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*Full Length Research Paper*

# Comparison the 154 and 380 kv transmission system network of Northwest Anatolia by making power flow emulation with constraint analysis in Turkey

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**In this study, thereby explaining under which circumstances an interconnected transmission network works that, in Turkey 380 and 154 kV power transmission lines connected to each other and consist of 18 generation and 96 load buses that the interconnected power network of Northwest Anatolia taken up with 114 buses and also done the power flow and constraint analysis in order to plan for new establishing systems. With these analysis, the loading of generation power plants was enabled in the most proper way. At Northwest Anatolia network; power flow analysis is done for different load conditions thereby using PSAT programme which is generated by Matlab, plants are determined which will be finished in 2010, proper generation planning is prepared according to high and normal load estimations and also all new rates are found out at buses. Newton-Raphson iteration method is used in PSAT programme. Supplement tranformers, transmission lines and power generation units are determined according to obtained analysis results.**

**Key words:** Power systems, load flow, load estimation, constraint and risk analysis.

## INTRODUCTION

Electrical power is one of the main necessities in today's social and economical life. Developing technology, rising life standard and with growing population we need this power more,day after day. Electrical power consumption is the most important point which shows development level of countries.The most appropriate way to balance this increasing demand that already had a plan which is made for the future (Tinney et al., 1967). Interconnected transmission system consists of thousands of equipment such as power transmission lines, generators, transformers, buses, reactors and capasitors. We need to do many studies to operate this system in safe such as power flow analysis, short circuit analysis, temporary stability analysis, constraint analysis, harmonics analysis, flicker analysis, insulation coordination and impedance modelling (Kolcun et al., 1983). In normal operating conditions, power systems should transfer the power plants' maximum generation to the system and should keep voltage and frequency rates in definite limits which are stable or in constraint circumstance. Constraint analysis is inspection of its operability within definite limits without any power outagesbecause of other component's over loading in case of existing any disabled component in power systems. Transmission systems plans for loading under thermal limits, not to lose any consumer, not to change system stability and not to divide as isolated pieces (Ren et al., 2008; Lauby et al., 1983).

A possible power outages could prevent thereby transferring the electrical power from an other part to related part with connection lines during the equipment fault which can occur in interconnected systems or at the moment when any equipment is disabled because of maintenance and repair. There are so many ways as much as possible to keep electrical power continual for consumers. To determine the additional investments and precautions; size of load, its location and delay time based on power outagesis quite important (Pamuk, 2009).

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The purpose of this study that planning the transmission system. In this purpose; Interconnected network has been defined planning transmission systems at the first part, at the second part; basic power flow rules and computation methods have explained, at the third part; power flow and constraint analysis have done thereby presenting power system which is belong to Northwest Anatolia network of Turkey. Optimum results have been achieved by comparing values between PSAT programme results and real measurement values. As a final, we have suggested upon necessaries in the future about the additional power plant and investments thereby evaluating with achieved results at the fourth part.

## BASIC POWER FLOW RULES AND COMPUTATION METHODS

Power flow analysis is a common analysis method in power system emulation. Power flow problem is the calculation of its flowing at transmission lines and transformers in order to compensate consumptions at all buses in power systems. It needs to be that tranmission lines and transformers should not been overloaded, voltages at buses should keep their rates into definite limits and reactive production of generators should keep into acceptable limits (Dacosta et al., 1999). Power flow analysis can use in existing power systems planning, controlling, operating and also use for longlife power systems planning. Proper operating for power systems depends on to be experienced when new production and consumption power plants added to the system or when added tranmission line was disabled. It is possible that determination the most proper place for capacitors and also determination their capacities in order to boosting voltages at buses and power factor with power flow analysis (James, 2001).

Whilst solving power flow problem, we suppose that the system is in balance and works under steady state conditions also element of transmission lines use positive constituent rates. In power systems, each bus define with 4 variables. These are amplitude|V|, voltage angle rate δ, active power (P) and reactive power (Q) (Weedy and Cory, 1998). Usually, system buses divide into 3 types: Slack Bus: This bus takes as a reference bus in power flow analysis that known variables are │V│and δ. Other variables (P,Q) can find with calculation.

Load Bus: This bus calls as P Q bus and known variables are P and Q. │V│and δ are variables which is trying to find.

Voltage Controlled Bus or Generator Bus: At this type of buses, P and V are known. Voltage can keep in constant rate with Q limits at this bus. By the way generator, static capacitor etc. are connected with this bus like other system components.

Basic informations which we need to know for power flow analysis that:

1. Impedance and capacitive admittance of transmission lines.
2. Impedance of transformers and tap changing rates.
3. Admittance of shunt connected equipments such as static capacitor or reactor.
4. Power rate for each bus in the system.
5. Production capacity for each generator.
6. Reactive production of generators.
7. Maximum and minimum reactive production limits for generators.

With above mentioned informations:

1. Unknown voltage amplitude for each bus in system.
2. Voltage angle of each bus.
3. Reactive production for each generator with unknown reactive production.
4. Active, reactive power flow and their currents for each transmission line and each transformer can calculate (Neyer et al., 1990 and Ramalingam, 2004).

## NEWTON-RAPHSON METHOD

Different kind of iteration methods for solution are used as a reason that power flow problem consists of so many nonlinear equations. Whilst Newton-Raphson method using initial states estimate for unknown rates.

Correction in the function goes to zero thereby doing error corrrection for independent variables which are related to with the function. We try to reach solution thereby making clear around of $x_o$ with Taylor series to make error towards the zero.

$$\begin{aligned} Vi &= |Vi|\angle \delta_i \\ Vj &= |Vj|\angle \delta_j \\ Yij &= |Yij|\angle \theta_{ij} \end{aligned} \tag{1}$$

$$PTi = V_i \sum_{j=1}^{n} Y_{ij} V_j \cos\left(\delta_i - \delta_j - \theta_{ij}\right) \tag{2}$$

$$Q_{Ti} = V_i \sum_{j=1}^{n} Y_{ij} V_j \sin\left(\delta_i - \delta_j - \theta_{ij}\right) \tag{3}$$

To execute this method at the solution of power flow problem, complex power which flows towards the any i bus inside of n buses, power system can defined such as above mentioned (2) and (3) equations. If we write bus voltages and bus impedance matrix in polar coordinates and if the first bus select as slack bus; second and next ones are omitted. The (4) equality is achieved when (2) and (3) equations made clear with taylor series.

$$\begin{pmatrix} \Delta P \\ \cdots \\ \Delta Q \end{pmatrix} = \begin{pmatrix} J_1 & \vdots & J_2 \\ \cdots & \cdots & \cdots \\ J_3 & \vdots & J_4 \end{pmatrix} \begin{pmatrix} \Delta \delta \\ \vdots \\ \Delta |V| \end{pmatrix} \tag{4}$$

Elements of $J_1$, $J_2$, $J_3$ and $J_4$ in Jacobien matrix are partial differentials of active and reactive power which shows from (2) and (3) equations and also $\Delta\delta i^{(k)}$ and $\Delta|Vi^{(k)}|$ are calculated partial differentials.

$$J_1 = \frac{\partial P_i}{\partial \delta_k} = -V_i V_k y_{ik} \sin\left(\delta_i - \delta_k - \theta_{ik}\right), k \neq i$$

$$J_2 = \frac{\partial Q_i}{\partial V_k} = -V_i y_{ik} \cos\left(\delta_i - \delta_k - \theta_{ik}\right), k \neq i$$

$$J_3 = \frac{\partial Q_i}{\partial \delta_k} = -V_i V_k y_{ik} \cos\left(\delta_i - \delta_k - \theta_{ik}\right), k \neq i$$

$$J_4 = \frac{\partial P_i}{\partial V_k} = -V_i y_{ik} \sin\left(\delta_i - \delta_k - \theta_{ik}\right), k \neq i$$

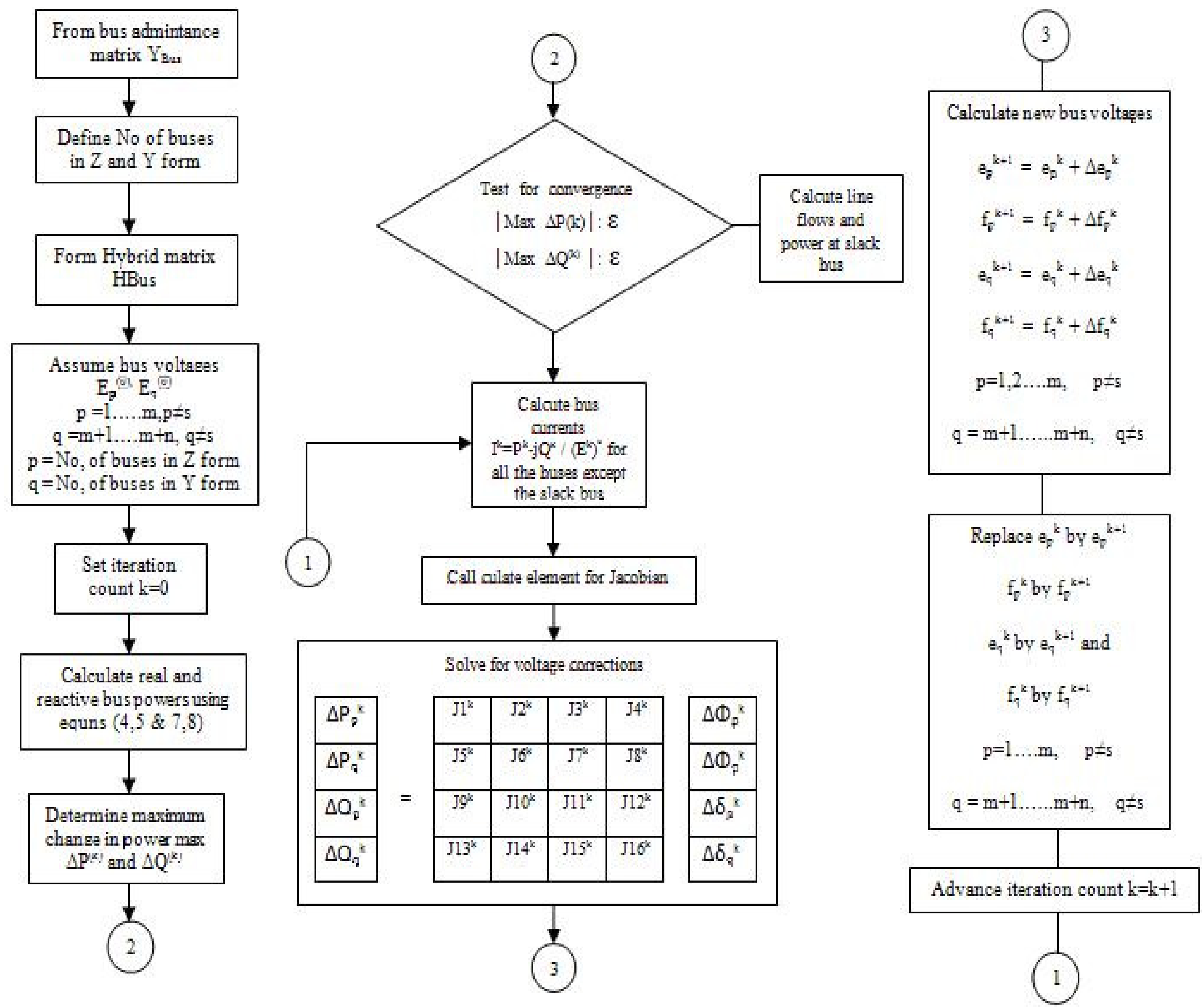


**Figure 1.** Flow chart for Newton-Raphson method.

Power flow problem solves thereby following below steps with Newton - Raphson method (Baus, 1998). Newton-raphson method of flow chart and constraint analysis of flow chart are given in Figures 1 and 2.

1. Step : $P_i^{(k)}$ and $Qi^{(k)}$ calculate for k. iteration from (2) and (3) equations. The iteration is started from zero and use the initial state for voltage and phase angles. At next iterations the last voltage and angle rates are used.
2. Step : $\Delta P_i^{(k)}$ is calculated from (5) and (6) equations.

$$\Delta Pi^{(k)} = P_i^{(given)} - P_i^{(k)} \tag{5}$$

$$\Delta Qi^{(k)} = Qi^{(given)} - Qi^{(k)} \tag{6}$$

3. Step : Jacobien matrix is calculated.
4. Step : $\Delta\delta i^{(k)}$ and $\Delta|Vi^{(k)}|$ are calculated thereby inversing Jacobien matrix.
5. Step : New rates of $\delta i^{(k)}$ and $|Vi^{(k)}|$ are found from below equations.

$$\delta_i^{(k+1)} = \delta_i^{(k)} + \Delta\delta_i^{(k)} \tag{7}$$

$$|Vi^{(k+1)}| = |Vi^{(k)}| + \Delta|Vi^{(k)}| \tag{8}$$

Iteration keeps going until reach given limits for $\Delta P$, $\Delta Q$ and $\Delta\delta$, $\Delta|V|$. P and Q rates at slack bus and Q rate at generator buses are found with help of (2) and (3) equations.

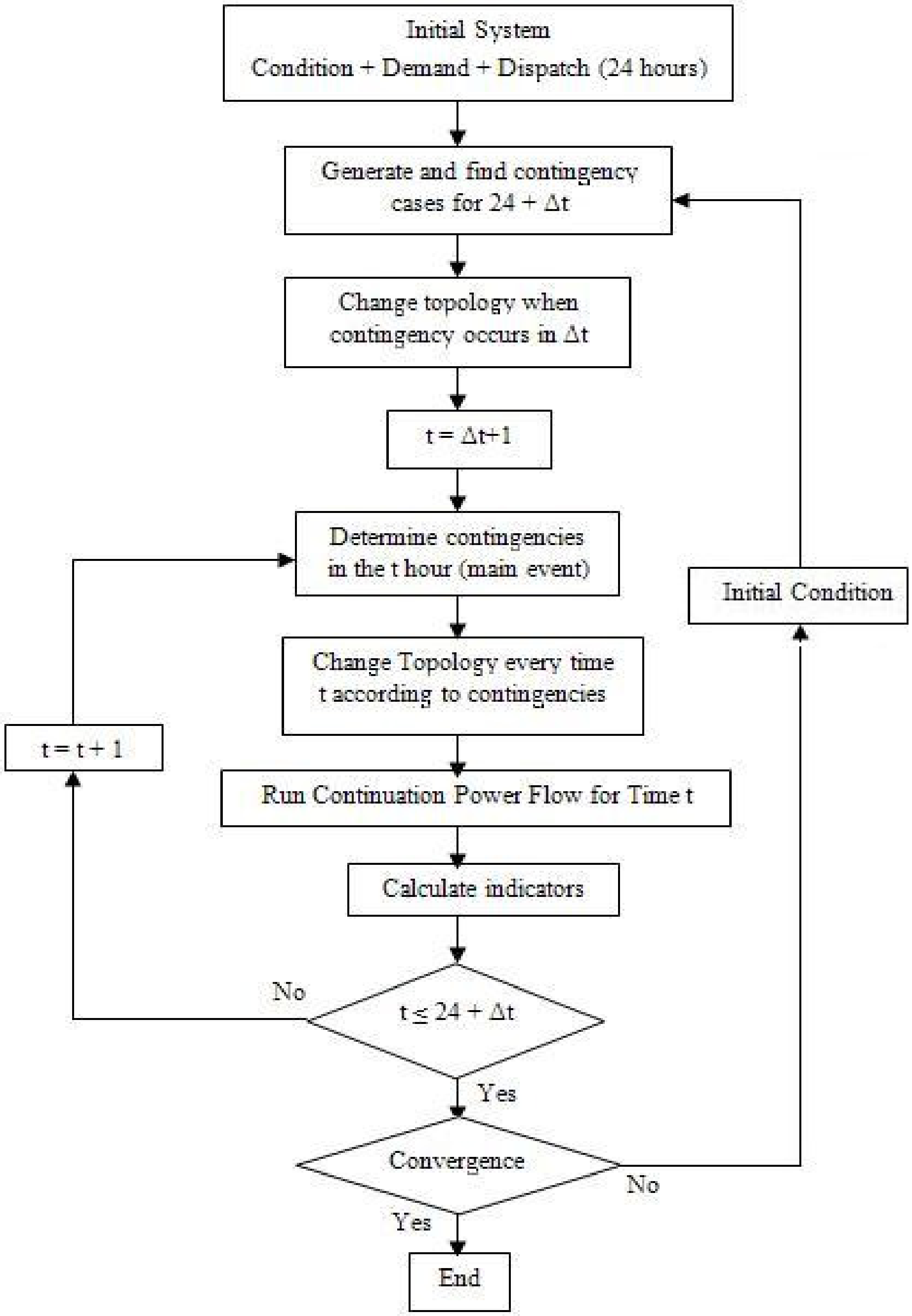


**Figure 2.** Flow chart for constraint analysis.

## DESCRIBING OF PSAT PROGRAMME WHICH IS USED FOR MODELLING IN POWER SYSTEM

Power system analysis Toolbox (PSAT) is a matlab application that makes analysis of electrical power systems and its emulation by the way it works in lots of works. Programme could be with commands which is entried from programme command line. Programme is compatible with GNU Octave. Programme is capable of main works, power flow, optimal power flow, small signal stability analysis, time domain emulation, phasor measurement unit (PMU), FACTS models, wind turbine models, data conversion in some formats and programme result report. It makes sensitive and correct calculations in order in steady and optimum power flow calculations whereby GAMS and UWPFLOW.

Programme, which is solved with help of Newton-Raphson iteration admits to enter synchronous machine loads, control systems, FACTS apparatuses, wind turbines as mathematical besides of static loads for correct and entire power flow analysis.

This programme is unable to realize these duties. Fault analysis, earthing system, harmonic analysis, protection analysis and coordination- because of toolboxes which can not execute by matlab (Milano, 2009).

## DESCRIBING THE POWER SYSTEM WHICH IS BELONG TO NORTHWEST ANATOLIA NETWORK IN TURKEY

Production-Consumption balance must be kept continuously in interconnected system operating. It is possible to keep this balance thereby controlling from one center. For very big systems, these zones are controlled from their own centers thereby dividing the system as zones more than one. Northwest Anatolia zone is one of zones in Turkey. Northwest Anatolia region map is given in Figure 3.

Existing operation voltage in Northwest Anatolia zone is 154 and 380 kV. There are 12 buses with 380 kV and 102 buses with 154 kV in zone. Among these 114 buses, 18 buses are for production and 96 buses are for load bus. In this system there are 5 autoproducer power plants, 4 special power plants, 7 thermic power plants and 2 hydraulic power plants.

All 380 and 154 kV line rates in the system were conversed the PU (per unit) system to adapt. Northwest Anatolia network on PSAT programme. Characteristic rate of autotransformers were used. Numbers were given from 1 to 114 for all buses. Autoproducer and free production power plants which are connected to the system from medium voltage level were not existing but existing power plants which have special 154 kV switchyard (Enerjisa,Entek…) were considered however produced at medium voltage level. 380 kV Ada Doğalgaz 1 transformer center was selected as slack bus thereby writing bus voltage rate for each bus. Power flow analysis was made thereby accepting the transmission loss provided from this bus. Indeed, this bus already is a high generator bus (1350 MW).

Power plants which are connected with other zones were described as negative load and existingpower plant that it acts the voltage. Transformer loads at all buses, entered the programme as kinf of pu (per unit) at the moment when we want analysis. Coupling breaker was described as very short line at stations (Adapazarı, Bursa doğalgaz, Eskişehir3) where both buses are independent, be able to supply same or different part and has possibility to converse into one bus with switch off the coupling breaker. Real rates were used at autotransformer thereby thinking a line which exists between two buses. The state of disabled line and autotransformer because of fault or other reason-were indicated thereby putting breaker information which is according to lines. Voltage level difference was not considered because of calculation with per unit rates. Result of above mentioned implementations, PSAT programme was executed and obtainedanalysis results (Teias, 2008; Farrag, 1998).

### Power flow analysis

Total consumption is 8481,5 MW under peak load conditions in 2009 except internal consumption of power plants and loses at lines. The sum of active power loses at lines is 250.229 MW. Approximately 2,865 % of power in 8731,729 MW is loses at transmission lines. The most loaded tranmission line with 83,2 % loading rate is between Bursa and Bursa Sanayi with 954 MCM conductor that according to their transmission capacity. It works for all transmission lines under peak load condition (2009) and under normal operating condition with enabled transformers.

In this instance, from Bursa Sanayi transformer center towards the Bursa transformer center, 298,7 MW and 75 MVAR power flow the line. The highest voltage is realized as 405,080 Kv (1,0660 p.u.) in Ada Doğalgaz transformer center and the lowest voltage is realized 377,683 Kv (0,9989 p.u.) in Bursa Sanayi. The highest voltage is realized as 160,189 Kv (1,0402 p.u.) in Paşaköy transformer center and the lowest voltage is realized 144,396 Kv (0,9376 p.u.) in Gerkonsan trans-former center. Results of power flow analysis which is belong to Northwest Anatolia network are given in Figures 4 and 5.

### Constraint analysis

Normal function of system performance is expected not to exceed the other component's transmission capacity in constraint analysis. System components were controlled thereby disabling all lines one by one. Double circuit lines on same masts were considered as disabled simultane-ously. Results of constraint analysis in 2009 were indicated in Table 1 and Figure 6.

In this purpose, when a line disabled, over power flow happens at other lines or other transformers and voltages occur furthermore limit rates of bus voltage. As seen from Table 1, when transmission line disabled between Tepeören and Ümraniye, he 154 kV transmission line loads 128.4 % between Ümraniye and Küçükbakkalköy. When 380 kV power transmission line disabled bet-ween Bursa natural gas combined cycle power plant and Bursa Sanayi, over loaded lines in system loads like 138.6% in Demirtaş Bursa NGCCPP, 117.1% in Bursa NGCCPP Otosantit, 130.7 % in Bursa Sanayi Bosen.

The comparison of emulation results on PSAT and real system rates which are taken from load distribution admin are seen in Table 2. Small differences occur between real system and achieved results from programme.

These differences rise because of reading and mea-surement errors from transformer centers and because of iteration methods on PSAT programme.

**Table 1.** Brief results for constraint analysis of Northwest Anatolia network.

| Constraint (n-1) | Loaded Line, Loading Rate (%) |
|---|---|
| (154kv) Tutes Şalt Tutes B | Kütahya - Tutes Şalt (107,0) |
| (154kv) Adapazarı Köseköy | Nuh çimento - Köseköy (105,3) |
| (154kv) Diliskelesi Çolakoğlu | Diliskelesi - İçmeler (103,3) |
| (380kv) Tepeören Ümraniye | Ümraniye Küçükbakkalköy(128,4) |
| (380kv) Bursa Doğalgaz Bursa Sanayi (1) | Demirtaş Bursa Doğalgaz (138,6) |
| (380kv) Bursa Doğalgaz Bursa Sanayi (2) | Bursa Doğalgaz- Otosantit (117,1) |
| | Bursa Sanayi – Bosen (130,7) |

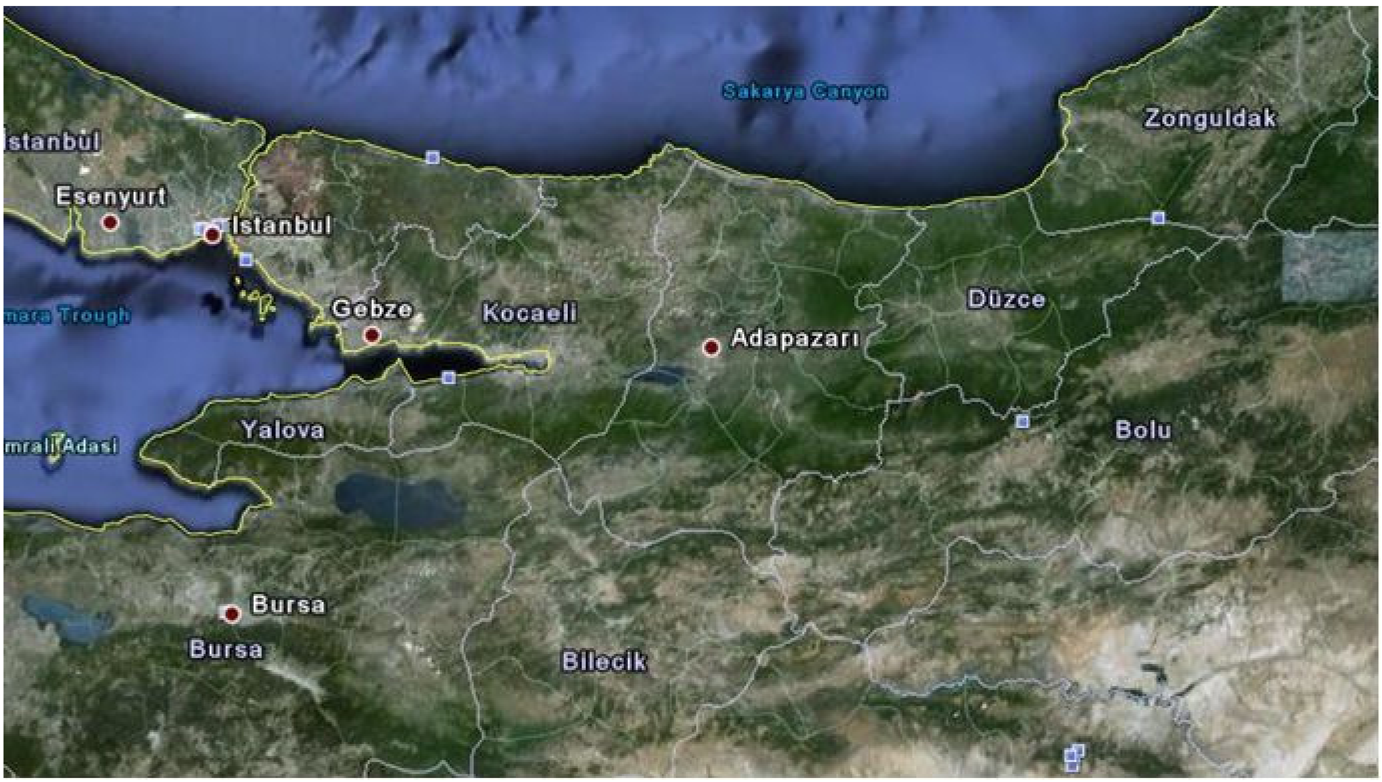


**Figure 3.** Northwest Anatolia region map in Turkey.

**Table 2.** Compare with PSAT rates and real system rates.

| Transfer center | V | | $\varphi$ | | P | | Q | | P loss | | Q loss | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PSAT | Real system | PSAT | Real system | PSAT | Real system | PSAT | Real system | PSAT | Real system | PSAT | Real system |
| 380 kv Seyitöma | 389.9 | 387 | -0.18 | -0.16 | 270 | 270 | 262 | 213 | -46.3 | -42 | -77.2 | -73 |
| 380 kv Osmanca | 386.1 | 384 | -0.08 | -0.09 | 0 | 0 | 0 | 0 | 167.4 | 159 | 157.4 | 144 |
| 154 kv Bursa dgkçs | 154.3 | 155 | -0.26 | -0.25 | 215 | 220 | 439 | 403 | 11.3 | 14 | 15.7 | 13 |
| 154 kv Eskeşehir | 148.1 | 150 | -0.34 | -0.31 | 0 | 0 | 0 | 0 | 100.4 | 93 | 8.6 | 7 |
| 154 kv Hendek | 156.7 | 155 | -0.08 | -0.12 | 0 | 0 | 0 | 0 | 37 | 34 | 15.7 | 13 |
| 154 kv Orhaneli | 158 | 155 | -0.22 | -0.24 | 130 | 130 | 141 | 134 | 7.8 | 5 | 3.6 | 5 |
| 154 kv Yarimca | 155.5 | 154 | -0.12 | -0.11 | 0 | 0 | 0 | 0 | 55.4 | 52 | 9.4 | 8 |
| 154 kv Paşalar | 153.3 | 154 | -0.21 | -0.19 | 0 | 0 | 0 | 0 | 58 | 53 | 28.8 | 23 |

POWER FLOW REPORT

| | |
|---|---|
| Buses: | 114 |
| Lines: | 170 |
| Generators: | 18 |
| Loads: | 100 |

SOLUTION STATISTICS

| | |
|---|---|
| Number of Iterations: | 5 |
| Maximum P mismatch [MW] | 0 |
| Maximum Q mismatch [MVar] | 0 |

POWER FLOW RESULTS

| Bus | V [kV] | phase [rad] | P gen [MW] | Q gen [MVar] | P load [MW] | Q load [MVar] |
|---|---|---|---|---|---|---|
| 380ada dg | 405.08 | 0 | 6074.229 | 23351.4564 | -88.3 | -47.5 |
| 380ada dg | 393.8377 | 0.00218 | 362 | -20750.2568 | -133.4 | -11.8 |
| 380adapaz | 395.6688 | -0.04213 | 0 | 0 | 346.1 | 200.6 |
| 380bursa | 382.2796 | -0.19229 | 210 | 105.9353 | -128.3 | -93.1 |
| 380bursa | 377.6836 | -0.22158 | 0 | 0 | 36.6 | 191.9 |
| 380ereğli | 382.3544 | -0.12598 | 0 | 0 | 105.2 | 66.8 |
| 380osmanc | 386.0963 | -0.08713 | 0 | 0 | 167.4 | 157.4 |
| 380pasakö | 396.7424 | -0.04215 | 0 | 0 | 260.8 | 65.2 |
| 380seyitö | 389.88 | -0.18338 | 270 | 261.8058 | -46.3 | -77.2 |
| 380tepeör | 388.5324 | -0.09907 | 0 | 0 | 537.5 | 174.7 |
| 380tutes | 380.95 | -0.20078 | 105 | -369.2094 | 0 | 0 |
| 380ümrani | 387.783 | -0.10142 | 0 | 0 | 357.8 | 99.8 |
| adapazarı | 159.9521 | -0.0473 | 0 | 0 | 300.2 | 205.4 |
| akcalar | 154.23 | -0.24186 | 0 | 0 | 8 | 1.1 |
| akçakoca | 155.349 | -0.1123 | 0 | 0 | 21 | 3.9 |
| altıntaş | 153.7063 | -0.22044 | 0 | 0 | 4 | 0 |
| asilcelik | 149.4425 | -0.30707 | 0 | 0 | 102.1 | 11 |
| b.bakkalkö | 156.7584 | -0.09835 | 0 | 0 | 160 | 81.8 |
| bartın | 158.0037 | -0.19031 | 0 | 0 | 38 | 8.7 |
| besevler | 153.0085 | -0.22965 | 0 | 0 | 72.3 | 22.3 |
| bilorsa | 153.0062 | -0.21512 | 0 | 0 | 30 | 8.9 |
| bolu1 | 147.2988 | -0.15895 | 0 | 0 | 65.1 | 25.7 |
| bolu2 | 144.8779 | -0.18989 | 0 | 0 | 30 | 10.7 |
| boluçiment | 144.4795 | -0.19638 | 0 | 0 | 10 | 12 |

**Figure 4.** Analysis of the results section to the buses that shows the voltage.

LINE FLOWS

| From Bus | To Bus | Line | P Flow [MW] | Q Flow [MVar] | P Loss [MW] | Q Loss [MVar] |
|---|---|---|---|---|---|---|
| göztepe | selimiye | 1 | -14.5263 | -5.3942 | 0.00582 | -0.84186 |
| göztepe | k.bakkalkö | 2 | -90.4737 | -18.7058 | 0.03804 | -8.8771 |
| selimiye | ümraniye | 3 | -107.6322 | -37.8524 | 0.05595 | -8.6849 |
| ümraniye | vaniköy | 4 | 0 | -0.37985 | 0 | -0.37985 |
| tepeören | ümraniye | 5 | 26.0211 | 2.9184 | 0.08023 | -1.9766 |
| dudullu | ümraniye | 6 | -70.7335 | -28.6964 | 0.25948 | 0.40755 |
| dudullu | tepeören | 7 | -65.2666 | -18.3036 | 0.43537 | 0.27274 |
| k.bakkalköy | ümraniye | 8 | -35.9606 | -15.1151 | 0.03235 | -0.30193 |
| k.bakkalköy | ümraniye | 9 | -36.6077 | -15.2632 | 0.03327 | -0.26815 |
| b.bakkalköy | k.bakkalkö | 10 | 81.2174 | 7.2553 | 0.21653 | 0.57389 |
| b.bakkalköy | k.bakkalkö | 11 | 74.1454 | 6.2535 | 0.20283 | 0.28456 |
| pasaköy | b.bakkalkö | 12 | 177.8774 | 56.4305 | 1.3583 | 8.0899 |
| pasaköy | b.bakkalkö | 13 | 177.8774 | 56.4305 | 1.3583 | 8.0899 |
| kartal | b.bakkalkö | 14 | -16.8475 | -10.6238 | 0.01063 | -11.2192 |
| soganlık | b.bakkalkö | 15 | -20.8093 | -12.264 | 0.00811 | -10.2962 |
| kartal | soganlık | 16 | 128.5161 | 39.7078 | 0.32534 | 1.2718 |
| 380tepeöre | 380ümrani | 17 | 451.4785 | 129.6344 | 0.56799 | 0.53386 |
| 380tepeöre | 380ümrani | 18 | 451.4785 | 129.6344 | 0.56799 | 0.53386 |
| 380pasaköy | 380tepeör | 19 | 1638.4272 | 488.6719 | 8.8969 | 88.9728 |
| 380ada dgk | 380pasakö | 20 | 2533.2873 | 886.2773 | 17.4059 | 106.4879 |
| kurtköy | tepeören | 21 | -229.5359 | -36.5156 | 1.6596 | 7.1421 |
| kurtköy | tepeören | 22 | -237.7736 | -37.7805 | 1.7198 | 7.4488 |
| kartal | kurtköy | 23 | -181.5269 | -28.0522 | 0.71026 | 2.9039 |
| kartal | kurtköy | 24 | -189.3356 | -29.4784 | 0.73674 | 3.0616 |
| kartal | tuzla | 25 | 70.114 | 11.8112 | 0.42975 | 0.52992 |
| icmeler | kartal | 26 | -75.082 | 4.6754 | 0.098 | 0.11083 |
| kroman celi | tuzla | 27 | 34.322 | 17.2721 | 0.00626 | -0.04654 |
| diliskelesi | icmeler | 28 | 104.9495 | 26.5849 | 0.93148 | -13.6905 |
| colakoglu | kroman cel | 29 | 171.019 | 69.9845 | 2.597 | 11.3124 |
| colakoglu | diliskeles | 30 | 12.1184 | 29.5494 | 0.05152 | -0.78411 |
| colakoglu | diliskeles | 31 | 90.8919 | 225.5108 | 0.38637 | 1.777 |
| nuhcimento | diliskeles | 32 | 55.7003 | -108.3668 | 2.3766 | 0.68876 |
| adapazarı | nuhcimento | 33 | 36.9638 | 1.3477 | 0.37993 | -4.0892 |
| colakoglu | gosb | 34 | -0.02925 | 40.8607 | 0.08393 | -0.6212 |
| gosb | tepeören | 35 | -134.1132 | 13.7819 | 0.36375 | 1.3916 |
| diliskelesi | tepeören | 36 | -59.4534 | 14.8269 | 0.20777 | -0.11005 |
| enerjisa | izmitgis | 37 | 57.7883 | 3.4144 | 0.18607 | -0.12679 |
| enerjisa | köseköy | 38 | -16.7883 | 108.0639 | 0.24965 | 0.84657 |
| nuh enerji | nuhcimento | 39 | 85 | -50.7902 | 1.5131 | 3.6879 |
| köseköy | nuhcimento | 40 | -6.0196 | -52.2832 | 0.35085 | -0.75754 |
| entek2 | köseköy | 41 | 97 | -174.7887 | 0.27348 | 1.234 |
| izmitgis | tepeören | 42 | -13.3978 | -18.9588 | 0.11981 | -4.498 |
| tepeören | yarımca1 | 43 | 30.8362 | 8.623 | 0.14056 | -2.0476 |
| şile | tepeören | 44 | -85.1235 | -18.8941 | 0.21573 | 0.2292 |
| isaköy | şile | 45 | -35 | -8.9 | 0.02349 | -0.90593 |
| köseköy | gölcük | 46 | 16.7489 | 1.8106 | 0.04888 | -2.7894 |
| ford otosan | köseköy | 47 | -223.1007 | -35.8414 | 3.6738 | 11.0807 |
| ford otosan | karamürsel | 48 | 173.4007 | 0.84137 | 5.0357 | 14.5985 |
| karamürsel | yalova | 49 | 116.365 | -43.3571 | 1.7667 | 4.8201 |

**Figure 5.** Power flow analysis results and power system line diagram.

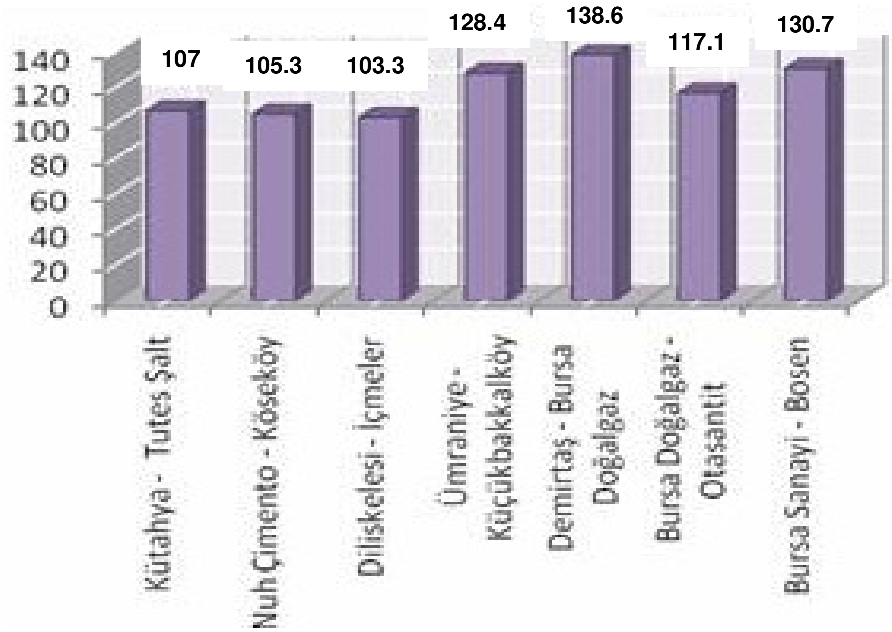


**Figure 6.** The most loaded lines with result of constraint analysis.

## CONCLUSIONS AND SUGGESTIONS

Power flow and constraint analysis are done in this study for the purpose that to operate power systems in most proper way, to prevent the negative happenings which be able to occur in the future and to make appropriate plannings. Close rates are obtainedeachother in Table 2 thereby comparing with power flow results on PSAT programme and power flow results of real system. In constraint analysis, other lines in system overload on their transmission capacity when the double circuit switched off because 380 kV Bursa - NGCCPP Bursa Sanayi and 380 kV Tepeören – Ümraniye power transmission lines carry on same masts.

In Table 1, according to high load estimations; constraint analysis was done at Northwest Anatolia network for 154 and 380 kV in Turkey and 5 sample buses which are under ciritical state were discussed. In the discussed system, when 380 kV Bursa – NGCCPP Bursa Sanayi power transmission lines (double circuit) switched off simultaneously, 154 kV Demirtaş-Bursa NGCCPP buses load with 138.68% rate. When 154 kV TutesŞalt-Tutes B power transmission line disabled, the most ciritical loading happens at 154 kV Kütahya-TutesŞalt bus with 107% rate. Critical loading rate of buses which is determined by Turkey electrical transmission incorporated company (TETIC) are 10% for 154 kV buses and 20% for 380 kV buses (Teias, 2008).

According to analysis result, it is seen that 154 Tutes şalt Tutes B and 380 Kv Bursa – NGCCPP-Otosantit buses close the critical loading rate and 380 Kv Demirtaş-Bursa NGCCPP and 380 Kv Bursa Sanayi - Bosen buses are over than limit rate to prevent the power outages for mentioned transformer centers, we should extend the capacity for high loaded line or should eliminate a number of loads. We should string up high capacity conductors or should construct new transmission lines to prevent these negativities.

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