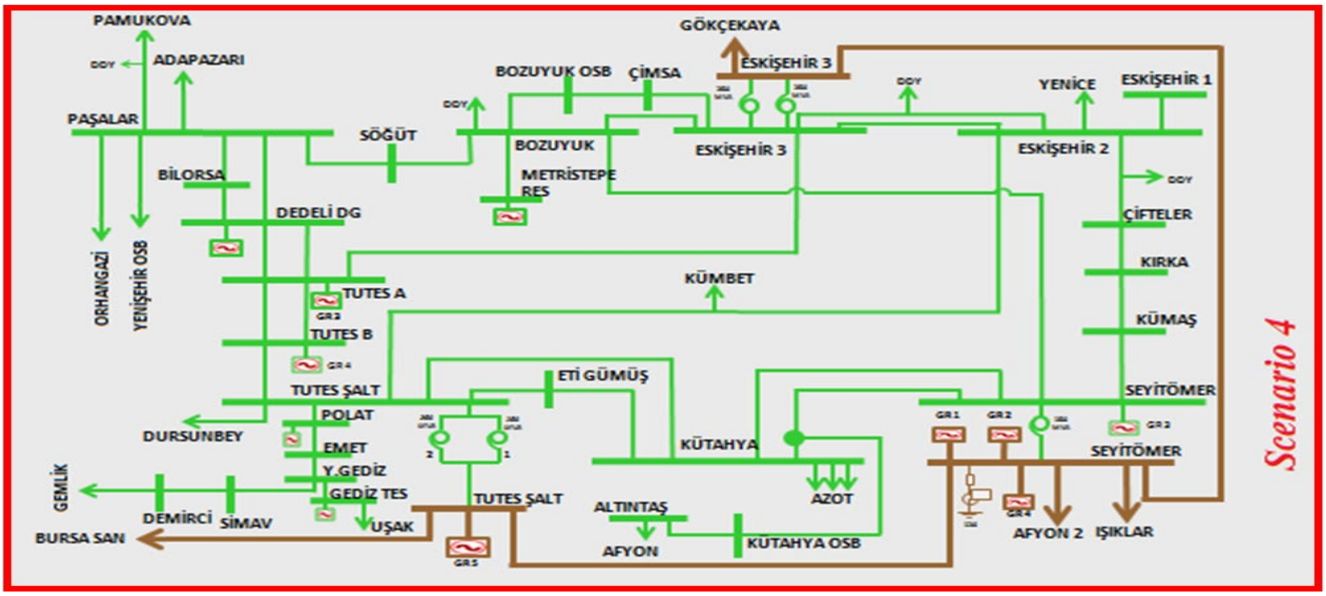

Figure 8. The single transmission line diagram of the Marmara region electrical power system for scenario 4.

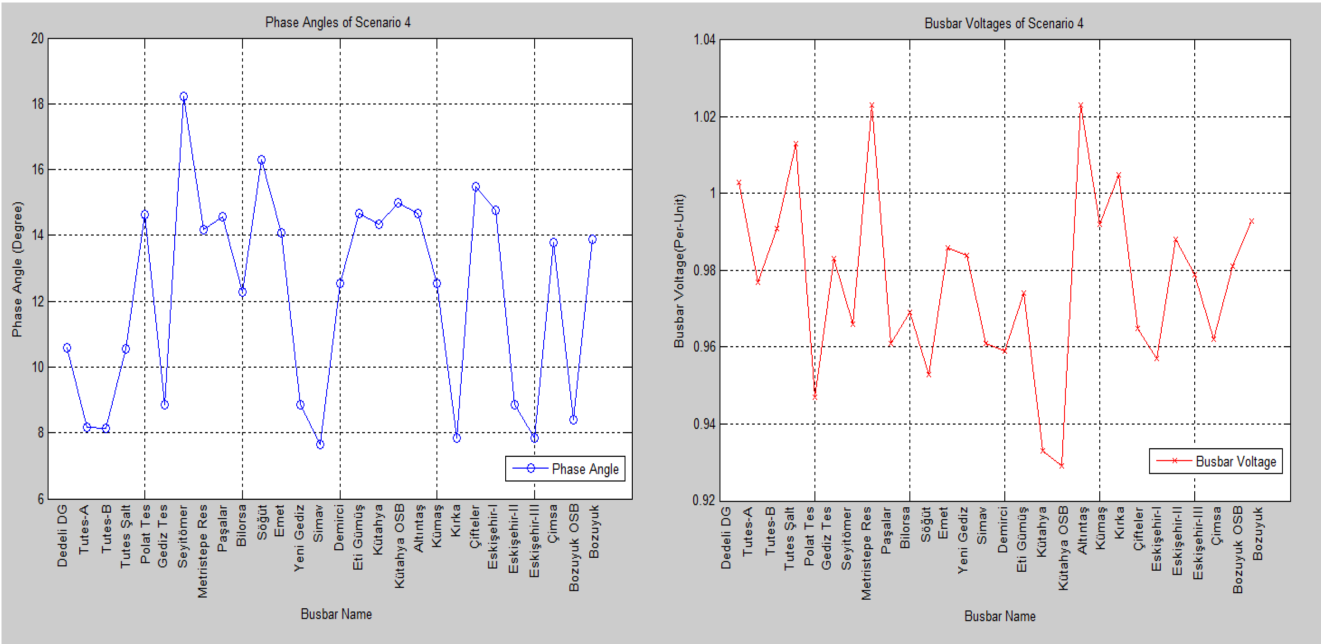

Figure 9. The bus station voltages and phase angles of the Marmara region electrical power system for scenario 4.

The bus station voltage values and phase angles for scenario 4 are shown in figure 9. The voltage phase angles are closer to the reference values as a result of the voltage increase in the bus stations of Polat Tes, Seyitömer, Metristepe Res, Paşalar, Söğüt, Emet, Eti Gümüş, Kütahya, Kütahya OSB, Altıntaş, Çifteler and Eskişehir-I.

5. Conclusions

This paper deals with multiple cascading failure outages scenarios of Marmara region interconnected power grid in Turkey. Criticality or super criticality in the branching process implies a high risk of catastrophic and wide spread cascading failures. Maintaining sufficient sub criticality in the branching process according to a simple criterion would limit the propagation of failures and reduce this risk. In this study, the Marmara region interconnected power grid is tested for overloads due to various contingencies. Firstly, Power transmission line and generator outages are considered as contingencies. Other dynamic problems are not considered. The voltage levels in the cases of maximum and minimum electricity power consumption demand are evaluated in the power grid analyses made. In this evaluation, it is shown that the voltage profile is more stable due to the maximum generation in the peak demand period. Since the power transmission lines have limited capacity to carry energy, they can easily get overloaded if the power flow on the tripped transmission lines is redistributed through them. Out of all the possible single power transmission line contingencies, 23 contingencies were identified as set of potentially dangerous contingencies.

Furthermore, the electrical power grid voltage is closer to the nominal level when the demand response is included into the power transmission system in both scenarios. Particularly, the contribution of demand response to the grid voltage is more in the minimum consumption period. In addition, the voltage control is carried out exactly by means of controlling the electricity consumption in the demand side. As a result of the critical line scenarios performed, many reasonable and significant outcomes are achieved as follows: It is foreseen that the demand response will play a key role in the control of power transmission systems. It is obvious that the demand response consideration will provide the crucial contributions to power grid security and energy market in the stages of planning and operating of power systems. The overloading cases in power transmission lines will be prevented and the system voltage will be more stable by meeting the electricity demand on the consumer side. Thus, the capacity investments of power transmission systems and the power grid losses will be reduced. In future works, more large-scale power grid analyses can be done in the existing interconnected power transmission system. The effects of different generation resources or variable loads on the power grid can be analyzed in detail. Especially, the long-term capacity planning and the power grid steady analyses can be realized by considering a regional power demand reply.

References

[1] M. Eremia, M. Shahidehpour (April 2013). Handbook of Electrical Power System Dynamics: Modelling, Stability and Control. Wiley-IEEE Press. Pages. 291-339.

[2] A. S. Sambo (Fourth Quarter 2008). Matching Electricity Supply with Demand in Nigeria. International Association for Energy Economics. Pages. 32-36.

[3] V. Vesma (2009). Energy Management Principles and Practice. British Standards Institution. London, United Kingdom, Pages. 1-36.

[4] A. A. El-Alaily, M. M. Mandour, (1998). A Comprehensive Form for the Protection of Very Short Transmission Lines. Electric Power System Research. Vol. 14, No.3, Pages. 227-232.

[5] D. Nasser, C. Eng (2008). International Standards for Short-Circuit Analysis in A.C. Power Systems. Power System Modelling and Fault Analysis. Vol.5, No.1, Pages. 451-484.

[6] C. Kigen, N. A. Odero (December 2012). Optimizing Voltage Profile of Distribution Networks with Distributed Generation. International Journal of Emerging Technology and Advanced Engineering. Vol. 2, No. 12, Pages. 89-95.

[7] I. Musirin, N. D. M. Radzi, M. M. Othman, M. K. Idris, T. K. A. Rahman (April 2008). Voltage Profile Improvement Using Unified Power Flow Controller via Artificial Immune System. Wseas Transactions on Power System. Vol. 3, No. 4, Pages. 194-204.

[8] N. Thekla, S. Boutsika, A. Papathanassiou (2008). Short-Circuit Calculations in Networks with Distributed Generation. Electric Power Systems Research. Vol. 78, No.7, Pages. 1181-1191.

[9] N. H. Sohtaoglu (29-31 May 2000). Investigation of the Effects of Differing Investment Programs and Macroeconomic Parameters on Long-Term Power Transmission Planning, II Case Study Results. IEEE Electrotechnical Conference. (MELECON 2000). 10th Mediterranean. Pages. 1019-1022.

[10] A. P. S. Meliopoulos, D. Taylor, C. Singh, F. Yang, S. W. Kang, G. Stefopoulos (April 2005). Comprehensive Power System Reliability Assessment: Final Project Report. Power System Engineering Research Center. PSERC Publication 05-13, Pages. 3-15.

[11] N. V. Panagis, E. K. Aristides, A. R. Wallace, P. H. Gareth (February 2007). Centralized and Distributed Voltage Control: Impact on Distributed Generation. IEEE Transactions on Power Systems. Vol. 22, No. 1, Pages. 476-483.

[12] S. Tomonobu, M. Yoshitaka, Y. Atsushi, U. Naomitsu, F. Toshihisa (April 2008). Optimal Distribution Voltage Control and Coordination with Distributed Generation. IEEE Transactions on Power Delivery. Vol. 23, No. 2, Pages. 1236-1242.

[13] J. Hernandez, Y. D. Valle, G. K. Venayagamoorthy, R. G. Harley (2006). Optimal Allocation of a STATCOM in a 45 Bus Section of the Brazilian Power System Using Particle Swarm Optimization. IEEE Swarm Intelligence Symposium. Indianapolis, Indiana. Paper 349.

[14] F. D. Galiana, K. Almeida, M. Toussaint, J. Griffin, D. Atanackovic, B. T. Ooi, D. T. McGillis (November 1996). Assessment and Control of the Impact of Facts Devices on Power System Performance. IEEE Transactions on Power Systems. Vol. 11, No. 4, Pages. 1931-1936.

[15] I. Dobson, B. A. Carreras, V. E. Lynch, D. E. Newman (2007). Complex Systems Analysis of Series of Blackouts: Cascading Failure, Critical Points, and Self-Organization. Chaos: An Interdisciplinary Journal of Nonlinear Science. Vol. 17, No. 2, Paper 026103.

[16] G. Andersson, P. Donalek, R. Farmer, N. Hatziargyriou, I. Kamwa, P. Kundur, N. Martins, J. Paserba, P. Pourbeik, J. Sanchez-Gasca, R. Schulz, A. Stankovic, C. Taylor, V. Vittal (November 2005). Causes of the 2003 Major Grid Blackouts in North America and Europe, and Recommended Means to Improve System Dynamic Performance. IEEE Transactions on Power Systems. Vol. 20, No. 4, Pages. 1922-1928.

[17] D. P. Nedic, I. Dobson, D. S. Kirschen, B. A. Carreras, V. E. Lynch (2006). Criticality in a Cascading Failure Blackout Model. International Journal of Electrical Power and Energy Systems. Vol. 28, No. 9, Pages. 627-633.

[18] M. Wierzbowski, W. Lyzwa, I. Musial (May 2016). MILP Model for Long-Term Energy Mix Planning with Consideration of Power System Reserves. Applied Energy. Vol. 169. Pages. 93-111.

[19] J. D. Weber (1997). Implementation of a Newton-Based Optimal Power Flow into a Power System Simulation Environment. Wisconsin University MSc Thesis. Urbana, Illinois.

[20] A. Mills, R. Wiser, K. Porter (February 2009). The Cost of Transmission for Wind Energy: A Review of Transmission Planning Studies. Ernest Orlando Lawrence Berkeley National Laboratory. LBNL-1471E. Pages. 1-66.

[21] S. Benedettini, F. Pontoni (2013). Italian Regulation of Electricity Distribution and Its Impact on Efficiency, Investments and Innovation: A Qualitative Assessment. Competition and Regulation in Network Industries. Vol.14, No. 4, Pages. 365-384.

[22] U. Fesli, R. Bayır, M. Özer (5-8 November 2009). Design and Implementation of A Domestic Solar-Wind Hybrid Energy System. International Conference on Electrical and Electronics Engineering. (ELECO 2009). Bursa, Turkey. Pages. 29-33.

[23] C. Zhao, U. Topcu, S. H. Low (27-29 June 2012). Frequency-Based Load Control in Power Systems. 2012 American Control Conference. (ACC'09). Montreal, QC, Canada. Pages. 4423-4430.

[24] H. Chen, T. N. Cong, W. Yang, C. Tan, Y. Li, Y. Ding (2009). Progress in Electrical Energy Storage System: A Critical Review. Progress in Natural Science. Vol.19, No.3,

Pages. 291-312.
[25] A. M. Gonzalez, A. M. S. Roque, J. G. Gonzalez (2005). Modelling and Forecasting Electricity Price with Input-Output Hidden Markov Models. IEEE Transactions on Power Systems. Vol. 20, No. 1, Pages.13-24.
[26] S. Jalilzadeh, A. Kazemi, H. Shayeghi, M. Madavi (2008). Technical and Economic Evaluation of Voltage Level in Transmission Network Expansion Planning Using GA. Energy Conversion and Management. Vol. 49, No. 5, Pages. 1119-1125.
[27] Y. Zhou, H. Liu, Z. Pan, L. Tian, J. Shi, G. Yang (2014). Two-Stage Cooperative Multicast Transmission with Optimized Power Consumption and Quarantined Coverage. IEEE Journal on Selected Areas in Communications. Vol. 32, No. 2, Pages. 274-284.
[28] L. G. Hewitson, M. Brown, R. Balakrishnan (2005). Simple Calculation of Short-Circuit Currents. Practical Power System Protection. Vol. 4, No.1, Pages. 11-25.
[29] G. C. Ejebe, G. D. Irisarri, S. Mokhtari, O. Obadina, P. Ristanovic, J. Tong (1995). Methods for Contingency Screening and Ranking for Voltage Stability Analysis of Power Systems. Proceedings of IEEE Power Industry Computer Application Conference. Salt Lake City, UT. Pages. 249-255.
[30] N. Pamuk (6-7 November 2015). Analysis of Marmara Region Electrical Power System Stability under the Critical Fault Conditions. International Conference on Energy Efficiency Engineering. UBT Conferences. Durres, Albania. Pages. 91-100.
[31] N. Pamuk (2009). Power Flow Simulations of 380 and 154 kV Northwest Anatolia Grid. Sakarya University MSc Thesis. Sakarya, Turkey. (in Turkish)
[32] E. Özdemirci, Y. Akkaya, B. Boyrazoglu, S. Buhan, A. Terciyanli, O. Unsar, E. Altintas, B. Haliloglu, A. Acik, T. Atalik, Ö. Salor, T. Demirci, I. Cadirci, M. Ermis (2007). Mobile Monitoring System to Take P-Q Snapshots of Turkish Electricity Transmission System. In proc. IEEE IMTC. Warsaw, Poland. Pages. 1-6.
[33] E. Lobato, I. Egido, L. Rouco (March 2012). Monitoring Frequency Control in the Turkish Power System. Electric Power Systems Research. Vol. 84, No. 1, Pages. 144-151.
[34] Turkish Electricity Transmission System Supply Reliability and Quality Regulation (2004). Last Accessed on December 12, 2009. [Online]. Available: http://www.teias.gov.tr/yonetmelikler/supply.doc
[35] IEC 61000-4-30 (2003). Testing and Measurement Techniques - Power Quality Measurement Methods.
[36] N. Pamuk, Y. Uyaroglu (January 2011). Comparison the 154 and 380 kV Transmission System Network of Northwest Anatolia by Making Power Flow Emulation with Constraint Analysis in Turkey. Scientific Research and Essays. Vol. 6, No.2, Pages. 469-478.